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Surgical Service Journeyman

Volume 5. Surgical Pharmacology, Surgical Wound Management

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THIS IS THE FINAL VOLUME of CDC A4N151, *Surgical Pharmacology, Surgical Wound Management*. In volume 4, we finished with a discussion of the general intraoperative routines and duties the surgical technician performs in the role of scrub or circulator. In this volume, the focus shifts to some of the specific knowledge and skills the surgical technician must master to assist the surgeon intraoperatively.

The first unit covers surgical pharmacology—the handling, preparation, and use of the many drugs and solutions used in modern surgery. It starts with a discussion of the methods we use to administer drugs and solutions to the surgical patient, paying particular attention to the supplies and equipment used to do so. The next section covers how we handle drugs, solutions, blood, and blood products in the surgical environment. The first unit ends with a discussion of the types and uses of the various pharmaceutical agents.

Unit 2 covers hemostasis and internal surgical stapling devices. The first section covers some of the thermal methods used to control surgical blood loss, focusing on electrosurgery and surgical laser use. We then move to the chemical hemostatic agents, and finish the unit with the mechanical hemostatic devices, surgical clips, and internal stapling devices.

In Unit3, we look at how we close the surgical wound. The unit opens with a discussion of the various materials used to close the surgical wound, paying particular attention to sutures. The next section focuses on how the surgical technician prepares the sutures for use, starting with how to determine what to use and when to use it, then moving to preparation of the different types of sutures and needles. The last section covers how the surgical wound heals, and also the techniques of wound closure used to help the wound heal. The unit finishes with a look at one of the most common surgical wounds, the abdominal incision. We look at how we typically "close" the abdomen.

A glossary of terms, abbreviations and acronyms used in this course are included at the end of this volume.

To get a response to your questions concerning subject matter in this course, or to point out technical errors in the text, unit review exercises, or course examination, call or write the author using the contact information on the inside front cover of this volume.

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This volume is valued at 21 hours and 7 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

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Unit 1. Surgical Procedures

AT THIS STAGE IN YOUR TRAINING, you are aware that surgical personnel handle an abundance of drugs, solutions, and other agents. While most drugs and solutions are actually administered by a licensed provider, such as a nurse or physician, surgical technicians frequently retrieve, prepare, and otherwise handle them. You must have a working knowledge of commonly used medications and solutions, particularly those you are required to mix, transfer, or prepare on the sterile field while scrubbed in. You should also have an understanding of basic surgical pharmacology so you can safely start intravenous infusions, work in the postanesthesia recovery room, or assist anesthesia personnel during anesthesia administration and emergency situations.

The purpose of this unit is to increase your knowledge of the drugs, agents, and solutions most often used in the operating room. We will not try to make you “mini-pharmacists,” but will focus primarily on basic information about the medications, agents, and solutions you will handle or see used in surgery. We start with the methods of administration, including the supplies and equipment used. We move on to safely handling drugs, solutions, blood, and blood products, and then finish the unit with a discussion of the specific agents you will frequently see or use.

1–1. Methods, Supplies, and Equipment for Administration of Drugs, Solutions, Blood, and Blood Products

We use numerous methods, supplies, and devices to administer drugs, solutions, and blood products to our patients. As a surgical technician, you will often be the one to retrieve, set-up, and care for these items. We start by covering how drugs and solutions are administered so you know which supplies are needed for each method.

801. Methods of administering drugs and solutions

You use different methods to administer the different agents you use in surgery. Some drugs or solutions can be administered using only one method; other drugs offer multiple routes of administration.

Routes for administering medications

The route of administration is simply the manner a drug or solution is given to the patient. The method of administering a drug varies depending on the physical and chemical properties of the agent, the condition of the patient, the desired action of the medication, its speed of absorption in the body, and the desired speed of action. The three basic routes of drug administration are oral, topical, and parenteral (pronounced pa **ren’** ter al).

Oral route

Oral medications are solids (tablets, powders, or capsules) or liquids given to the patient to take by mouth (usually abbreviated as "PO). You generally think of oral medications as being swallowed by the patient, but any medication given by mouth may be considered an oral medication. Oral administration is the safest and most common, economical, and convenient way to give medication. This method does not require any special equipment and is painless (a big plus from the patient's point of view!). Oral administration is the method of choice; most doctors use it unless there is a specific reason for or advantage to using another route. Surgery is one of these reasons. You seldom see a medication given orally in the surgical suite because you try to keep patients' stomachs as empty as possible to reduce chances of aspiration.

Drugs given by mouth and swallowed by the patient are designed to have a systemic effect. They are absorbed into the circulatory system, through the walls of the alimentary (digestive) tract, and the medication is carried throughout the body. They are usually slower acting, longer lasting, and less potent than drugs administered via other routes. They may also result in unwanted side effects, such as nausea and vomiting caused by gastric irritation or allergic reaction to the drugs.

Sublingual medications, such as nitroglycerin (used to control "heart pain"), are placed under the tongue until they dissolve and are absorbed through the mucous membranes into the blood vessels under the tongue. The sublingual method is a fast, efficient, and convenient method of administering a systemic affecting drug that would be destroyed by the digestive processes. Oral medications can also be administered to achieve a local effect on the mucous membranes of the mouth and throat. One method for achieving this is the buccal method of administration. This method involves holding a medication, such as a lozenge, inside the mouth against the mucous membranes of the cheek until it is dissolved and absorbed. Cough drops and throat lozenges rely on the buccal method to achieve their localized effects. Other methods to achieve a local effect include using mouth rinses or gels. Some sublingual and buccal drugs are also classified as topical medications.

Topical application

Topical medications are applied to the skin and mucous membranes. They usually have a localized action, affecting only the immediate area of application, but some (like sublingual nitroglycerin) are absorbed and have a systemic effect. You should be familiar with some topical drugs from the discussion in volume 3 on conduction (local) anesthetic agents. Topical medications can be applied to virtually any area of the body. Examples include optic (eye), otic (ear), nasal (nose), vaginal, rectal, and pulmonary (lung) applications. Topical agents come in many forms—creams, ointments, gels, lotions, tinctures, baths, impregnated dressings, suppositories, or sprays. Common uses of topical medications include coating urinary catheters and endotracheal tubes with lidocaine gel before insertion; packing an ear, nose, and throat (ENT) patient's nose with cocaine-soaked gauze; and packing open wounds with iodophor gauze. Some of the inhalant agents used by anesthesia are also classified as topical agents. When you scrub your hands or prep a patient with an antiseptic solution, you are applying the germicidal agent topically.

Parenteral administration

A simple definition of parenteral administration is injecting a drug or solution through a needle or infusing it through a catheter. Advantages to parenteral injections are:

- Medications are absorbed rapidly into the circulatory system. This enables the person administering the drug to predict and control the onset of action.
- Parenteral medications are almost totally absorbed; oral medications may be partially destroyed by the digestive system. As a result, smaller doses can achieve the desired effect.
- Parenteral administration allows drugs to be given to patients who cannot or will not swallow, such as patients who are unconscious or uncooperative.

Unfortunately, there are some major disadvantages and hazards associated with parenteral administration of medications. The external skin barrier is compromised during injection and vascular infusion; body cavities are entered during catheterization. This increases the risk of infection, so anyone using the parenteral method to administer a drug must use a strict aseptic technique. Because parenteral administration involves penetrating the body abnormally, the risk of possible nerve damage, tissue necrosis, abscess, and pain increases. As a result, parenteral administration is reserved for those individuals certified as having the appropriate knowledge and skills to administer the medication safely, usually a licensed provider.

The rapid absorption of parenterally administered medications may cause equally rapid adverse reactions. Unlike topical or oral administration, you cannot usually retrieve a medication once it has been injected or infused. The person administering the drug must be prepared to deal with possible allergic reactions and other unfavorable responses. Parenteral administration also causes the patient much greater anxiety and physical discomfort (very few people prefer a “shot” to a pill) than topical or oral methods. This method is also more expensive due to the extra supplies and equipment required.

There are several different methods of administering drugs and solutions parenterally. The most common methods are intradermal injection, subcutaneous injection, intramuscular injection, and intravenous injection.

Intradermal injection

Intradermal injections (fig. 1–1, A) are made between the layers of the skin—specifically the epidermis and dermis. The amount of medication given is small and, because the blood supply to this area is poor, the rate of drug absorption is slow when compared to other parenteral methods. Although intradermal injections are unsatisfactory for administering therapeutic drugs, they are useful for administering local anesthetic agents and for allergy testing. Injecting the local anesthetic before inserting the intravenous catheter is an example of an intradermal injection.

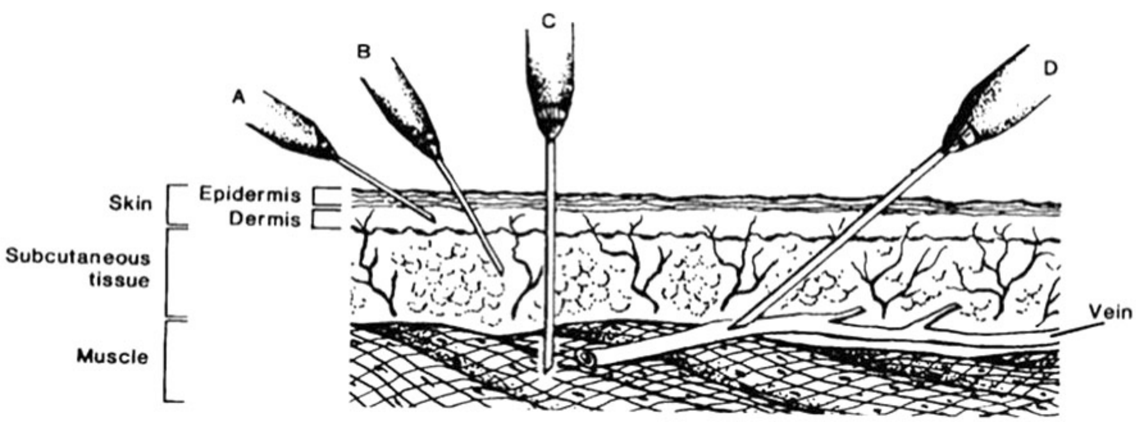

Figure 1–1. Methods of parenteral administration via injection.

Subcutaneous injection

The subcutaneous (SQ) injection is made in the subcutaneous tissues between the dermis and muscle (fig. 1–1, B). Since the blood supply to subcutaneous tissue is better than that of the dermal layers, absorption of drugs is faster than intradermal injection, but not as fast as injections given in more vascular tissues. Heparin and insulin are commonly administered via subcutaneous injection.

Intramuscular injection

Intramuscular (IM) injections are made through the skin and subcutaneous tissue, directly into the “meat” of a large muscle group (fig. 1–1, C). Since muscle is highly vascular tissue, medication absorption is rapid. IM injections are useful when administering drugs that must act rapidly, or for drugs too irritating (they "burn") or too toxic to be injected subcutaneously or intravenously. Two common administration sites for intramuscular injections are the deltoid (shoulder) and gluteal (hip) muscles. Most pain medications, such as Morphine and Demerol, are administered using an IM injection. You most commonly see IM injections used on recovering patients in the postanesthesia care unit (PACU).

Intravenous injection or infusion

Intravenous (IV) injection or infusion is the most commonly used method to deliver drugs or solutions in the surgical environment. IV injection or infusion involves administering the medication directly into a vein (fig. 1–1, D) to achieve the most rapid, nearly immediate, effect. This method of administering medication requires the most knowledge, skill, and care, because of the serious complications that may result. IV infiltration is also the most useful method for emergency administration of drugs and solutions. This is the reason nearly all surgical patients have an IV line started before their operations. You should remember from our lesson on anesthesia in volume 3, many anesthetic agents and related drugs are also administered intravenously.

Other methods of parenteral administration

The four methods we just outlined are by far the most common methods of parenteral drug administration. Other methods include intrathecal (intraspinal), intra-arterial, and intracardiac. You can review the lessons on spinal and epidural anesthesia in volume 3 if you do not remember much about intrathecal administration. Intra-arterial injections are commonly used to administer x-ray detectable dyes into the arterial system for diagnosing vascular conditions (arteriograms). The most seldom used parenteral drug administration method is the intracardiac injection. It is only used to inject a drug directly into the heart muscle during cardiac arrest when a physician determines it is required to save a patient's life.

You should now have a basic understanding of the different routes and methods of administering drugs and solutions. We will now focus on the specific supplies and equipment most commonly used to administer them.

802. Supplies and equipment used for parenteral administration

Before you can safely prepare medication for administration, you need to be familiar with the supplies you will use. Since parenteral administration is the method used for most of the medications used in surgery, we focus on the different syringes, needles, and other supplies used for injection or infusion. We also cover some of the devices you use to help control the administration of some solutions or medications.

Supplies and equipment

You need to become thoroughly familiar with two basic supply items: syringes and needles. We briefly discussed selecting these items in the unit on anesthesia in volume 3. Now, we need to expand your knowledge base. Some of this information is simple and basic, but it is essential for you to know the parts and uses of syringes and needles to ensure you can handle them aseptically and safely.

Syringes

Figure 1–2 shows three basic components of a syringe: the barrel, plunger, and tip. This figure also displays finger and thumb flanges, which allow you to apply pressure. The barrel is the round outer part, the plunger is the piston-like part that moves up and down inside the barrel, and the tip is the small projection that fits inside the hub of the needle. Most syringes, designed for injection, have a plain tip which is sometimes referred to as a slip tip, or they may have a locking tip. The syringe in figure 1–2 has a plain tip; its tip is tapered to fit tightly inside the hub of the needle. Friction holds the needle in place. The locking tip, usually a "luer-lock," consists of a shortened slip tip surrounded by a collar or ring with internal threads.

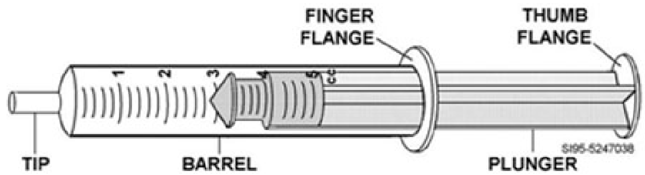

Figure 1–2. Parts of a syringe.

The top syringe (fig.1–3) and the control syringe (fig. 1–4) have luer-lock tips. The user locks the needle to the syringe by screwing the needle hub onto the tip of the syringe. Some syringes are designed for irrigation and have a large bore “catheter” tip. These syringes are not usually used for injections.

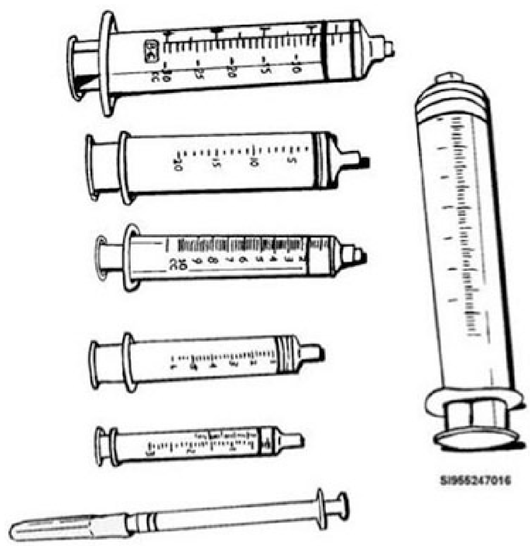

Figure 1–3. Assorted sizes and types of plastic syringes.

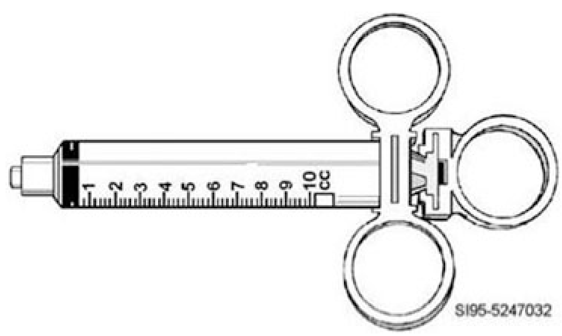

Figure 1–4. A 3-ring “control” syringe.

How does it work? When you pull back on the plunger, a vacuum is created inside the barrel. If the tip of the syringe (or needle) is immersed in a solution, the solution is drawn into the barrel; if the tip is not immersed, air fills the barrel. When the desired amount of solution (or air) has been drawn into the syringe, you stop pulling on the plunger. Whenever you draw up a solution for injection or irrigation, it must be sterile. If you are not wearing sterile gloves, you should touch only the end of the syringe plunger and the outside of the barrel. To keep them sterile (and pyrogen-free), the tip, the inside of the barrel, and the plunger shaft should never be touched by a non-sterile object.

Syringes are generally made from either plastic or glass, with plastic being the most commonly used. As shown in figure 1–3, there are many different sizes and types of syringes used in surgery. You usually find sizes ranging from the 1 cubic centimeter (cc) “tuberculin” syringes to the large volume 60cc or 70cc “Toomey” irrigating syringes. You also find cartridge syringes, cartridge-needle syringes, pre-filled syringes, 3-ring “control” syringes (fig. 1–4), and a host of other special designs and types. Some syringes are prepackaged with needles attached, but most are not. Some syringes are designed for a specific purpose, such as insulin syringes. Some syringes also have safety shields to reduce accidental needle sticks. Syringe selection is based on the site of injection, purpose of the injection, volume of the medication to be administered, and need for accuracy in medication dosage.

While plastic syringes are most commonly used for routine use, glass syringes are also used in surgery. The glass plunger is somewhat different from the plunger on a plastic syringe. The plunger of a plastic syringe has an attached rubber stopper to form a tight, leakproof seal in the barrel. Glass syringes do not have this stopper. The glass syringe’s plunger fits snugly inside the barrel. The tolerances between the outside of the plunger and the inside of the barrel are very close; many manufacturers numerically code the plunger and barrel; check these numbers before use to ensure you are using a matched set. Glass syringes are also delicate, so be careful not to break or chip them.

NOTE: CC and milliliter (ml) are often used interchangeably.

The outside of the syringe barrel is marked with graduated lines to show the volume of solution in a syringe. As shown in figures 1–5 through 1–7, these graduations or calibrations may be expressed in ccs, mls, units [insulin], or in minims (m). A minim is an apothecary measure roughly equal to one drop. Milliliters and ccs are considered to be interchangeable metric fluid (volume) measures, so the syringe will be marked with either one. Generally speaking, the smaller the syringe volume, the more accurate the measurements. For example, a 1cc tuberculin syringe (fig. 1–6) is calibrated in increments of 0.1, 0.05, and 0.01 (tenths, five-hundredths, and one-hundredths) ccs. This allows you to achieve a very precise medication dose. In contrast to a 20cc tuberculin syringe, that is calibrated in 1cc and 5cc increments.

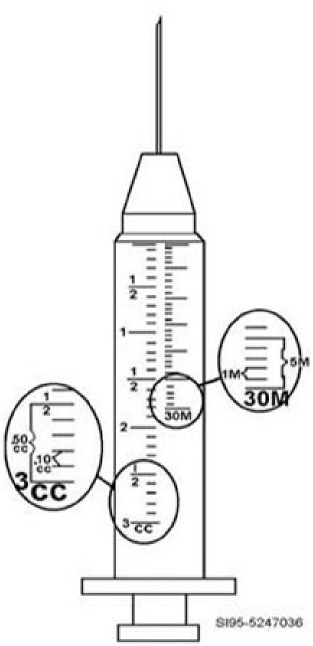

Figure 1–5. Calibrations commonly used on syringes.

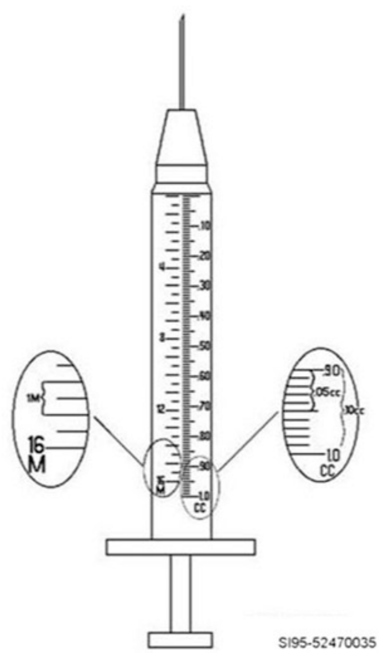

Figure 1–6. Accuracy of a 1cc tuberculin syringe.

You measure the volume of solution in a syringe by looking at or “reading” the point where the end of the plunger lines up with the calibrations. When reading the solution volume in a syringe, hold the syringe in an upright position directly in front of your eyes. Measure the volume after removing all air from the medication. The measurement should not include the small amount of solution in the tip of the syringe and shaft of the needle.

CAUTION: Some syringes are calibrated to measure precise volumes or concentrations of specific medications. For example, the insulin syringe (fig. 1–7) may look like a standard 1cc, 2cc, or 3cc syringe, but is usually calibrated to deliver a specific dose or *unit* of insulin. These units may be very close to, but are not interchangeable with, syringes calibrated in the metric or apothecary systems. Always check the label on the syringe barrel for the measurement scale it uses.

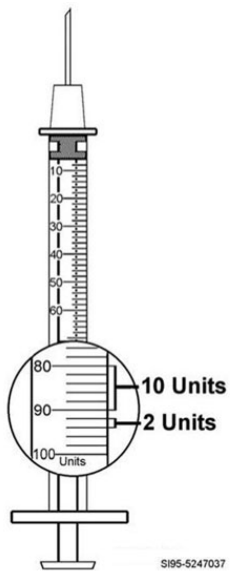

Figure 1–7. Insulin syringe calibrated in units.

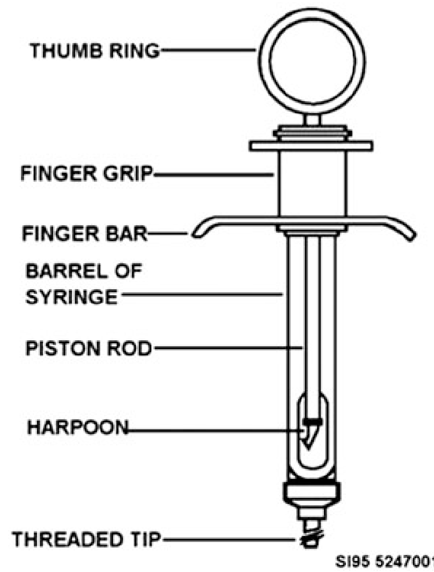

Figure 1–8. A cartridge (dental) syringe.

Other types of syringes are also sometimes used in surgery. Two of these are the prefilled cartridge (fig. 1–8), often called a dental syringe, and the prefilled cartridge/needle syringe (fig. 1–9), sometimes called a “Tubex” syringe. Both types are usually made of metal, though some plastic models are available.

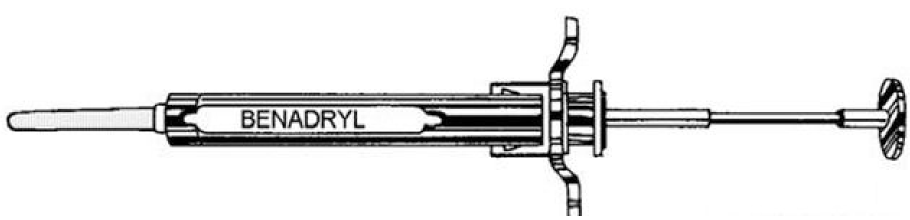

Figure 1–9. A cartridge/needle (Tubex) syringe.

The cartridge syringe uses a specially designed needle and a separate cartridge; while, as the name implies, the cartridge/needle syringe uses a cartridge with an attached needle. We discuss both types a little more in detail later.

Another type of syringe/cartridge unit is shown in figure 1–10. It consists of a prefilled cartridge and a plastic barrel with an attached needle, and is commonly called a “Bristoject,” after the brand name of the company that first developed it. This type of syringe is often used for emergency medications, such as those used during a cardiac arrest. They guarantee single-use dosage accuracy and save valuable time during these life-or-death emergencies.

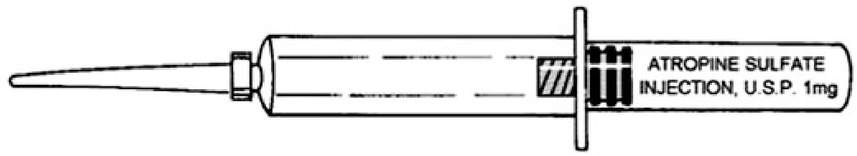

Figure 1–10. A prefilled cartridge/plastic barrel syringe (Bristoject).

Needles

The basic components of the needle (fig. 1–11) are the hub, shaft, and bevel. The hub is the enlarged portion at the base of the needle. It has an opening large enough to fit over the tip of a syringe, and usually has a rim or ridge to lock into the collar ring of a luer-lock syringe. The shaft is the long, slender part, and the bevel is the angled tip (point) of the needle. The needles most often used in surgery are hypodermic needles; they are classified by the diameter of the hole through (internal diameter) and by the length of the shaft. The diameter is measured by *gauge*, an inverse measurement. As the diameter of the needle gets larger, the gauge number of the needle gets smaller. Thus, an 18 gauge needle has a much larger diameter than a 27 gauge needle. The length is usually measured in inches, but may be measured in mls or centimeters. There are many sizes of hypodermic needles available, from 1/2-inch long, 30 gauge needles to 3-inch long 18 gauge needles. Figure 1–12 shows an assortment of standard hypodermic needles.

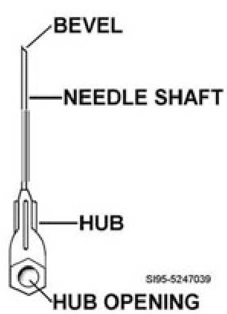

Figure 1–11. Parts of a needle.

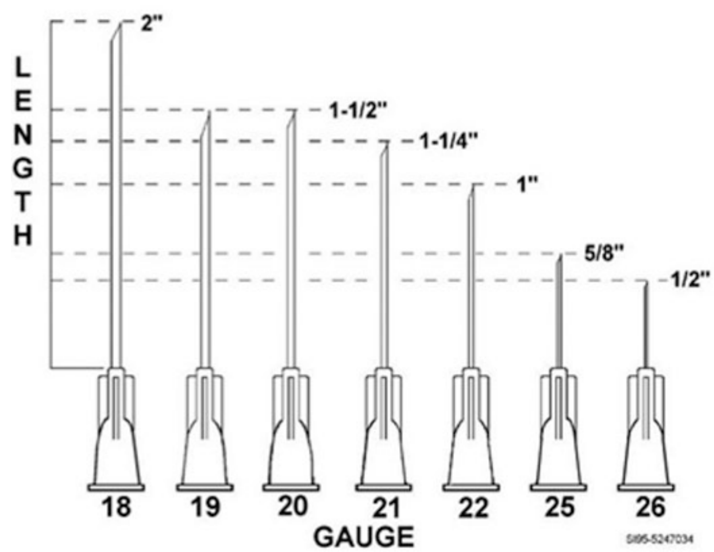

Figure 1–12. Common sizes of hypodermic needles.

There are longer needles, such as those routinely used for spinal injections, and larger diameter needles, such as those used to aspirate tissue biopsies. We covered the types of needles and catheters used for intravenous infiltration in the unit on anesthesia in volume 3; you can review it if you need to. There are many other types of specialty needles designed for specific applications. Examples include extra-long spinal needles, epidural needles, blunt needles, biopsy needles, and intravenous needles, but they are seldom used for routine drug administration.

The bevel of the needle often determines its use. Figure 1–13 illustrates various bevel shapes and needle points. Generally, the longer the bevel, the more easily the needle penetrates; thus needles for spinal anesthesia generally have long bevels to help penetrate the ligaments and the dura. The disadvantage is the longer bevel also increases the risk of unintentionally penetrating a nerve or other structure. For this reason, the bevels of epidural needles are often shorter and blunter, such as in the Crawford needle, to reduce chances of penetrating the dura. Other epidural needles, such as the Touhy needle, have a curved bevel with the lumen opening on the side of the shaft. Some needles, particularly long thin ones used by anesthesia, have a "security bead" near the base of the shaft; the bead prevents the needle from disappearing under the skin if it accidentally breaks.

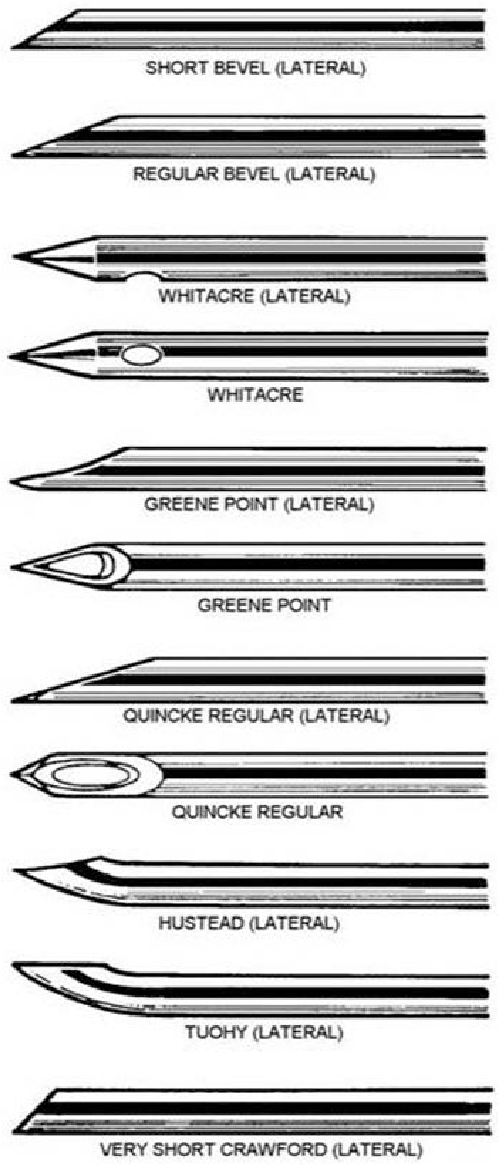

Figure 1–13. Various shapes of needle bevels.

Cartridge syringes also use special needles. The cartridge needle (fig. 1–14) extends all the way through the hub and protrudes on both sides. The inside of the needle hub is threaded to screw on to the syringe tip, and the short end of the needle protrudes up into the syringe barrel. When a cartridge is loaded in the syringe, the needle penetrates the rubber diaphragm to allow for injection. Most cartridge needles used in surgery range between 25 – 30 gauge in diameter and 1" – 15/8" in length.

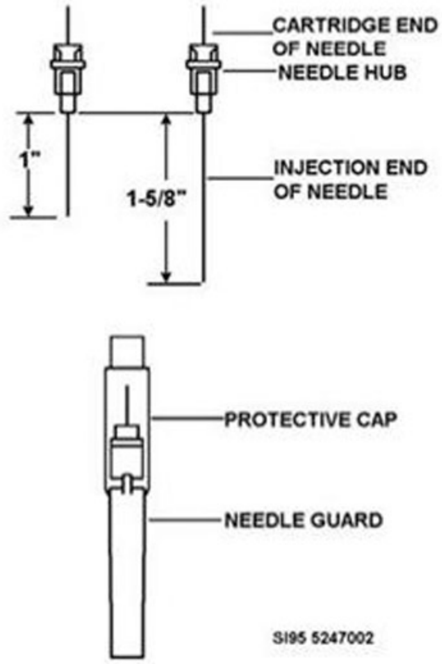

Figure 1–14. A cartridge syringe needle.

The care provider usually determines and specifies the specific type and size needle for injecting the patient. Your job is to attach it and ensure it is serviceable. You should ensure the bevel is sharp and free of burrs, and the shaft is not kinked or severely bent. This is particularly important if the same needle is used for multiple injections during local anesthetic administration. If you are tasked with selecting the needle, use the smallest gauge and shortest length possible; the volume to be injected, the viscosity (thickness) of the solution, and the patient's sensitivity are all factors to consider. For example, you do not select a 21 gauge 2" needle to inject a local anesthetic with a water-like viscosity into an awake patient scheduled for a mole removal. A 26 gauge 1/2" needle is much more appropriate. The larger needles not only cause the patient more pain and anxiety, but also make it more difficult for the person administering the medication to precisely control the rate and volume of injection.

Although some syringes and needles are packaged as a unit, most needles used in surgery come in individual sterile packages. This allows you to select or change needles without having to discard the entire syringe and solution. If attaching a needle without wearing sterile gloves, keep the needle sterile. Touch only the outside of the protective cap; also, never recap a needle after use—it greatly increases your risk of needle-stick injury and exposure to blood-borne pathogens.

Solution containers

As we discussed in volume 3, intravenous solutions generally come in bags or bottles. Plastic bags are most commonly used, and they range in size from 50ml to 3000ml. The most common sizes used in surgery are the 500ml and 1000ml bags. Smaller bags, ranging from 50ml to 250ml, are primarily used for "piggy-back" infusion, which is the addition of a secondary solution or medication into the main IV line. Some solutions are still packaged in glass bottles because they interact with plastic, but these are seldom seen in the operating room.

Most medications for parenteral administration are packaged in either ampules or vials. An ampule (fig. 1–15) is a sealed glass container that usually holds a single dose solution of medication. It is made completely of glass, with a cylindrical base and a candle-flame-shaped top. The "neck" of the vial separates the base from the top, and is either marked with a ring or has a "scored" line around it. This ring or line is the point the ampule is broken to gain access to the medication.

A vial is also a glass container; it is basically a small bottle sealed with a rubber stopper and a plastic or soft metal cap. Figure 1–16 shows a typical vial with a plastic protective cap. Vials may contain a single-dose or a multi-dose of medication, but in the operating room, they are nearly always handled as a single dose. Vials may contain powders or solutions; the medication may be withdrawn using a needle through the rubber stopper, or by removing the entire cap and stopper.

Figure 1–15. An ampule.

Figure 1–16. A vial.

Other medications, particularly local anesthetic agents, come in small glass cartridges designed to be used with the cartridge syringes discussed above. A cartridge (fig. 1–17) is simply a small glass tube filled with a medication or other solution, and then sealed with a rubber stopper on one end and an aluminum cap with a rubber diaphragm on the other. Some cartridges have a capped needle affixed instead of the aluminum cap with diaphragm. Each cartridge is clearly labeled with the medication name, dosage, strength, and volume contained.

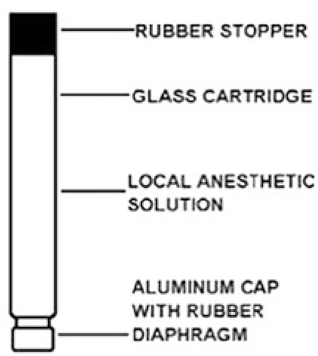

Figure 1–17. A cartridge.

Pre-filled, disposable medication syringes and other medication and solution containers are also used in surgery, but we have covered the ones you will most commonly see. As always, follow local instructions and manufacturers guidelines when handling them.

Infusion pumps, controllers, and pressure bags

Many devices help regulate the flow of intravenous solutions. These devices may be sophisticated electronic devices or may be simple balloon-like pressure bags. When an electronic infusion device (EID) is needed, it usually accompanies the patient to the operating room from the nursing unit; pressure bags are usually maintained by anesthesia personnel because they are most often used for blood transfusions.

Electronic infusion devices

EIDs can be used to control the volume and flow rate of intravenous fluids. Although these devices monitor and adjust the flow rate, they are not infallible and do not relieve surgical personnel of the responsibility for monitoring the IV! They should be used with, not instead of, manual control and monitoring methods. EIDs are not used for every IV, but they are used when a precise flow rate is required because of the patient's condition or because of a type of medication being administered. These devices fall into two general categories: infusion pumps or infusion controllers.

Infusion pumps electronically monitor and adjust intravenous infusion by delivering the fluid under positive pressure, literally pumping the solution into the patient. The solution is monitored and metered as it passes through the tubing in a specially designed chamber in the pump, and the pressure increases or decreases to maintain a constant flow. Some advantages of these devices are they can overcome resistance to flow caused by the patient changing position, and they can be used for arterial or deep central venous (cutdown) infusions. They are also useful for patients with multiple IV lines. Their main disadvantage is they may continue to increase pressure to overcome resistance of a mal-positioned IV catheter and result in extensive tissue infiltration. Another disadvantage is they cannot be used to deliver toxic medications, such as those used in chemotherapy, because these medications may destroy surrounding tissue if infiltration does occur.

Infusion controllers electronically monitor and adjust gravity-fed intravenous lines by counting the drops as they fall through the drip chamber and adjusting the flow rate by constricting or releasing the tubing. Because they are gravity fed, they cannot adjust for increases or decreases in flow resistance caused by patient positioning. Therefore, you must exercise caution when transferring the patient and the IV solution container; positioning the container too high or too low influences the controller's effectiveness. Most controllers require the container be placed 30- to 36- inches above the infusion site. An advantage of infusion controllers over infusion pumps is infiltration or obstruction of the IV is more easily detected because the flow slows or stops. There is no device to increase pressure of delivery so the extent of infiltration is less than with a pump.

EIDs use one of two methods of delivery. The drops-per minute, or rate consistent, method delivers the solution at a constant rate of flow; it usually maintains a specific level of medication in the patient's system. The milliliter-per-hour, or volumetric, method delivers a specified amount of solution over a specified time. Volumetric devices are useful when a patient needs to maintain a specific fluid level. For example, an extensively burned patient may need to receive 250ml of fluid per hour to maintain vital functions; the rate the solution is infused is not as critical as the volume received.

Figure 1–18 shows the control panel of a typical infusion controller using the rate consistent method of delivery. Notice the IV tubing from the solution container enters the rate clip regulator at the top and exits at the bottom. The rate of administration is monitored and adjusted as the solution passes through the tubing in the clip. The display shows the controller is programmed to deliver 20 drops per minute (20 gtt/min).

Figure 1–19 shows the control panel of a typical infusion pump using the volumetric method of delivery. The IV tubing being used with the pump shown is a "Y"-type administration set. The solution from two separate containers enters from the top and side, then passes through the pump (not shown, it is behind the door panel), and emerges as a single IV line. Some pumps use standard IV tubing threaded through the pump; other pumps use IV tubing with special chambers or cartridges to monitor and pump the solution. The display shows the pump is programmed to deliver 125 milliliters per hour (ml/hr).

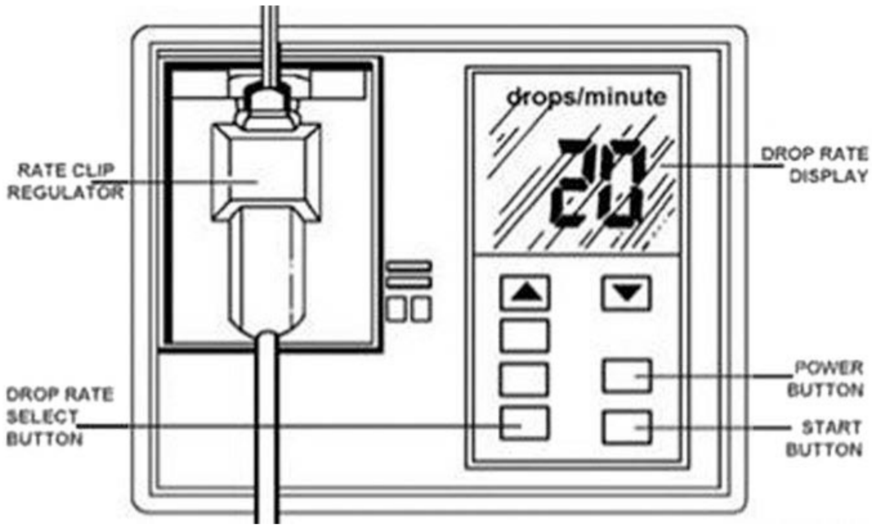

Figure 1–18. An infusion controller.

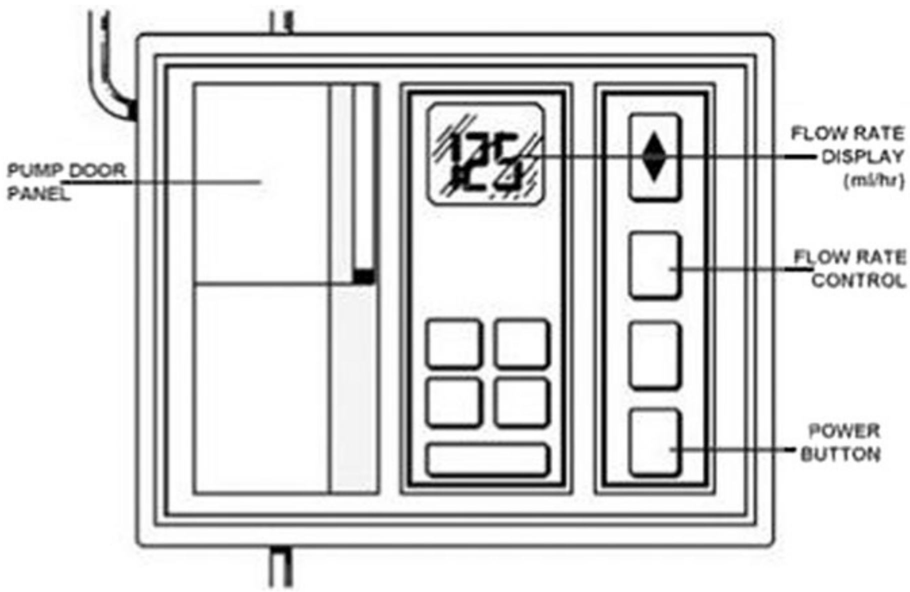

Figure 1–19. An infusion pump.

Most EIDs have some or all of the following features:

- A flow setting control button that allows you to set, with a display that shows, the rate or volume of solution the EID is programmed to deliver. Some models allow you to set minimum and maximum levels of infusion.
- A meter display that shows the amount of fluid actually being infused. Some models display the amount of fluid that has been delivered, some display the amount still to be delivered, and some models display both. Still other meter’s display shows the rate of infusion.
- A drop (rate) sensor that detects the flow of solution through the tubing or drip chamber.
- An air sensor that detects the presence of air in the lines.
- An occlusion detector that monitors increases in pressure or resistance to solution flow.

- An infiltration detector that monitors the temperature of tissue surrounding the IV site. If the skin surrounding the IV catheter reaches a pre-determined cool temperature, infiltration may have occurred.
- Alarms, visual (lights) and audible (beeps or tones), that trigger when various conditions arise. Frequent alarm triggers include solution flowing too slowly, solution flowing too rapidly, air in the IV line, solution container being empty, and IV line being occluded (stopping flow completely). Because infusion controllers rely exclusively on gravity, they are more prone to frequent alarms than infusion pumps.
- Rechargeable batteries that allow patients to ambulate or be transported without interrupting the intravenous infusion.

Pressure bags

Pressure bags, sometimes known as pneumatic infusion pumps, are simply nylon bags containing an inflatable bladder inside with a cloth or nylon mesh front. They are only used with bags of solution or blood. The patient's IV bag is sandwiched between the mesh and the bag, and then the unit is suspended from an IV pole. The pneumatic bladder is inflated with a hand bulb, just like the one on a blood pressure cuff, to the pressure determined by the physician; a gauge indicates the inflation pressure. When the bladder is inflated, the solution is squeezed against the mesh on the front side of the bag, and the pressure increases the rate of flow into the patient. Pressure bags are primarily used to rapidly infuse large quantities of solution or blood in emergency situations.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

801. Methods of administering drugs and solutions

1. What are the three basic routes for administering medications?

2. Which drug administration method is safe, most common, convenient, and economical?

3. How do drugs given by mouth and swallowed by the patient have a systemic effect?

4. What method of administering drugs involves placing the medication under the tongue?

5. List five forms a topical agent may take.

6. What is a simple definition of parenteral administration?

7. List three advantages of administering drugs parenterally.

8. What type of parenteral administration involves injection of medication between the epidermis and dermis?

9. What type of injection is made into the tissue between the dermis and muscle layer?

10. What two areas of the body are most often used for IM injections?

11. What method of parenteral drug administration is most commonly used in surgery?

12. What type of parenteral administration may be used by a doctor to inject drugs into the heart muscle during a cardiac arrest?

802. Supplies and equipment used for parenteral administration

1. What are the three basic parts of a syringe?

2. What type of syringe is not usually used for injections?

3. If you are not wearing sterile gloves, how should you handle a syringe when “drawing-up” a solution?

4. What four calibrations or graduations are commonly found on syringe barrels?

5. What size syringe is generally more accurate—smaller or larger?

6. Briefly describe how you measure or "read" the volume of medication in a syringe.

7. List the three basic parts of a hypodermic needle.

8. Briefly describe the relationship between the gauge and the diameter of needles.

9. How does the needle bevel influence tissue penetration?

10. If the same needle is used for multiple injections during local anesthetic administration, what needle function or aspect should be checked prior to the next injection?

11. Briefly describe an ampule.

12. Briefly describe a vial.

13. Briefly describe the difference(s) between an infusion pump and an infusion controller.

1–2. Handling Drugs, Solutions, Blood, and Blood Products

Knowing how to prepare and handle drugs and solutions safely is a very important part of your job as a surgical specialist or technician. Even though you seldom, if ever, directly administer medications to patients, you do draw up medications, prepare special cartridge-type syringes, transfer drugs to the sterile field, and mix or otherwise prepare medications and agents on the sterile field. Errors made during any of these activities could result in serious injury, infection, physiological complications, and even death for your patients. Also, careless handling of medications and supplies jeopardizes the safety of surgical team members, delays an operation, prolongs anesthesia administration, and wastes valuable pharmaceutical agents and supplies.

The purpose of this section is to reinforce your knowledge of the techniques used in preparing and handling medications and blood products. The first lesson concentrates on medications and other agents; the second lesson focuses on handling blood and blood products.

803. Handling drugs and solutions

You should recall we briefly discussed safety guidelines for handling drugs, solutions, and caustic chemicals in volume 1 in the unit on operating room safety. We will now not only refresh your memory, but add some specific procedures to ensure you know how to handle surgical medications in a safe, efficient manner.

Safety guidelines for handling medications

Any time you prepare, handle, or pass medications to the surgeon or other surgical team members, follow the guidelines and principles shown in the following.

When Medicines Must be Identified
All medications should be identified at least three times before use on the sterile field: 1. Before it is opened. 2. Immediately before transfer. 3. Immediately after the transfer.

The circulator performs the first identification by silently reading the label before opening the container. The second identification should be visual (reading) and oral (reciting) by the scrub and the circulator. Before transferring the drug or agent, the circulator, as a minimum, reads aloud the type, strength, expiration date, and amount of the drug being transferred. The scrub then reads the container label, reciting the information back to the circulator.

The drug or agent is transferred, and then the third identification is made the same way as the second.

When Medicines Must be Identified
All medications should be identified at least three times before use on other than the sterile field: 1. When it is removed from the storage cabinet or shelf. 2. As it is drawn up or removed from its container. 3. Immediately before being administered to the patient.

The following table identifies medication safety guidelines:

Medication Safety Guidelines	
DO	• Use strict aseptic techniques during the preparation, handling, and transfer of all medications and solutions. Ensure you do not contaminate the medication or the administration devices. (We discuss procedures for transferring drugs to the sterile field later in this lesson.) • Keep all empty drug, solution, blood, or blood component containers in a conspicuous location in the operating room until after the procedure is over. This is necessary in case any questions arise about the drugs and solutions administered, particularly if complications develop that may be triggered by certain agents. • **DISCARD AND REPLACE A SOLUTION OR MEDICATION IF YOU ARE EVER LESS THAN 100% CERTAIN OF ITS IDENTITY**. All medications or solutions that are removed from their original container must be labeled properly in accordance with Joint Commission standards and local policy. Local policy will dictate whether a locally developed or commercially manufactured label is used. (Keep in mind that solutions or medications that are not labeled should be discarded from the surgical field immediately.) • Use only warm (not hot), sterile saline for wound irrigation, unless the surgeon specifically requests otherwise. • Always tell the name, concentration (strength), and amount of the medication when passing a medication to another member of the surgical team. • Confirm a request for a medication by repeating the order back to the provider when the request is made. If you have any doubt about the order, ask for verification. Never pass a medication unless you are 100% sure it's exactly what the provider ordered. • Keep track of the amount of irrigation solution or drugs used on the sterile field. Irrigation solution volume is used to compute blood loss. Keeping track of and reporting drug volume reduces the likelihood of an inadvertent overdose, and is required for intraoperative records. • At the conclusion of the surgical procedure make sure that you properly dispose of any unused solutions or medications in accordance with federal guidelines and local policy. This can be done by soaking up any unused fluids with extra sponges or towels that are left over from the procedure, emptying syringes into the trash or placing them into a sharps container. On the chance that you are working in the PACU or with anesthesia and you are required to clean up the anesthesia carts; remember if at any time narcotics are left over from the surgical procedure two licensed providers must witness the disposal of the item. Usually this is accomplished by an anesthesia provider and a nurse.
DO NOT	• Use or accept an expired drug. Always check the medication label for the drug expiration date during the identification process. • Use or accept a medication from a glass container that is chipped or cracked, or has other visible evidence of mishandling. The contents may contain glass fragments or may be bacterially contaminated. • Use of accept the contents of a container that has been opened for an extended period. When a solution container is opened, the entire contents should be used, or the contents not used should be discarded. • Save unused portions of medications or solutions for use on another surgical procedure. This increases the risk of cross-contamination between patients. Discard the medication or solution at the end of the case; if local policy allows, medications such as ear drops, ophthalmic ointments, or bacitracin may be sent to the nursing unit for postoperative use by the specific patient. • Use the saline you used to moisten sponges as wound irrigation saline. It likely contains lint and other particles that may cause foreign body reactions. • Re-cap a container for later use because the edges of the cap are considered contaminated. • Use or accept medications or solutions that appear discolored or cloudy. These are signs the medication has been chemically altered or contaminated.

Medication refrigeration

Some medications such as Sodium Dantrolene must be refrigerated. Many operating rooms will be equipped with medication refrigerators normally kept in the anesthesia work room. These refrigerators will be designated for medication use only and should not be used for anything else. (**NOTE:** They do not meet the requirements for tissue or blood storage [we will discuss blood refrigeration later in this unit]). At the start of each duty day, the refrigerators should be inspected for proper function. This inspection should include checking and logging temperature. The temperature must be kept between 2°- 8°C as indicated by a mercury thermometer placed in the middle of the refrigerator. Local policy will dictate what form to document these temperatures and what action is required if there is any deviation from normal temperature range.

As you can see, there are a lot of "do's and don'ts;" you must learn about handling drugs and solutions. Study and remember these guidelines. Your patients' safety and lives may depend on your application of safe medication handling principles.

Preparation of parenteral medications

By this time in your training, you have probably prepared some medications under direct supervision. Just to be sure you know how to do so safely and properly, we briefly cover the basic steps involved. You may be surprised to find you are not doing things as safely or as easily as you should. Even a simple task, such as attaching a needle to a syringe to withdraw medication from a vial, can result in injury or waste if not performed properly. So, to prevent you from hurting or embarrassing yourself, and to stop you from contaminating valuable pharmaceutical supplies, we now discuss the "ABCs" of parenteral drug preparation.

Assembling needles and syringes

The first step in preparing parenteral medications is to gather the supplies you need. Consult the preference card or scheduling slip, or ask the requester (nurse, anesthetist, or surgeon). You need to know the type and size of syringes and needles, any specialty requirements, and the specific medication or agent to be administered. Next, before handling any sterile supplies, thoroughly wash and dry your hands. Inspect all syringe and needle packages for damage and integrity before opening them. If any package is compromised, discard the item (per local policy) and obtain a new one. If the agent or medication will be prepared on the sterile field, open the supplies as you would any other sterile supply item. The rest of this section covers preparing a medication off the sterile field—either for immediate use or for transfer to the sterile field. Remove the syringe and needle from the packaging, ensuring you do not contaminate:

- The entire tip, plunger (except for the thumb flange), and inside of the barrel of the syringe.
- The entire needle tip and shaft, and inside of the needle hub. If at all possible, you should keep the entire needle sterile by touching only the outside of the protective cap.

Keep the protective cap over the needle shaft and tip. Hold the needle in one hand, the syringe in the other, and then carefully guide the syringe into the needle hub and tighten it by twisting it clockwise. Next, loosen the protective cap over the needle, but do not remove it completely. Be very careful when you loosen the cap; if it comes off easily or suddenly, you may jerk back and stab yourself. The syringe and needle are now ready to be filled.

If you are using a cartridge syringe, preparation involves loading the cartridge into the barrel and attaching the needle to the tip of the syringe. The threaded tip of the syringe, and the inside of the barrel at the threaded tip, must be sterile. All parts of the cartridge needle, except the outside of the needle hub, must also be kept sterile. Ideally, just like a standard needle, keep the entire needle sterile by touching only the outside of the protective cap. To attach the needle, insert the cartridge end of the needle into the lumen of the threaded tip of the syringe. Then, holding the syringe as shown in figure

1–20, screw the needle hub onto the threaded tip by turning it clockwise. Leave the needle's protective cap in place until you are ready to inject the patient.

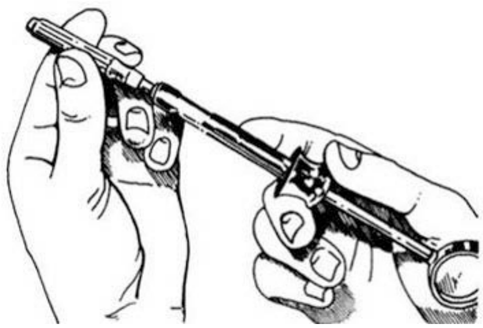

Figure 1–20. Attaching a cartridge syringe needle.

Insert the rubber-stopper end of the cartridge into the barrel first (fig. 1–21). Pull back on the syringe plunger (it is usually spring-loaded) until you can insert the diaphragm end of the cartridge into the syringe, then push the plunger forward until the needle punctures the diaphragm and the harpoon engages the rubber stopper. The rubber stopper serves as the plunger tip when engaged. Figure 1–22 shows a cartridge syringe ready for use.

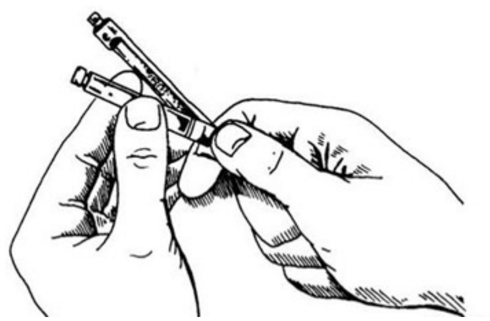

Figure 1–21. Inserting a cartridge.

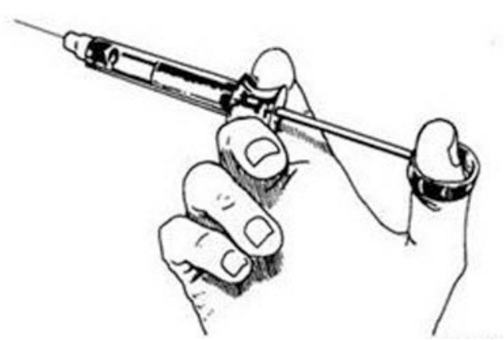

Figure 1–22. A cartridge syringe ready for use.

Figure 1–23 shows how to load a cartridge/needle syringe. The entire back of the syringe barrel "breaks" to allow insertion of the cartridge-needle unit. Notice the protective cap of the needle is kept in place as the cartridge is inserted. The cartridge is inserted until the needle hub is firmly seated in the tip of the syringe. Then, the back of the syringe is replaced and the plunger harpoon is engaged the same as it is in the cartridge syringe. The needle cap is not removed until immediately before injection.

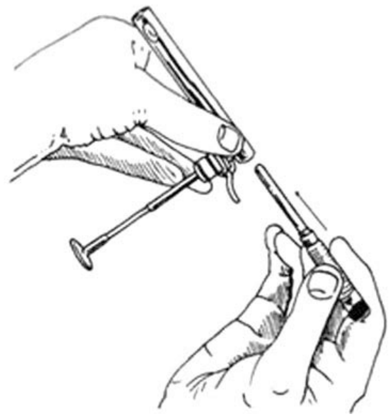

Figure 1–23. Loading a cartridge/needle (Tubex) syringe.

Preparing a "Bristoject" type cartridge syringe is easy; simply:

1. Pop the plastic cap off the end of the barrel/needle unit (fig. 1–24, A).
2. Pop the plastic cap from the cartridge-plunger unit (fig. 1–24, B).
3. Insert the cartridge into the barrel. The end you popped the top off—the diaphragm end—goes into the barrel first.
4. Twist the cartridge clockwise until it stops. At this point, the end of the needle protruding from inside the barrel will have penetrated the seal on the cartridge.
5. Figure 1–24. A prefilled cartridge/barrel (Bristoject) emergency medication syringe.

Figure 1–24 (C) shows a unit ready for use. Many of the emergency drugs used during cardiac arrest or other life-jeopardizing situations are packaged in these needle-barrel plunger/cartridge type units. They can be assembled in seconds with minimal risk of contamination.

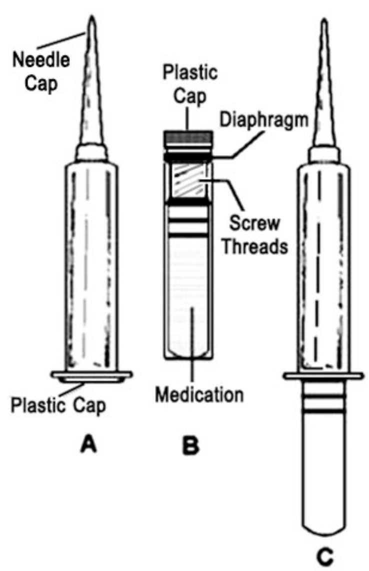

Figure 1–24. A prefilled cartridge/barrel (Bristoject) emergency medication syringe.

Withdrawing medications from ampules

As we saw in the last lesson, ampules have two chambers connected by a narrow neck. To remove the medication, you should first hold the ampule upright and "flick" the side of the ampule (fig. 1–25) to empty the medication from the top chamber into the lower chamber. Then, as in figure 1–26, wrap a sterile 2×2, 4×4, or 4×8 gauze sponge (depending on what you have and the size of the ampule) around the neck of the ampule and snap off the top. Always point the ampule away from you and other people as you break off the top to prevent injury in case the glass shatters. Discard the sponge and the ampule top; you are ready to pour or aspirate the solution.

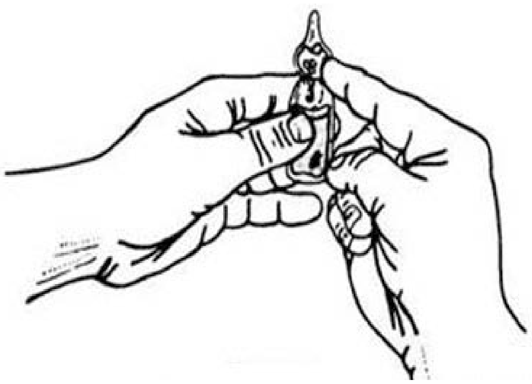

Figure 1–25. "Flicking" an ampule.

Figure 1–26 "Snapping" open an ampule.

To prevent contamination of the medication, you should draw up the solution as soon as the ampule is open. Generally, you use a syringe with the same approximate volume as the ampule, and a large-bore needle, such as 18- or 20-gauge needles. There are many ways to hold the syringe and ampule as you draw medication. Use the method most comfortable for you, but be sure you do not contaminate the needle by touching the side or neck of the ampule during the process. One simple method of withdrawing medication from an ampule is illustrated in figure 1–27.

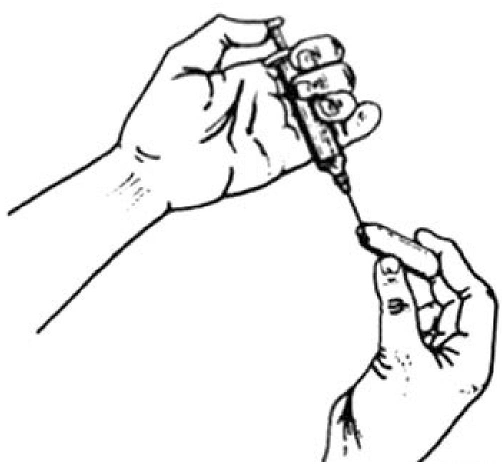

Figure 1–27. "Drawing up" solution from an ampule.

To draw up a solution using this method:

1. Hold the ampule in one hand, tipped horizontally and almost parallel to the floor (at about a 20° angle). This allows any tiny glass fragments resulting from breaking the neck to settle into the bottom of the ampule, away from the area where you will aspirate the medication.

2. Carefully insert the needle into the ampule so the tip of the needle remains just below the surface of the solution. Position the needle so the open part of the bevel is facing down and the needle points towards the bottom of the ampule.
3. Push the plunger up with the thumb of the hand holding the syringe. Ensure you touch only the side of the thumb-flange end of the plunger! If you allow your thumb to touch the plunger below the flange, the syringe and solution are considered contaminated.
4. Gradually tip the ampule more horizontally to keep the solution covering the tip of the needle as you aspirate the contents. Avoid touching the bottom of the ampule to prevent drawing up any glass fragments.

By holding the syringe and needle stationary, and tipping the ampule, you can better control your hands to prevent contamination. You may find it helpful to brace your elbows against your body to reinforce your hands when drawing up solution from an ampule.

If you are unable to use the method just outlined, you can set the ampule on a flat surface and use both hands to manipulate the syringe. Again, carefully insert the needle into the medication, but this time hold the syringe steady with one hand as you pull back the plunger with the other hand. You may be able to brace the hand holding the syringe on the flat surface.

Once you have withdrawn the solution from the ampule, pull the needle out of the ampule, remove the needle from the syringe (discard it properly), and place the ampule with the other solution containers. Remember not to discard the ampule in case the contents need to be verified later in the procedure. Replace the needle with a fresh one. Do not use the same needle you used to draw-up the medication to administer it. The shaft of the aspirating needle is most likely contaminated from contacting the broken edge of the ampule.

After drawing up the medication, you need to remove the air bubbles and any excess medication from the syringe. (You should always draw up a little more medication than you need to allow for these adjustments.) Hold the syringe with the needle pointing up, and then draw back on the plunger until there is a small air pocket between the top of the medication and the tip of the barrel. Tap (“flick”) the barrel with your fingers until air bubbles in the solution rise to the surface and disperse into the air pocket. Keep the syringe in an upright position as you slowly push in the plunger to force the air out of the syringe. Once all the air is gone, hold the syringe over a basin or other container and express any excess medication. Do this slowly and carefully to avoid inadvertently dumping too much of the medication.

Do not “squirt” the excess solution in the air while doing this! Although it may look dramatic, nobody needs a “drug shower”–and you may contaminate a sterile item. As we mentioned earlier, read the syringe at eye level, and never recap the needle. Always place the syringe and medication in a highly visible place, but one where it will not be rolled or knocked to the floor. Better yet, transfer it to the sterile field, give it to the person who requested it, or administer the medication to the patient (under direct and close supervision of a nurse or doctor). Do not leave any prepared medication lying around, and also do not leave it unattended.

In some hospitals, you must use a special filter needle, or a filter that goes between the tip of the syringe and the needle hub, when drawing up medications. This filter keeps glass fragments and other particulate matter out of the medication and out of the patient. After you draw up the medication, replace the filter needle (or filter) with a fresh sterile needle for the injection. Even if you do not use a filter needle, you should never use the needle you draw up the medication with to inject the patient.

Withdrawing medications from vials

Vials are either single or multi-dose containers sealed with a thick rubber stopper. The stopper, or diaphragm, is covered with a metal or plastic cap to ensure sterility. The medication in a vial may be a solution or a dry, sterile powder. If the medication is powdered, you must reconstitute it, or mix it, with fluid (called a diluent) before administration.

Vials are vacuum-packed. To withdraw the solution, you must first inject an amount of air equal to the amount of medication you want to withdraw from the vial. After you assemble your syringe and needle, remove the protective cap from the vial to expose the diaphragm. Pull back the plunger (aspirate air) until it reaches the volume of medication you want to withdraw, then insert the needle through the center of the rubber diaphragm. Holding the syringe and vial as shown in figure 1–28, inject the air into the vial. Then, keep the needle tip immersed in the solution and aspirate the medication. (Notice the fingers in fig. 1–29), hold the syringe and vial securely without touching the vial diaphragm, the syringe plunger, or the needle.) If you have injected enough air, the syringe starts to “automatically” fill itself because of the positive pressure in the vial. If you find yourself having difficulty aspirating the solution, you have not injected enough air and are creating a vacuum as you remove the solution. Depending on local policy, you must inject more air into the vial, or you must start over with a fresh vial if you cannot overcome the resistance of the vacuum. After you have drawn up the desired amount, change the needle, eliminate air bubbles, and get rid of any excess medication the same way as for an ampule.

Figure 1–28. Injecting air into a vial.

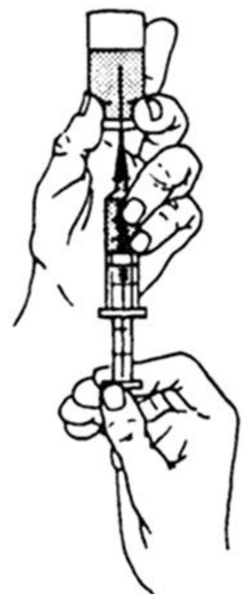

Figure 1–29. Aspirating solution from a vial.

When reconstituting a powdered medication, draw up the recommended amount of diluent. Change the needle, and then inject the solution into the vial containing the powdered medication. When you inject the diluent, you create positive pressure inside the vial, so hold the vial upright (diaphragm at the top) to prevent the medication from “squirting” out the hole you puncture in the diaphragm.

Shake to mix the medication thoroughly, and then label the vial with the date and time of the reconstitution, volume and type of diluent, name and concentration of the drug, expiration date and time, and the name of the person reconstituting the drug (you). Once the medication is mixed and labeled, aspirate the desired amount of medication as you would from any other vial. If the vial only contains enough reconstituted medication for a single administration, you do not need to label it as just described. Simply keep the container with the other medication and solution containers until after the procedure is complete.

You may occasionally see another type of vial that contains the powdered drug and diluent in the same bottle. This special vial (called a “Mix-O-Vial”) has two compartments separated by a rubber stopper. The external opening is sealed with a rubber diaphragm designed to be pushed down like a plunger. When the top plunger is depressed, it creates positive pressure in the upper chamber that forces the second (internal) stopper down into the lower chamber. This allows the diluent in the upper chamber to mix with the powdered drug in the lower chamber. Mix the medication thoroughly, and then withdraw the medication as you would with an ordinary vial. Change needles and adjust the medication as mentioned before.

One guideline is worth repeating here. Always remember to triple check the drug identification before administering it. First, ensure you have the right drug when you take it out of storage by checking the label against the information on the preference card or scheduling slip, or by looking at the doctor's orders in the patient's chart. Second, re-check the medication label with another staff member immediately before drawing up the medication; then, make a final check after preparing the medication, but before administering it.

Transferring medications to the sterile field

By now, you should have a thorough understanding of basic surgical asepsis, and you can apply the proper rules when pouring solutions. Some of the medications and other agents you transfer to the field are simply poured. If you feel you need a review, refer to volume 2. We now focus on some special techniques we use to safely transfer drugs to the sterile field.

There are three basic methods we use to transfer drugs from vials or ampules to the sterile field. Using the first method, the circulator draws up the medication following the previously covered guidelines. The circulator then changes the needle, and "squirts" or drips the agent into a medicine glass or other container the scrub has placed at the edge of the sterile table. This method allows the circulator to precisely control the volume of medication dispensed, and also prevents the circulator from reaching over the sterile field. The syringe is held to the side of the sterile field, and only the sterile needle shaft is over the sterile field. Remember, the circulator and scrub must identify the agent before and after the transfer takes place.

The second method is also simple, but it involves a greater risk of contaminating the medication if extreme care is not taken. This method is used only for agents contained in vials. To transfer solutions using this method, the circulator removes the entire lid from the vial, including the metal retaining strip around the rubber diaphragm, and the diaphragm itself. This may be done using a standard bottle opener, by using a "salvage" instrument, or by using cut-alls or bandage scissors to pry the lid off. Regardless of the method used, you must exercise great caution to avoid touching the rim of the vial with the instrument and to prevent the unsterile parts of the lid from dragging across the sterile areas. After you remove the lid, pour the contents into a suitable container on the sterile field using a standard aseptic technique. Again, do not forget to properly identify the agent before and after the transfer.

The third method requires a true "team effort" and gets the scrub more involved. Using this method, the circulator opens the ampule or vial and presents the open end to the scrub. The scrub selects a syringe large enough to accommodate the desired volume of solution, and then attaches a sterile, large gauge (usually 18 gauge) needle to the syringe. When using this method, the scrub must attach a new sterile needle, not a needle from the sterile field, to draw up the medication. The needles on the field are sterile only for the patient; if a staff member accidentally gets "stuck" with one, they may be exposed to blood-borne pathogens. Obviously, the appropriate syringes and needles must be on the field before this method can be used. Next, the circulator and scrub work together to transfer the solution. If the agent is contained in a vial, transfer is made in the following manner:

1. The circulator holds the vial with the exposed rubber diaphragm facing down and the vial tipped at an approximate 45° angle. The vial should be held at or just above the scrub's eye level so he or she can see the diaphragm without squatting or bending.
2. The scrub draws the same volume of air into the syringe as she or he wants to withdraw solution from the vial. The scrub then inserts the needle through the diaphragm, into the solution, and injects the air.

3. The scrub aspirates the desired volume of solution, and then carefully disconnects the syringe from the needle, being very careful not to contaminate the syringe or the gloved hands. The needle should be left sticking through the diaphragm in the vial the circulator is still holding.
4. The scrub then attaches the appropriate size needle to administer the medication.
5. The circulator leaves the empty vial in a conspicuous location until the end of the procedure; the needle (that was left) in the vial is disposed of in accordance with local policies.

If the medication is contained in an ampule, the transfer process is as follows:

1. The circulator holds the ampule with the opening angled up, at about a 20° angle, and at the level of the scrub's chest. This allows the scrub to see the ampule opening easily and keeps any glass fragments settled in the bottom of the ampule.
2. The scrub inserts the needle into the upper end of the ampule with the bevel facing down and the tip of the needle immersed in the solution.
3. As the scrub aspirates the solution, the circulator gradually tips the ampule to a more horizontal position so the fluid flows from the bottom of the ampule towards the needle tip. The scrub should be careful not to immerse the tip too deeply in the ampule, and the circulator should be careful not to tip it too sharply to ensure air and, possibly, glass fragments are not aspirated.
4. After withdrawing the medication, the scrub carefully removes the needle from the syringe and leaves it in the ampule. Then, the scrub attaches the appropriate size needle to administer the medication.
5. As with the vial, the circulator leaves the empty vial in a conspicuous location until the end of the procedure; the needle (that was left) in the ampule is disposed of in accordance with local policies.

In any of the transfer methods used, the circulator must avoid reaching over the sterile field. She or he should hold the vial or ampule near, but not over, the sterile field to transfer the medication. If the third method is used, the circulator should provide a stationary target for the scrub by using the free hand to stabilize the hand holding the container. The circulator can achieve even more stability by bracing both elbows against his or her torso. After drawing up the medications and attaching the needle for administration, the scrub should follow the guidelines we discussed earlier for flushing air from the syringe and adjusting the volume of medication. The scrub and circulator should know the exact location and identity of all drugs or solutions transferred to the sterile field. All medications and solutions should be labeled on the sterile field.

804. Handling blood and blood products

We now shift our focus from generic solutions and medications to the specific guidelines recommended for handling blood and blood products. These rules are designed not only to protect the patient, but also to protect all surgical staff members. Some of these rules are a review of the ones we covered in volume 3, but are reviewed here because of the risk involved.

Safety precautions for identifying and transporting blood and blood products

As a surgical technician, you are most likely the first surgical team member to come in contact with a unit of blood ordered for a patient. Usually, this occurs when you retrieve the blood from the laboratory blood bank. Before leaving the operating room to retrieve blood, ensure you have a copy of the specific patient identification label, the surgery schedule, or some other written identification information. Local policy determines the exact identification device or information you need.

When you arrive in the laboratory, the blood bank technician usually removes blood units requested by the operating room (OR) from storage, and then places them in an area where you can check them. The information on the individual unit, patient information you brought from the operating room, and

Standard Form (SF) 518, Medical Record—Blood or Blood Component Transfusion[must be individually checked and must match exactly. Local policy dictates exactly what identification information you check when retrieving the blood, but, as a minimum, you should check:

- The recipient's (patient) first name, last name, and middle initial (if applicable) on the blood unit, patient ID slip from the OR, and SF 518.
- A unique identification number, usually the hospital register number or sponsor's social security number with beneficiary prefix on the blood unit, patient ID slip from the OR, and the SF 518.
- The donor unit number on the blood unit and the SF 518.
- The A, B, or O blood group (ABO group) on the blood unit and the SF 518.
- The Rhesus factor (Rh) (type) on the blood unit and the SF 518.
- Any expiration date(s) listed on the blood unit and the SF 518.

In addition, most blood banks maintain a log or other record of transactions you must sign before the blood units are released. The information in the log should match the information on the blood unit, patient ID slip from the OR, and the SF 518. If there is a discrepancy in any information, do not accept the unit for transport to the OR.

After you accept the units of blood from the blood bank, it is your responsibility to get them to the OR in usable condition. Most blood is stored between 1°C and 6°C; blood is generally not suitable for transfusion when it reaches 10°C. At normal room temperature, blood reaches 10°C in about 30 minutes. So, you should ensure the blood gets to the OR well before the 30 minute mark is reached—this is not the time to socialize or grab a quick break!

There is one blood product that requires different handling—platelets. Platelets are usually stored between 20°C to 24°C, and, generally, are transfused within six hours after separation from whole blood. Do not retrieve platelets from the laboratory until you are specifically told to do so, and give them directly to a responsible staff member (preferably the nurse or anesthesia provider attending the patient) rather than placing them in storage.

As of this writing, no nationally recognized standard governs the type of container used for in-house transport of blood units; it is a locally determined policy. Containers and methods vary greatly; some hospitals use insulated coolers (ice chests), some simply use a pillow case. Regardless of the method used, be considerate of patients and visitors who may see you in the hallways; try to use a non-transparent (opaque) container. As always, follow local policy, but, if policy allows, consider using a rigid, leak-proof container with a lid, such as a plastic bin or extra-large specimen container, to transport blood. Although the risk of a blood unit leaking is small, and the risk of contacting contaminated blood from a leak is even smaller, why take a chance if you do not need to? Also, a plastic container with a lid can help the blood units maintain a more steady temperature during transport. If your OR does not have a blood refrigerator to store blood awaiting transfusion, an ice chest or similar device is highly recommended.

Storing blood products in the operating room

Most ORs no longer have a blood refrigerator to store blood during the patient's surgery. However, if you do have a blood refrigerator, the refrigerator must meet the same standards as the refrigerators in the laboratory blood bank before it can be safely used to store blood for surgery. The minimum requirements are:

- The temperature range must be set for the specific blood product to be stored. In the OR, whole blood and packed (not frozen) red blood cells are most commonly stored, so the refrigerator is kept between 1°C and 6°C. (Remember; do not store platelets in the refrigerator!)

- The refrigerator must have a fan or other device to circulate air to maintain a constant temperature throughout.
- The refrigerator must have some type of system to continuously monitor the temperature while blood is being stored, and the temperature must be recorded at least every 4 hours (it is usually monitored continuously). The temperature records should be maintained by the blood bank.
- The refrigerator must have an audible alarm that sounds before the refrigerator conditions reach a point where the blood may be damaged. The alarms must be loud enough to sound in an area where staff members are always present to hear it so corrective measures can be immediately taken.
- Written instructions must be readily available. The instructions must cover procedures for routine handling and storage, as well as, emergency and corrective actions. In the OR, most instructions require you to return all blood to the blood bank if the OR blood refrigerator malfunctions.

In addition to these minimum standards, most facilities have other rules applying to OR blood refrigerators. Usually, only blood is stored in the refrigerator; if other solutions, or if tissue is stored, it must be in a clearly separate storage area and must be clearly labeled. The interior should be kept clean and be well lighted to aid in identification of the contents. Since the top shelf warms fastest in event of a malfunction, the recording thermometer should be located on the highest shelf. The recording thermometer should be immersed in a liquid-filled container equal to or smaller in volume than the smallest sized blood container that will be stored in the refrigerator. Large refrigerators should have an additional thermometer on the lowest shelf. The alarm system and electronic monitoring devices should have an independent emergency back-up power system in the event of power failure.

Most operating room blood refrigerators have automatic monitoring systems, but these do not remove the responsibility for manual monitoring. You, as a surgical technician, will most likely be assigned to monitor and change temperature graphs or other devices on the refrigerators. When you change a chart or graph, as a minimum you should write the refrigerator identification, the inclusive dates the graph covers, your name, and the time. Any discrepancies from normal temperatures should be explained. The completed chart or graph should be taken to the blood bank and maintained in their records.

We covered procedures for assisting with a blood transfusion in the unit on anesthesia in volume 3. We covered the personal protective devices you should use and the measures you should take if accidentally contacting blood or body fluids in the lessons on safety and on infection control. You can review them if you need to refresh your memory. Remember to return any blood not transfused to the blood bank for storage as soon as possible; the SF 518 should be returned with the blood. Blood is a valuable asset; ensure you do your part to prevent wasting any of it. Ensure you learn and become thoroughly familiar with all the proper procedures for safely handling blood.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

803. Handling drugs and solutions

1. Briefly describe how a medication or solution should be identified before it is used on the sterile field.

2. Why should you never use a medication or solution from a glass container that is chipped or cracked, or has other visible evidence of mishandling?

3. What should you do with unused portions of medications or solutions following the completion of an operation? Why?

4. What should you do if you are not exactly sure what solution is in a basin?

5. How do you prepare a Bristoject needle-cartridge syringe for use?

6. Briefly describe how to “draw-up” medication from an ampule.

7. What should you do after puncturing the rubber diaphragm, but before aspirating fluid from a vial?

8. Briefly describe the three methods of aseptically transferring medications to the sterile field.

804. Handling blood and blood products

1. When retrieving blood from the laboratory blood bank, identify minimum information review requirements. Explain when to complete checks and why.

2. Above what storage temperature is blood generally considered unsuitable for transfusion?

3. Between what temperatures are platelets normally stored?

4. Within what time frame (after separation from whole blood) are platelets generally transfused?

5. List the minimum operating room blood refrigerator operating standards.

1–3. Common Surgical Medications and Solutions

Obviously, we use numerous different medications and solutions in the operating room. A detailed description of each one is not only not practical in this career development course (CDC), it is not necessary. We do cover some of the most commonly used solutions to give you an idea of how, when, and why they do what they do. We start with solutions.

805. Solutions commonly used in the operating room

Solutions used in surgery can be divided into two basic categories: parenteral and external. As you now know, a solution used parenterally will be injected or infused into internal body structures—primarily veins, ducts, and hollow organs. IV infusion solutions are the most commonly used parenteral solutions, so they are the ones you need to become familiar with. External solutions are used in and around the body, but they are not injected or infused. They include solutions used for skin cleaning and antisepsis (povidone-iodine and chlorhexidine gluconate), for cleaning and rinsing soiled surgical instruments (sterile distilled water), and irrigating wounds (normal saline). We also use solutions for disinfecting and cleaning supplies, equipment, and furnishings, but we discussed them in volume 2, so we will not go over them again.

Soaps and detergents

When combined with the physical mechanical action of scrubbing, soaps and detergents help reduce or remove the oils, soil, and waste products from the surface of the skin. They also help remove dead skin cells. Desired characteristics of soaps and detergents include, but are not limited to, the following:

- They easily combine with water and have an acidity measurement (pH) as close as possible to normal, healthy skin.
- They are odorless, or have a slightly pleasant odor, and produce a generous lather, even in hard water.
- They do not irritate the skin nor alter normal skin physiology in any way.
- They are easy to use and usually dispensed as a liquid, though some are in bars.

Soaps and detergents are seldom used in the OR, but are usually used during the patient's preoperative preparation routine. You use a soap or detergent when you need to make lather for a razor shave. You occasionally use them to clean exceptionally dirty skin or nails from trauma patients admitted directly from the emergency room, but we usually use a detergent falling under the next category of solution—the antiseptics.

Antiseptic solutions

Antiseptic solutions are used externally. They are usually used topically on the skin, but some are occasionally used for wound irrigation.

General characteristics

Since chemicals that are powerful enough to kill bacteria also destroy tissue cells, it is impossible to sterilize the skin. As we discussed in volume 4, we routinely use antiseptic agents to render the skin surgically clean by reducing the bacterial count. An ideal antiseptic solution has the following characteristics.

- It acts upon a wide variety of bacteria (broad-spectrum) to rapidly destroy and reduce the microbial count.
- It is easy to use and apply, and maintains a long-lasting effectiveness, at least as long as the operation.
- It is non-toxic and as non-irritating to the skin and other tissue as possible.

- It remains effective and is not inactivated when exposed to blood, body fluids, other organic matter, alcohols, soaps, or detergents.
- It is non-flammable and can be used with electrosurgical, laser, and other energy-emitting devices.

Types and uses of common antiseptic agents

Very few antiseptic agents meet all these criteria; you choose one agent that meets as many as possible for the specific patient and procedure performed.

Alcohol

Both isopropyl and ethyl alcohol may be used as an antiseptic; of the two, 70% isopropyl is most commonly used. For alcohol to be an effective antiseptic the liquid must remain in contact with the surface for several minutes; it should be allowed to evaporate. Alcohol not only serves as an antiseptic, but also removes oils and fats from the skin. It is a clear liquid, so the surgeon can monitor the patient's skin color throughout the procedure. However, alcohol is seldom, if ever, used by itself because it is irritating to the skin (especially open wounds) and it destroys delicate tissue. When it is used, it is often as a rinsing agent as a final step after a standard prep. Alcohol is also mixed with other germicidal agents to form tinctures. You should be particularly safety conscious when using alcohol-based solutions; alcohol is flammable. Use solutions containing it in small amounts, and never allow them to pool on or near the patient's skin. Allow tinctures and other alcohol-containing solutions to dry thoroughly before applying the drapes. Otherwise, the alcohol can create pockets of highly flammable vapors under the drapes as it evaporates.

Iodine and iodophors

Iodine is an excellent germicidal agent, and tincture of iodine (1% or 2% iodine mixed with 70% isopropyl alcohol) was once the most commonly used antiseptic. However, iodine is fairly toxic to skin; it causes irritation and burns. Iodine also stains heavily, so it is seldom used today. When it is used, you must allow it to dry thoroughly, and then rinse it from the skin using 70% alcohol.

Iodophors are chemical complexes of iodine mixed with detergents; they were developed to reduce the irritation of iodine tincture while retaining its excellent antiseptic properties. Iodophors such as povidone-iodine (Betadine) are now the most commonly used surgical antiseptics. They are relatively nontoxic and nonirritating to the skin and mucous membranes. Iodophors are effective even in the presence of pus, and they are long acting. The brownish-yellow film left by these agents helps the user define the area of application. Because they are combined with detergents, the iodine is also less of a staining problem than it is when used in tinctures or other concentrated solutions.

One of the drawbacks to iodine and iodophors is that some people are allergic to iodine (and consequently iodophors). Care must be taken to observe patients for allergic reactions (skin rashes, hives, etc.) following application of these antiseptic solutions. An allergy to shellfish is often a primary indicator of allergy to iodine (shellfish contain high levels of iodine).

Hexachlorophene

Hexachlorophene (pHisoHex) was once commonly used for antisepsis, but, because of its toxic effects on the nervous system, it is almost never used today. Hexachlorophene is effective against gram-positive microorganisms, and may be used on intact, non-broken skin if other methods of combating a gram-positive infection have failed. As a surgery technician, leave the use of hexachlorophene agents to the licensed providers.

Chlorhexidine gluconate

Chlorhexidine gluconate (CHG) is an agent that is becoming more and more popular for both surgical scrubs and patient skin preps. Tinctures of this agent (0.5% CHG in 70% isopropyl alcohol) are an excellent skin antiseptic for several reasons. First, chlorhexidine is bactericidal at low concentrations

(0.025%), nonirritating, and nontoxic. It starts killing bacteria rapidly and antibacterial activity persists for up to 4 hours after application. Its actions and effectiveness are not noticeably reduced by the presence of organic matter or soap, and its bactericidal activity increases as environmental temperatures increase (a good agent to use under heat-retaining surgical drapes). Chlorhexidine comes in tinted or clear solutions. The tinted solution can help define the prepared area; the non-tinted is used for procedures where the surgeon wants to observe the patient's natural skin color. Two commonly used examples of chlorhexidine gluconate tincture are Hibiclens (soap) and Hibitane (paint).

The major drawback to CHG is it can be highly irritating to mucous membranes and other delicate tissues. CHG should never be used around the ears or eyes because studies have shown it to cause deafness and blindness.

The next time you do a scrub or cleansing skin prep on a patient, you should have a better understanding of the agents you use to disinfect the skin to minimize the chance of a postoperative infection**.**

IV solutions

Although you will not personally select the IV solutions administered to surgical patients, you should have some basic knowledge about these solutions because you may be required to start and monitor IV infusions. The specific type of solution used depends on the patient's condition, fluid and electrolyte balance, and the purpose for the IV. There are too many types and uses of IV solutions to cover here, so we touch on only the general characteristics of IV solutions and briefly describe the ones most routinely used in surgery.

General characteristics

The basic characteristics all IV solutions share include clarity, sterility, pH, and tonicity. They also must be pyrogen-free.

Clarity

IV solutions should be clear and free from particulate matter. Cloudiness or sediment indicates the solution has started to break down chemically or has been contaminated. As you recall from our discussion of helping the anesthetist start IVs, you should immediately discard any solution that is discolored, appears cloudy, or contains particulate matter, and obtain a fresh container.

Sterility

Obviously, any solution for injection or infusion into the body must be sterile to protect the patient from infection. Since you cannot "see" sterility, the only way you can be reasonably sure a solution is sterile is to check the container for visible signs of tampering or damage. All IV solution containers are sealed and sterilized by the manufacturer. IV solutions packaged in plastic or glass bottles have a seal over and around the stopper or cap. The more commonly used flexible plastic containers are sealed inside an external plastic bag, and also have a cap or cover over the connection port(s). Before using any IV solution, check the integrity of all the seals; remember the primary rule of sterility–when in doubt, toss it out!

pH

As you may recall from other lessons, pH refers to the degree of acidity or alkalinity of a substance. IV solutions should be as close as possible to the normal body pH of 7.4 (almost neutral). Very acidic or very alkaline solutions are not usually tolerated very well by the veins or other internal body structures. (Under certain circumstances, such as metabolic acidosis or alkalosis, administration of an alkaline or acidic solution may be beneficial in restoring the chemical balance within the body.)

Tonicity

Tonicity refers to the concentration of dissolved chemicals, or solutes, in a solution as compared to the concentration of the same dissolved chemicals in the body cells. To understand tonicity and why it is an important characteristic of IV solutions, you first need to understand the process of osmosis.

Osmosis is the process of water "spreading out" and penetrating across a cell's semipermeable membrane to balance the concentration of fluid on both sides of the membrane. The water moves from the area of higher water concentration (fewer substances dissolved in the water), through the membrane, to the area of lower water concentration (more substances dissolved in the water). The water tends to pass through the membrane, leaving the solutes behind, until the concentration is equal on both sides of the membrane. In a normal human body, the concentration is usually balanced (called equilibrium) between the inside and outside of the cells. Because the concentration is equal, water normally does not try to move into or out of cells; the chemical balance between the body cells and the surrounding fluid is maintained.

If, however, we introduce a solution with a different concentration, the water moves across the cell membranes in an attempt to re-establish the balance. The concentration of the solution introduced influences the direction the water moves, and also influences the size of the cells. To help you get a basic understanding of tonicity and osmosis, let us look at a simplified example of how they affect a red blood cell.

Figure 1–30 illustrates a cell surrounded by a solution with the same concentration of solutes normally found inside the cell. This type of solution is known as an isotonic solution. In the illustration, the "+" symbol stands for the solutes; you can see the number of + symbols outside the cell is the same as the number of + symbols inside the cell. The cell remains balanced and stable. In the human body, 0.9% sodium chloride is an isotonic solution.

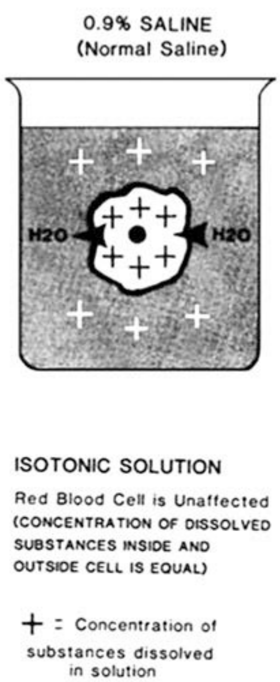

Figure 1–30. A cell in isotonic solution.

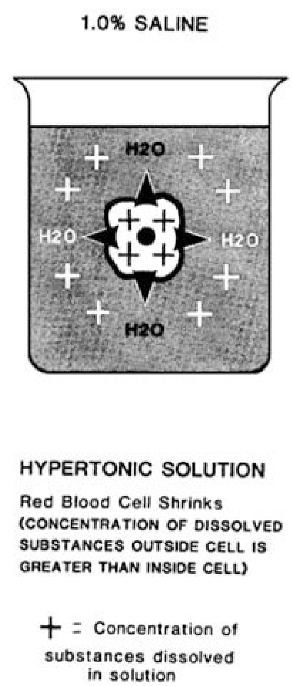

Figure 1–31. A cell in hypertonic solution.

Figure 1–31 illustrates a cell surrounded by a solution with a higher concentration of solutes than is normally found inside the cell. This type of solution is known as a *hypertonic* solution. You can see the number of + symbols outside the cell is higher than the number of + symbols inside the cell. The water inside the cell passes through the cell membrane to try to re-balance the concentrations; this causes the cell to lose its water and shrink. In the human body, solutions with a higher concentration than 0.9% sodium chloride (“normal” saline), such as 1.25% sodium chloride, are hypertonic.

Figure 1–32 illustrates a cell surrounded by a solution with a lower concentration of solutes than is normally found inside the cell. This type of solution is known as a hypotonic solution. You can see the number of + symbols outside the cell is less than the number of + symbols inside the cell. The water outside the cell passes through the cell membrane to try to re-balance the concentrations; this causes the cell to swell. In the human body, solutions with a lower concentration than 0.9% sodium chloride, such as 0.45% sodium chloride, are hypotonic.

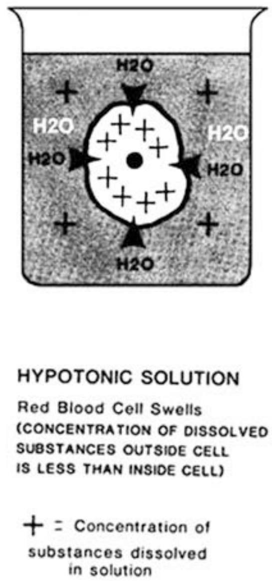

Figure 1–32. A cell in hypotonic solution.

Pyrogen-free

Have you ever read the labels on different IV solution containers and wondered what the term “nonpyrogenic” meant? The word “pyrogen” means “fever producing,” so the word “nonpyrogenic” means “not fever producing.” Pyrogens are simply substances that may cause a fever if introduced into the body. Nonpyrogenic solutions have been specially filtered, chemically processed, and sterilized to ensure all pyrogens have been removed so the solutions will not cause a fever when used internally on a patient (as long as the solution is not bacterially contaminated during handling and administration). You will see the term nonpyrogenic (or pyrogen-free) on the labels of all parenteral (injectable) solutions, and on all external solutions commonly used for wound irrigation.

Types and uses

You administer IV solutions to restore fluid and electrolyte balance, provide parenteral nutrition, increase blood volume, and change the alkalinity or acidity of blood. The effect or outcome you are trying to achieve determines the solution used.

Electrolyte solutions

Electrolyte solutions are the IV solutions most often used in surgery. They are the solutions we use when starting a “routine” IV before surgery. Electrolyte solutions are primarily given to replace lost fluid or to maintain the fluid balance in the patient. When given for maintenance, the solutions supply the daily electrolyte requirements for patients whose oral intake has been limited for some reason (such as patients that are “nothing by mouth” [NPO] before surgery). Replacement fluids are administered to patients who have lost fluid and electrolytes due to surgery, trauma, burns, or shock.

The most commonly used IV electrolyte solutions for surgical patients are Ringer's lactate, 5% dextrose in Ringer's lactate (D5RL), and normal saline.

Normal saline (0.9% sodium chloride) and other saline solutions are used primarily as replacement solutions. IV normal saline solution is commonly used in surgery to prime the tubing before and flush the tubing after blood transfusions. In smaller quantities, normal saline for injection dilutes medications or reconstitutes powdered drugs. Besides normal saline, other saline solutions used include 0.45% and 0.2% saline.

Dextrose (glucose)-containing solutions, usually dextrose/saline or dextrose/Ringer's mixes, are primarily used for patients who need added calories and nutrients to restore or maintain their bodies' chemical balances. The most commonly used dextrose solution in surgery is D5LR. Other 5% dextrose solutions you may see include 5% dextrose in 0.2% sodium chloride (D5-.2NaCl) or D5-.2NS), 5% dextrose in 0.45 sodium chloride (D5-.45NaCl or D5 2 1 NS), and 5% dextrose in water

(D5W). There are also other concentrations of dextrose solutions, usually mixed in water. Two examples of other dextrose solutions are 10% dextrose in water (D10W) and 20% dextrose in water (D20W).

Ringer's solution contains the primary electrolytes found in blood plasma (sodium, potassium, calcium, and chloride); it is modified by adding sodium lactate to form lactated Ringer's (or Ringer's lactate) injection, abbreviated LR or RL. As we stated earlier, electrolyte solutions are the most commonly used solutions in surgery; Ringer's solutions are the most commonly used electrolyte solutions. They not only serve as excellent fluid replacement, but also have more essential electrolytes than those provided by saline solutions. (Ringer's solutions contain small amounts of potassium and calcium ions, in addition to sodium and chloride ions.) The added lactate in LR is metabolized to form bicarbonate. This reduces the likelihood of the patient developing metabolic acidosis. (The bicarbonate helps neutralize acid in the blood.)

These "standard" IV solutions are frequently modified by adding other electrolyte solutions, antibiotics, or other medications to treat various conditions. Mixing drugs with intravenous solutions is not your responsibility, but you should be aware of and watch for adverse reactions when these mixtures are given to a patient.

Blood volume expanders (blood substitutes)

Blood volume expanders increase the total circulating fluid (plasma) volume in a patient's body. They are most often administered when a patient has lost a large volume of blood. These "blood substitutes" help to maintain circulatory volume until either the patient can naturally replace the lost blood, or blood products can be administered. In the OR, you most often see these products used in critical situations (such as massive hemorrhage) when blood products are not immediately available or when time does not permit proper typing and cross-matching of blood. Blood volume expanders are used as supplements to other forms of IV fluid infusions, not as replacements for them. The most commonly used blood substitutes are:

- Dextran. It is a plasma substitute used primarily to control hemorrhagic shock.
- Albumin (normal human serum). It is used as a substitute for whole blood because it has all the blood factors, except the cells (therefore, it does not increase oxygen-carrying ability).
- Plasma protein fraction. This product not only helps maintain blood volume, but also helps the coagulation process.

Parenteral hyperalimentation

This is basically IV feeding; it provides the patient's nutrition intravenously, bypassing the gastrointestinal tract. It commonly provides nutrition to patients who have some type of severe gastrointestinal disorder. This type of therapy provides large amounts of essential nutrients required for growth and repair of body tissues. Since these solutions are designed to meet the body's total needs, they contain a much higher concentration of nutrients and calories than do normal IV solutions. They also contain varying concentrations of vitamins, minerals, and electrolytes. Examples of hyperalimentation solutions include protein hydrolysate basic fluid and crystalline amino acid solution.

Hyperalimentation solutions are extremely hypertonic and irritating to smaller veins. To prevent damage, they are usually infused through an intracatheter into one of the large central veins, such as the subclavian or jugular veins. Special infusion pumps are often used to ensure delivery of adequate volumes of the solution. Hyperalimentation solutions provide an excellent growth medium for microorganisms; as a result, infection is a common complication. You rarely see hyperalimentation therapy in the operating room.

Alkalinizing solutions and acidifying solutions

These are used to restore the acid-base balance of the blood. As was previously mentioned, normal body pH should be maintained near 7.4. A life-threatening situation develops when the pH varies too much from this level. Alkalinizing solutions include sodium bicarbonate and lactate solutions. Ammonium chloride is the most common acidifying solution.

No one expects you to be a pharmacological genius, but you do need to understand at least the basics of IV therapy. You should now have a better understanding of intravenous solutions. Much of this information will help you to understand irrigation solutions as well.

Irrigation solutions

More than any other type of solution used in the OR, you use sterile irrigation solutions—almost on a daily basis. Irrigation solutions have essentially the same general characteristics as IV infusion solutions.

General characteristics

Like IV solutions, irrigation solutions must be clear and free of particulate matter. The rules that apply to inspecting IV infusion solutions also apply to inspecting irrigation solutions. Never use a discolored or cloudy irrigation solution, or one with sediment in the bottom of the container.

Obviously, any irrigating solution used in the body must be sterile to prevent infection. To ensure the sterility of irrigation solutions, always check the integrity of all seals before use. If a seal is missing or broken, the solution is considered contaminated; discard it immediately. Also, follow all rules of surgical asepsis when transferring solutions to the sterile field. The pH and tonicity of irrigation solutions vary according to its intended use. Most irrigating solutions used in the body are isotonic; their pH is usually about 7.4, but this varies. When packaged, irrigation solutions are also pyrogen-free. Labeling containers, using irrigation containers only for irrigation (not moistening sponges), and using proper aseptic technique minimizes the chances of using a hyper- or hypotonic solution on or introducing pyrogens in the patient.

Most irrigation solutions are packaged in 1000- or 1500-ml plastic bottles with twist-off caps. Some irrigation solutions, such as those used for urological irrigation during cystoscopies, are packaged in 3- or 5-liter plastic bags similar to those used for standard IV solutions. Irrigation solutions are administered topically, usually with a bulb or asepto syringe. When used for continuous irrigation of the urinary tract during urological surgery, or when used to infiltrate joints during arthroscopies, we often use a large diameter, sterile tubing set that connects the solution container to a port on the operative instrument, such as a cystoscope.

Solutions for irrigation meet the same United States Pharmacopeia (USP) manufacturing standards and tests as solutions for injection. In fact, most irrigation solutions are simply injectable (IV) solutions in containers that allow them to be administered in large volumes (usually by pouring). Although sterile irrigation fluids are essentially the same as their injectable counterparts, they should not be used parenterally. (The labels of sterile irrigating solutions are clearly marked “not for injection.") Irrigation solution containers would pose a higher risk of contamination than closed containers during preparation and administration if they were used for infusion.

Just as medications, antiseptic solutions, and infusion solutions can cause adverse reactions, so too can irrigation solutions. Mass-volume irrigation of body cavities and wounds can result in a fluid or solute circulatory overload in the body; this can lead to pulmonary edema and congestive heart failure. The way this happens is the irrigation solution pools in body cavities and is absorbed into the blood stream if allowed to remain "pooled-up" in the body. Normally, this risk is minimal during an "open" surgical procedure because the irrigation solution is suctioned from the wound immediately after it is instilled. However, circulatory overload can occur in procedures such as cystoscopies, especially if the procedure time is extensive, because of continuous irrigation of the bladder. Another risk inherent to irrigation of a closed body cavity or hollow organ (such as the bladder) is it may be overfilled, or too rapidly filled, with large quantities of solution, particularly if the solution is administered under high pressure. This not only can lead to circulatory overload, but can also cause excessive pressure in the cavity or organ, resulting in tissue distention and damage.

If a hypotonic irrigating solution, such as sterile water, is used within the body, the red blood cells can be destroyed by a process called hemolysis. Simply explained, osmosis (discussed earlier) causes the red blood cells to absorb so much water that the membranes burst and the cells are destroyed.This is why it is absolutely critical that the irrigation solution you pass to the surgeon is an isotonic solution (like normal saline) unless the surgeon specifically requests otherwise. This is also why it is imperative you label all solution containers on the sterile field. This is also why some hospitals do not use sterile water to rinse or clean instruments on the sterile field (a recommended practice); they would rather pay for earlier replacement of instruments than risk injuring a patient.

Types and uses

You use irrigating solutions primarily to rinse or clean wounds, body cavities, tissues, indwelling urinary drainage catheters, and surgical wound drainage tubes. You also use them to soak, wash, and rinse surgical instruments, dressings, and some tissue specimens. You may also occasionally need to mix an antiseptic (povidone-iodine) or antibiotic (bacitracin-Neosporin) to make "bug juice" for irrigation. The most commonly used sterile irrigation solution by far is normal (0.9%) saline. You also use Ringer's solution, glycine, and sterile water for some procedures.

Normal saline for irrigation

Sterile normal saline, or 0.9% sodium chloride solution (in water), is most commonly used because it is isotonic and does not normally damage body cells. In the OR, sterile saline is used primarily for irrigating surgical wounds and soaking surgical sponges used inside the wounds. It may also be used as a diluent for mixing drugs or special radiographic (x-ray detectable) dyes used on the sterile field (except dyes that will be injected intravascularly).

Normal saline irrigation is occasionally mixed with antibiotic drugs and used to irrigate grossly contaminated ("septic") wounds, and also for wounds associated with orthopedic surgery. Other uses include irrigation of indwelling catheters and surgical wound drainage tubes; filling surgical drainage devices, such as chest bottles or Pleur-Evacs; cleaning powder and blood from surgical gloves; and wiping off soiled surgical instruments during an operation (if local policy allows). As we mentioned previously, saline is not recommended for soaking instruments because the salt can contribute to corrosion and pitting of the instruments. Because instruments should be kept clean during the surgical procedure, a clearly labeled basin of sterile water is recommended for soaking soiled instruments, and another clearly labeled basin should be filled with normal saline for wound irrigation. If you use both solutions on the field, you must keep them separated and identified so you do not accidentally use the hypotonic sterile water as an irrigant. As always, follow local policy regarding the types of solutions you routinely keep on the field.

Saline is not generally used for massive or continuous wound or body cavity irrigation during electrosurgical procedures because the solution can potentially conduct harmful electrical current to tissues not intended to be affected. This is especially true during procedures in closed body cavities (such as trans-urethral resections of bladder tumors). The dispersion of the electrosurgical currents throughout the irrigant may also interfere with the normal electrical activity of the heart, resulting in arrhythmias or cardiac arrest.

Ringer's solution

Ringer's for irrigation is very closely related to normal saline, and can be used for the same purposes. Some surgeons prefer to use Ringer's solution for infiltrating and irrigating joints during arthroscopic surgery. You rarely see Ringer's irrigation solution used if saline will do because normal saline provides almost identical benefits, and is usually cheaper and easier to obtain.

Glycine solution

Glycine is a sterile solution of aminoacetic acid in water. Glycine solution is often used for urological irrigation during transurethral endoscopy procedures. Glycine is isotonic, so it does not lead to hemolysis, and it contains no electrolytes to conduct electricity. It will also not distort the visual image through the endoscope any more than water does. Glycine is usually packaged in large volume flexible plastic containers (3- and 5-liter bags) designed to be used with special large diameter administration "TUR" tubing.

Sterile water

Sterile water for irrigation is distilled water, sterilized and packaged in a container suitable for large volume administration (pour bottle). This water has been filtered, deionized, and/or distilled to remove all dissolved chemical substances (solutes) and impurities. Since sterile water for irrigation is solute-free, it is considered a hypotonic solution and should never be used for wound irrigation unless specifically ordered by a physician. Sterile water is most recommended for soaking soiled surgical instruments on the sterile field, and for final rinsing of clean surgical instruments and reusable supplies during the normal processing cycle. Sterile water for irrigation is also used in pharmaceutical preparations and for preparing certain nutrient mixtures that will not be administered intravenously.

Some final guidelines for handling irrigation solutions:

- Store irrigating solutions at normal room temperature unless they will be used for internal irrigation of the body.
- Irrigating solutions used internally should be warmed to or slightly above normal body temperature, but should not be kept warmer than 40 °C (104 °F).
- Do not freeze irrigation solutions or heat them above 66 °C (150.8 °F). This may alter the chemical balance of some solutions.

806. Drugs often used in surgery

You use numerous drugs and other pharmaceuticals during surgery. We discussed some of these agents when we covered preanesthetic medications, anesthetic agents (general and local), and the different types of solutions. Now, we will briefly look at some of the drugs and other agents you frequently administer to surgical patients. The first drugs we will look at are primarily to aid in hemostasis used during the operations.

Constrictors and coagulants

Constricting agents work to aid hemostasis by "shrinking" the blood vessels. Coagulating agents work by helping the blood "clot" to stop the flow.

Epinephrine

We touched on epinephrine in the unit on anesthesia. Epinephrine is a vasoconstrictor (i.e., it causes the blood vessels to narrow). Epinephrine is frequently added to local anesthetics because the narrower vessels reduce the circulation and prolong the effect of the anesthetic. This reduced circulation also helps reduce blood loss. Epinephrine is also a cardiac stimulant (in fact, it is an emergency medication used during cardiac arrests) and its dosage must be carefully monitored.

Protamine sulfate

This agent is a protein-like substance used to counteract the anticoagulant effects of the drug Pitocin, which often prevents blood clotting during cardiovascular surgery. It is also administered postoperatively to reduce risk of strokes caused by circulating blood clots (thrombi). Protamine is a highly alkaline drug that is, by itself, a weak anticoagulant; when it contacts and combines with highly acidic heparin, they neutralize each other and form a stable salt with no anticoagulant ability. Protamine is usually administered intravenously and its action is very rapid; it can neutralize heparin in the blood within 5 minutes of injection.

Uterine constrictors

Uterine constrictors are drugs that have been synthesized to mimic the hormone oxytocin produced by the posterior lobe of the pituitary gland. This hormone stimulates and increases the force and rate of uterine contractions (labor) during childbirth. Oxytocic drugs also help contract uterine muscles and decrease hemorrhage after delivery of the placenta. Oxytocic agents can be administered intravenously, intramuscularly, subcutaneously, intranasally (via aerosol spray), and buccally. You will often hear obstetrics and gynecology (OB/GYN) surgeons ask the anesthetist to inject an oxytocic drug immediately after removal of the placenta during cesarean section deliveries. One of the most common synthetic oxytocic drugs is Pitocin, commonly referred to as “Pit.”

Anticoagulants

Anticoagulants lengthen the normal clotting time of blood. In surgery, you administer them intravascularly to prevent blood clots from forming, particularly during vascular and heart operations. This is important because if blood clots form during vascular surgery, they could break free from the bleeding site and enter the circulatory system. This can lead to obstruction of arteries supplying the brain, heart, and lungs. (A blood clot in the circulatory system is called a thrombus.) Anticoagulants are also sometimes added to a wound irrigation solution to help prevent clots from forming at the operative site. When a blood transfusion is initiated, an anticoagulant is often added to the normal saline or other IV solution administered with the blood. Two commonly used anticoagulants are heparin sodium and warfarin.

Heparin sodium

Heparin is a naturally occurring substance found in the lungs, liver, and intestinal mucosa. The heparin used in surgery is derived from beef lungs and the intestinal mucosa of sheep. It is used primarily for short-term anticoagulant effect, especially during kidney dialysis, blood transfusion, and cardiovascular surgery. It also prevents clotting in some laboratory blood samples. Heparin offers two advantages for surgical procedures. It is fast-acting, and it can also be rapidly reversed by protamine sulfate. Heparin’s primary disadvantages mainly concern long-term therapy. The first is it is not effectively absorbed in the intestinal tract so it must be given parenterally. The second drawback is fairly obvious; patients taking anticoagulants have a higher risk of hemorrhage.

Warfarin sodium

Warfarin (Coumadin) is mainly used for long-term anticoagulant therapy to control or treat venous thrombosis (clots in the veins), pulmonary embolism (blockage of the major vessels to the lungs), and coronary artery occlusion (blockage of the arteries of the heart). It is sometimes given in combination with heparin to provide immediate and long-term anticoagulant therapy simultaneously. Usually, patients undergoing long-term warfarin therapy stop taking it a few days before surgery, switching to heparin. This is done to reduce chances of intraoperative hemorrhage (heparin can be reversed rapidly, warfarin cannot) from this longer-acting anticoagulant. Warfarin can be administered orally and parenterally.

Antibiotics

Any drug that destroys or inhibits the growth of microorganisms in the body is generally referred to as an antibiotic. There are several different types of antibiotic agents, each designed to act on specific microorganisms. Some antibiotics are "broad-spectrum" and effectively destroy or inhibit the growth of many types of microorganisms. "Narrow spectrum" antibiotics work on only a few organisms. Some surgical patients take antibiotics before surgery (sometimes called prophylactic antibiotic therapy) to reduce the chances of infection. Patients who are scheduled for major operations of the gastrointestinal tract, cardiovascular system, or musculoskeletal system routinely receive prophylactic antibiotics. Sometimes, surgeons request parenteral administration of antibiotics during a case; some use antibiotic solution to irrigate the wound. Some surgeons apply antibiotic creams or ointments to suture lines before applying the dressing. Various other weapons in the surgeon's antimicrobial arsenal include antibiotic-impregnated gauze sheets to cover wounds, strips to pack body orifices, and antibiotic drops to place in the eyes and ears.

The list of antibiotic drugs is a long one and it grows constantly, so we limit our coverage to those used most often for surgical patients.

Penicillins

As you probably already know from high school science classes, penicillins come from common molds like the ones that grow on bread and fruit. Penicillins are some of the most effective and least toxic of all antibiotic drugs. There are several natural and synthetic derivatives of penicillin, but the breakdown is too complex (and unnecessary) for discussion in this text. We touch on the most important points to remember. They are broad-spectrum and can destroy many gram-positive bacteria and some gram-negative bacteria. The largest drawback to using penicillins is the high incidence of allergic (anaphylactic) reactions they cause. You often see "penicillin allergy" listed in the remarks section of the surgical checklist and prominently displayed on the cover of patients' charts. Another drawback is that some bacteria secrete an enzyme (penicillinase) that makes them penicillin-resistant.

Cephalosporins

These drugs are very similar to the penicillins in chemical structure, action, and bactericidal activity (they are broad-spectrum). The advantages they offer over penicillins are they are not affected by the enzyme produced by penicillin-resistant bacteria, and they do not cause the allergic reactions associated with penicillins. Cephalosporins are also effective against some bacteria that penicillins do not work on. A disadvantage is that patients allergic to penicillin may develop a cross-sensitivity to cephalosporins. Some of the more commonly used cephalosporins used in surgery are Cephalothin sodium (Keflin), Cephapirin (Cefadyl), Cefazolin (Ancef or Kefzol), and Cephalexin (Keflex).

Aminoglycosides

The antibiotics in this group are also broad-spectrum. The aminoglycosides include streptomycin sulfate, kanamycin sulfate (Kantrex), and gentamycin sulfate (Garamycin). Streptomycin commonly treats tuberculosis, and is used with penicillin to treat endocarditis (heart infection/inflammation). Kanamycin treats systemic infections caused by gram-negative bacilli. It is often used to "prep" the bowel before major abdominal and intestinal surgery. Gentamycin is very effective in treating bacterial infections of the blood (bacteremia), and also combats general infections caused by Proteus and Pseudomonas.

Miscellaneous antibiotics

There are numerous other antibiotic drugs. The polymyxins, such as polymyxin B sulfate (Aerosporin), are used mainly for urinary tract and systemic infections. Lincosamides are narrow-spectrum and can have serious side effects, but you may see them used to fight specific infections. Sulfonamides were the first type of antibiotics widely used–particularly before penicillin was discovered. Bacitracin is frequently used as an ointment or added to irrigation. Sometimes it is combined with another antibiotic, neomycin. They are still sometimes used for preoperative prep of the bowel, and for prevention or treatment of other infections.

Corticosteroids

These drugs are synthetic hormones used in surgery to reduce swelling and inflammation. They are used on delicate tissues, such as those found in the eye and urinary tract. They are also sometimes used to reduce swelling and inflammation of joints during and after orthopedic surgery. Plastic surgeons may inject steroids in the tissue around incision sites to prevent formation of excessive scar tissue called keloids. Some of the more commonly used corticosteroids include dexamethasone (Decadron), Betamethasone (Celestone), and polymyxin B-bacitracin-neomycin-hydrocortisone (Cortisporin) ointment. As you can tell from the name, the latter also includes antibiotics in its mixture.

Diuretics

These are drugs that remove fluid from the body by drawing it from the various tissues into the urinary system where it is eliminated. As a result, diuretics increase urine production and excretion. They are used in the treatment of hypertension, congestive heart failure, and pulmonary and cerebral edema caused by cardiac arrest. Two diuretics commonly used in surgical patients are furosemide (Lasix) and mannitol.

Furosemide is the diuretic agent of choice for long-term therapy, such as treatment of hypertension, pulmonary edema, and other fluid build-ups in the body caused by congestive heart failure, cardiac arrest, or renal failure.

Mannitol is used as a diuretic to relieve cerebral edema (brain swelling), especially during neurosurgery. It also treats diminished urine output (oliguria) caused by transfusion reactions and trauma related to major surgery. Non-surgical use includes relief of elevated intraocular pressure (glaucoma) and promoting excretion of toxic levels of sedatives after overdose.

Mannitol works by osmosis, so it may also be added to hypotonic irrigation solution during procedures involving high-volume irrigation of closed body cavities (such as transurethral prostate resections). The mannitol counteracts the hypotonic effects, thereby the hemolytic effects, of the irrigant. It also promotes excretion of any absorbed irrigation solution (which prevents the risk of circulatory overload) and reduces the need for postoperative irrigation.

You may keep containers of mannitol stored in solution-warming cabinets outside the ORs, particularly when neurosurgeons are working, because it tends to crystallize when stored at room temperature. Drug manufacturers recommend it be stored at temperatures less than 40°C (104°F), and preferably between 15°C to 30°C (59°F to 86°F). Because of this, long-term storage of the drug in warming cabinets should be avoided.

Dyes and contrast media

There are many sterile dye solutions and X-ray detectable contrast media used in surgery. As a surgery technician, you will often mix and prepare them on the sterile field. Always follow the manufacturer’s directions and surgeon’s instructions.

Dyes

Dyes are colored solutions that stain tissue; they can usually be seen with the naked eye. They are routinely used by surgeons, particularly plastic surgeons, to mark the skin before making surgical incisions. The sterile “skin pens” often used in surgery actually contain a dye solution. Dyes are also used in general and OB/GYN surgery to determine the patency (openness) of tubular structures, such as the fallopian tubes, and to see the extent of sinuses and fistulas (especially those associated with cysts). In urological patients, some dyes are used to determine the path of the urine from the kidneys through excretion. (The colored dye is injected into the blood and is excreted by the kidneys.) Eye surgeons (ophthalmologists) sometimes use dyes to determine corneal damage.

The dyes most frequently used in the OR include methylene blue, indigo carmine, and methylrosaniline chloride (gentian violet) and sodium fluorescein. Methylene blue is dark blue and used undiluted for marking the skin before surgery; when diluted it determines the patency of fallopian tubes. Indigo carmine is a purple-blue dye used by urologists to identify the openings of the ureters during cystoscopies, or as a marker to identify severed ureters during open procedures. Methylene blue and indigo carmine are also sometimes used as a marker to determine the extent of fistulas or other sinus tracts. Gentian or crystal violet is the purple-colored dye most often used in sterile skin marking pens. It is also used as a topical fungicide and bactericide to the treat certain skin infections, but should not be used on mucous membranes or unbroken skin because it is a possible carcinogen if systemically absorbed. Sodium fluorescein is an orange-red fluorescent dye sometimes used with an ultraviolet "black light" to determine the extent of corneal damage in eye patients.

Contrast media

Contrast media, often called X-ray (or radiopaque) dyes, are solutions containing organic iodine or other metallic elements. They are often clear and cannot usually be seen with the naked eye—only by X-ray. When a contrast medium is injected or introduced into blood vessels, ducts, or organs, the metallic elements are visible under X-ray. Contrast media are particularly useful for identifying internal structures or to outline objects contained within these structures. When you see the suffix "-gram" on the surgery schedule, you can plan on using a contrast medium of some type.

A cholangiogram is an injection of a contrast medium into the common bile duct, gallbladder, and hepatic duct to determine if there are any stones or obstructions present. The injected radiopaque dye appears white, while the stones and other solid obstructions appear as black spots within the white on the X-ray.

Before (and sometimes during) cardiovascular surgery and neurosurgery, a contrast medium may be injected into selected arteries to determine areas where blood flow is restricted or totally blocked (arterial stenosis or obstruction). These studies can help indicate the presence of and location of tumors or aneurysms (weakened, bulging areas in the artery walls). These diagnostic X-ray studies of the arterial system are generally referred to as angiograms or arteriograms.

Contrast media may also be injected into the subarachnoid space to diagnose or locate spinal cord tumors, congenital deformities, and herniated intervertebral disks. This type of X-ray dye study is a myelogram.

Before surgery of the esophagus, stomach, and small intestine, patients may need to swallow a thick, chalky solution containing barium sulfate (barium is a "metal" that makes this compound a radiopaque dye). This diagnostic procedure is called a "barium swallow" or upper gastrointestinal (GI) series because it outlines the structures in the upper portion of the GI tract. Patients scheduled for surgery on the lower half of the GI tract (large intestines or rectum) may receive a barium enema, also known as a lower GI series.

Some common intraoperatively used iodine-based contrast media include diatrizoate meglumine (Hypaque), diatrizoate sodium (Hypaque sodium, Renografin), iothalamate meglumine (Conray), and iodipamide meglumine (Cystografin). You mix these X-ray dyes in various concentrations and combinations depending on the structures you want to examine. Ask the surgeon exactly how he or she wants the contrast medium prepared, well before the time it is needed, so you have it ready for immediate injection. You must know how to prepare these substances properly; an improper mix can compromise the desired test.

Like all solutions, you must also keep contrast media properly labeled, if you accidentally hand the surgeon a syringe full of radiopaque dye instead of irrigation, an X-ray will show nothing but a "blob" of white wherever the "irrigation" was used. If you accidentally pass a syringe of irrigation instead of contrast media, the injected "dye" will not show on X-ray. This leads to an unnecessary delay of the operation, increases the patient's risk of infection or anesthetic complications, subjects the patient and staff to unnecessary radiation exposure, and generally ruins the surgical staff's day. As with all drugs or solutions, if you are not certain exactly how to prepare the dye—ask for help!

Vasodilators

Vasodilators are used to treat vascular disorders, including peripheral vascular conditions. These agents produce peripheral vasodilation by relaxing smooth muscle in the blood vessel walls. Some drugs act primarily on the veins or arterioles; others dilate both types of blood vessels. These agents are especially helpful in treating hypertension.

One of the commonly used vasodilators is diazoxide. Diazoxide causes the smooth muscle to relax, and this relaxation decreases the peripheral resistance. It is administered intravenously during hypertensive emergencies, such as malignant hypertension, because it promptly reduces blood pressure. Another common vasodilator used by anesthesia personnel to lower blood pressure is hydralazine, also known as apresoline.

Vasodilators are also used to control angina pectoris. Angina pectoris is a temporary interference with the flow of blood, oxygen, and nutrients to the heart muscle. It is characterized by pain behind the sternum. Probably one vasodilator you have heard of before is nitroglycerine. It is believed relaxation of the coronary smooth muscle causes coronary vasodilation, which in turn improves blood flow to the heart.

Emergency drugs

There are numerous drugs that may be administered during cardiac and respiratory emergencies. We covered what you need to know about them in volume 3 when we covered anesthesia and postoperative complications. If you feel you need a review, you can refer to that volume.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

805. Solutions commonly used in the operating room

1. List three characteristics of an ideal antiseptic solution.

2. What type of antiseptic is formed when alcohol is mixed with another germicidal agent?

3. What is the primary drawback to chlorhexidine gluconate as an antiseptic agent?

4. List five general characteristics of intravenous infusion solutions.

5. What should you do with an IV solution that appears cloudy? Explain your answer.

6. Why should IV solutions have a pH as close to 7.4 as possible?

7. To what does tonicity of a solution refer?

8. Briefly explain osmosis.

9. Why is 0.9% sodium chloride solution considered to be isotonic?

10. What happens to a red blood cell when it is placed in a hypotonic solution?

11. List three reasons for administering IV solutions.

12. What is the most commonly used type of intravenous solution in surgery?

13. Why are blood volume expanders, such as dextran, albumin, and plasma, administered to a patient?

14. What should you check to ensure an irrigation solution is sterile?

15. How are irrigation solutions administered?

16. What problems may occur when a closed body cavity or hollow organ is irrigated with large quantities of solution under high pressure?

17. Why should normal saline generally not be used for high volume or continuous irrigation during electrosurgical procedures?

806. Drugs often used in surgery

1. What agent is a protein-like substance used to counteract the anticoagulant effects of the drug heparin?

2. Cite two effects of oxytocic drugs.

3. What are the two primary advantages of heparin sodium?

4. Briefly define broad spectrum antibiotics and narrow spectrum antibiotics.

5. What is the largest drawback to using penicillins?

6. What are the corticosteroids primarily used for?

7. List some of the surgical uses of mannitol.

8. What is the difference between dyes and contrast media?

9. Define cholangiogram, arteriogram, and myelogram.

10. What drug is administered intravenously during hypertensive emergencies, such as malignant hypertension?

Answers to Self-Test Questions

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1. (1) Oral.
   (2) Topical.
   (3) Parenteral.
2. Oral.
3. They are absorbed into the circulatory system, through the walls of the alimentary (digestive) tract, and the medication is carried throughout the body.
4. Sublingual.
5. Any five of the following:
   (1) Creams.
   (2) Ointments.
   (3) Gels.
   (4) Lotions.
   (5) Tinctures.
   (6) Baths.

(7) Impregnated dressings.

(8) Suppositories.

(9) Sprays.

6. Administering a drug or solution by injection through a needle or by infusion through a catheter.
7. (1) Medications are absorbed rapidly into the circulatory system. This enables the person administering the drug to predict and control the onset of action.

   (2) Medications are almost totally absorbed; oral medications may be partially destroyed by the digestive system. As a result, smaller doses can achieve the desired effect.

   (3) Allows drugs to be given to patients who cannot or will not swallow, such as patients who are unconscious or uncooperative.
8. Intradermal.
9. Subcutaneous (SQ).
10. (1) Deltoid (shoulder) muscles.

    (2) Gluteal (hip) muscles.
11. IV injection or infusion.
12. Intracardiac.

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1. (1) Barrel.

   (2) Plunger.

   (3) Tip.
2. A catheter-tip syringe.
3. Touch only the end of the syringe plunger and the outside of the barrel.
4. (1) Cubic centimeters (cc).

   (2) Milliliters (ml).

   (3) Minims (m).

   (4) Units.
5. Smaller.
6. Measure the volume of solution in a syringe by looking at or "reading" the point where the end of the plunger lines up with the calibrations. When reading the solution volume in a syringe, hold the syringe in an upright position directly in front of your eyes to obtain the most accurate measurement. Only measure the volume after all air has been removed from the medication. The measurement should not include the small amount of solution in the tip of the syringe and shaft of the needle.
7. (1) Hub.

   (2) Shaft.

   (3) Bevel (angled tip).
8. As the diameter of the needle gets larger, the gauge number of the needle gets smaller.
9. Generally, the longer the bevel, the more easily the needle penetrates.
10. Ensure the bevel is sharp and free of burrs, and the shaft is not kinked or severely bent.
11. This is a sealed glass container that usually holds a single dose solution of medication. It is made completely of glass, with a cylindrical base and a candle-flame-shaped top. The "neck" of the vial separates the base from the top, and is either marked with a ring or has a "scored" line around it. This ring or line is the point the ampule is broken to gain access to the medication.
12. Basically, it is a small glass bottle sealed with a rubber stopper, and a plastic or soft metal cap. Vials may contain a single-dose or a multi-dose of medication, but, in the OR, they are nearly always handled as a single dose. Vials may contain powders or solutions; the medication may be withdrawn using a needle through the rubber stopper, or by removing the entire cap and stopper.

13. Infusion pumps literally pump the solution into the patient under positive pressure, and adjust the flow by increasing or decreasing the pressure. Infusion controllers simply count the drops as they fall through the drip chamber of gravity-fed lines, and adjust the flow rate by constricting or releasing the tubing.

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1. It must be identified at least three separate times—before it is opened, immediately before transfer to the sterile field, and immediately after the transfer. The circulator performs the first identification by silently reading the label before opening the container. The second identification should be visual (reading) and oral (reciting) by the scrub and the circulator. Before transferring the drug or agent, the circulator, as a minimum, reads aloud the type, strength, expiration date, and amount of the drug being transferred. The scrub then reads the container label, reciting the information back to the circulator. The drug or agent is transferred, and then the third identification is made the same way as the second.
2. The contents may contain glass fragments or may be bacterially contaminated.
3. Never save unused portions of medications or solutions for use on another surgical procedure. This increases the risk of cross-contamination between patients. Discard the medication or solution at the end of the case; if local policy allows, medications such as ear drops, ophthalmic ointments, or bacitracin may be sent to the nursing unit for postoperative use by the specific patient.
4. Discard and replace it.
5. Follow these steps:

   (1) Pop the plastic cap off the end of the barrel/needle unit.

   (2) Pop the plastic cap from the cartridge-plunger unit.

   (3) Insert the cartridge into the barrel. The end you popped the top off—the diaphragm end—goes into the barrel first.

   (4) Twist the cartridge clockwise until it stops. At this point, the end of the needle protruding from inside the barrel will have penetrated the seal on the cartridge.
6. Follow these steps:

   (1) Hold the ampule in one hand, tipped horizontally, almost parallel to the floor (at about a 20° angle).

   (2) Carefully insert the needle into the ampule so the tip of the needle remains just below the surface of the solution. Position the needle so the open part of the bevel is facing down and the needle points towards the bottom of the ampule.

   (3) Push the plunger up with the thumb of the hand holding the syringe. Ensure you touch only the side of the thumb-flange end of the plunger!

   (4) Gradually tip the ampule more horizontally to keep the solution covering the tip of the needle as you aspirate the contents. Avoid touching the bottom of the ampule to prevent drawing up any glass fragments.

   (5) If you are unable to use the method just outlined, you can set the ampule on a flat surface and use both hands to manipulate the syringe. Again, carefully insert the needle into the medication, but this time hold the syringe steady with one hand as you pull back the plunger with the other hand. You may be able to brace the hand holding the syringe on the flat surface.
7. Inject an amount of air equal to the amount of medication you want to withdraw from the vial.
8. (1) The circulator draws up the medication from the ampule or vial, and then changes the needle. Next, the circulator "squirts" or drips the agent into a medicine glass or other container the scrub has placed at the edge of the sterile table. The syringe is held to the side of the sterile field, and only the sterile needle shaft is over the sterile field.

   (2) This method is used only for vials. The circulator removes the entire lid from the vial, including the metal retaining strip around the rubber diaphragm, and the diaphragm itself. The circulator exercises great caution to avoid touching the rim of the vial with the removal instrument and to prevent the unsterile parts of the lid from dragging across the sterile areas. After removing the lid, pour the contents into a suitable container on the sterile field using standard aseptic technique.

   (3) The circulator opens the ampule or vial and presents the open end to the scrub. The scrub selects a syringe large enough to accommodate the desired volume of solution, and then attaches a sterile, large gauge (usually 18 gauge) needle to the syringe. When using this method, the scrub must attach a new sterile needle, not a

needle from the sterile field, to draw up the medication. Next, the circulator and scrub work together to transfer the solution in similar fashion to single-person withdrawal.

804

1. The recipient's (patient) first name, last name, and middle initial (if applicable) on the blood unit, patient ID slip from the OR, and SF 518; a unique identification number, usually the hospital register number or sponsor's social security number with beneficiary prefix on the blood unit, patient ID slip from the OR, and SF 518; the donor unit number on the blood unit and SF 518; the ABO group on the blood unit and SF 518; the Rh (type) factor on the blood unit and SF 518; and any expiration date(s) listed on the blood unit and SF 518.
2. 10°C.
3. 20°C to 24°C.
4. Six hours.
5. The temperature range must be set for the specific blood product to be stored. In ORs, whole blood and packed (not frozen) red blood cells are most commonly stored, so the refrigerator is kept between 1°C and 6°C. The refrigerator must have a fan or other device to circulate air to maintain a constant temperature throughout. The refrigerator must have some type of system to continuously monitor the temperature while blood is being stored, and the temperature must be recorded at least every 4 hours (it is usually monitored continuously). The temperature records should be maintained by the blood bank. The refrigerator must have an audible alarm that sounds *before* the refrigerator conditions reach a point where the blood may be damaged. The alarms must be loud enough to sound in an area where staff members are always present to hear it so corrective measures can be immediately taken. Written instructions must be readily available. The instructions must cover procedures for routine handling and storage, as well as emergency and corrective actions. In the OR, most instructions require you to return all blood to the blood bank if the OR blood refrigerator malfunctions.

805

1. Any three of the following:
   (1) It acts upon a wide variety of bacteria (broad-spectrum) to rapidly destroy and reduce the microbial count.
   (2) It is easy to use and apply, and maintains a long-lasting effectiveness, at least as long as the operation.
   (3) It is non-toxic and as non-irritating to the skin and other tissue as possible.
   (4) It remains effective and is not inactivated when exposed to blood, body fluids, other organic matter, alcohols, soaps, or detergents.
   (5) It is non-flammable and can be used with electrosurgical, laser, and other energy-emitting devices.
2. A tincture.
3. It can be highly irritating to mucous membranes and other delicate tissues.
4. (1) Clarity; (2) Sterility; (3) pH; (4) Tonicity; (5) Pyrogen-free.
5. Discard it; cloudiness indicates the solution may be contaminated or chemically altered.
6. To come as close as possible to the body's normal pH of 7.4 to prevent irritation of veins and internal body structures.
7. Tonicity refers to the concentration of dissolved chemicals, or solutes, in a solution as compared to the concentration of the same dissolved chemicals in the body cells.
8. Osmosis is the process of water "spreading out" and penetrating across a cell's semipermeable membrane to balance the concentration of fluid on both sides of the membrane. The water moves from the area of higher water concentration (fewer substances dissolved in the water), through the membrane, to the area of lower water concentration (more substances dissolved in the water). The water tends to pass through the membrane, leaving the solutes behind, until the concentration is equal on both sides of the membrane.
9. It contains the same concentration of dissolved sodium chloride (salt) as the fluid within the body cells. The cell remains balanced and stable. In the human body, 0.9% sodium chloride is an isotonic solution.
10. The cell will absorb water and swell; the cell will lose water and will shrink.
11. Any three of the following:

(1) Restore fluid and electrolyte balance.

(2) Provide parenteral nutrition (hyperalimentation).

(3) Increase blood volume.

(4) Change the alkalinity or acidity of the blood.

12. Electrolyte solutions are the most commonly used solutions in surgery; Ringer's solutions are the most commonly used electrolyte solutions.
13. These "blood substitutes" help to maintain circulatory volume until either the patient can naturally replace the lost blood or until blood or blood products can be administered.
14. The integrity of all seals.
15. Topically, usually with a bulb or asepto syringe.
16. Fluid or solute overload in the body; this, in turn, can lead to pulmonary edema and congestive heart failure. Distension and tissue damage can also result from excessive pressure.
17. The solution may conduct potentially harmful electrical current to tissues not intended to be affected by electrosurgery.

806

1. Protamine sulfate.
2. (1) Stimulates and increases the force and rate of uterine contractions (labor) during childbirth.

   (2) Helps contract uterine muscles and decrease hemorrhage after delivery of the placenta.
3. (1) It is fast-acting.

   (2) It can be rapidly reversed by protamine sulfate.
4. Broad-spectrum antibiotics effectively destroy or inhibit the growth of many types of microorganisms; narrow spectrum antibiotics work on only a few organisms.
5. The high incidence of allergic (anaphylactic) reactions they cause.
6. To reduce swelling and inflammation.
7. As a diuretic to relieve cerebral edema (brain swelling), especially during neurosurgery. It also treats diminished urine output (oliguria) caused by transfusion reactions and trauma related to major surgery.
8. Dyes are colored solutions that stain tissue, usually seen with the naked eye; contract media are solutions containing organic iodine or other metallic elements. They are often clear, and cannot usually be seen with the naked eye, only by X-ray.
9. Cholangiogram is an injection of a radiopaque dye into the common bile duct, gall bladder, and hepatic duct to determine the presence of stones or other obstructions; arteriogram is an injection of a radiopaque dye into the arteries to determine areas of restricted and obstructed blood flow, or aneurysms; and myelogram is an injection of a radiopaque dye into the spinal subarachnoid space to determine the presence of spinal cord tumors, congenital defects, or herniated intervertebral disks.
10. Diazoxide.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

Do not return your answer sheet to Air Force Career Development Academy (AFCDA).

1. (801) What is the *most* commonly used parenteral method in surgery?
   a. Intramuscular injection.
   b. Subcutaneous injection.
   c. Intravenous infusion.
   d. Subdermal infusion.

2. (801) The method of medication injection requiring the greatest skill and caution is
   a. intramuscular.
   b. subcutaneous.
   c. intravenous.
   d. sublingual.

3. (802) Which needle has the largest diameter?
   a. 26 gauge.
   b. 24 gauge.
   c. 20 gauge.
   d. 18 gauge.

4. (802) Which device monitors and adjusts the flow rate of gravity-fed intravenous lines?
   a. Manometer.
   b. Infusion pump.
   c. Infusion controller.
   d. Pneumatic pressure bag.

5. (803) Midway through a surgical procedure, the surgeon asks for irrigation. You have two unlabeled round bowls of solution on your back table, and know at *least* one of them contains saline. You are pretty sure all your sterile water is in a basin in the ring stand. What should you do?
   a. Ask the circulator which bowl contains the irrigation solution, then use a skin marker to label it.
   b. Discard the solution in both bowls and ask the circulator for fresh irrigation saline, even if it means delaying the procedure.
   c. Dip a clean gloved hand into each bowl, and use the warmer solution, only saline is kept warm and you do not want to delay the procedure.
   d. Visually examine the contents of each bowl; if one is clear and the other contains lint or powder, use the clear solution because the other is your sponge bowl.

6. (803) What should you do *first* when preparing to open a glass ampule?
   a. Shake the ampule to ensure all contents are thoroughly reconstituted.
   b. Wrap a 2 x 2, or 4 x 4, gauze sponge around the neck to protect your fingers.
   c. Flick the side of the ampule with your finger until all medication settles in the lower chamber.
   d. Use an alcohol swab to disinfect the tip of the syringe and needle that you will use to aspirate the medication.

7. (803) What is the purpose of using special filter needles, or using filters placed between the syringe tip and needle hub, when drawing up medications?
   a. Removes all microorganisms from the medication before injection.
   b. Filters out any pyrogens that may have contaminated the medication.
   c. Prevents small air bubbles from being aspirated into the syringe barrel.
   d. Keeps glass fragments and other particulate matter out of the medication.

8. (803) How much air should you inject into a full 30 ml vial to withdraw 15 ml of solution?
   a. 10 ml.
   b. 15 ml.
   c. 20 ml.
   d. 30 ml.

9. (803) What is the *primary reason* the scrub uses a new sterile needle and *not* a needle from the sterile field, to draw up medication from a vial or ampule held by the circulator?
   a. Prevent introduction of *pyrogens* into the solution.
   b. Prevent introduction of *pathogens* into the solution.
   c. Reduce the chance of exposing the patient to blood-borne pathogens.
   d. Reduce the chance of exposing the circulator to blood-borne pathogens.

10. (804) At normal room temperature, approximately how many minutes does it take a unit of blood to reach 10 °C after which it is *not* generally suitable for transfusion?
    a. 15.
    b. 30.
    c. 45.
    d. 60.

11. (804) What should you do with platelets after you retrieve them from the laboratory blood bank?
    a. Give them directly to the nurse or anesthesia provider attending the patient.
    b. Place them in an OR blood refrigerator set between 1° to 6°.
    c. Place them in a blood warming coil until they reach 40°.
    d. Nothing. Only a licensed provider can retrieve platelets from the laboratory.

12. (804) Who (or what section) should maintain the chart, graph, or other temperature records of the operating room blood refrigerator?
    a. Surgery noncommissioned officer in charge (NCOIC) or superintendent.
    b. Surgery flight chief.
    c. Infection control.
    d. Blood bank.

13. (805) What is a germicidal agent mixed with alcohol called?
    a. A tincture.
    b. A gluconate.
    c. An aldehyde.
    d. An iodophor.

14. (805) Red blood cells immersed in a hypertonic solution will
    a. lyse.
    b. swell.
    c. shrink.
    d. be unaffected.

15. (805) Why is dextran or albumin parenterally administered?
    a. Reduce hyperalimentation.
    b. Reduce swelling of the brain.
    c. Increase metabolic acidosis.
    d. Increase circulating plasma volume.

16. (806) In surgery, which protein-like substance, which drug is administered to counteract the effects of heparin?
    a. Pitocin.
    b. Thrombin.
    c. Warfarin sodium.
    d. Protamine sulfate.

17. (806) Oxytocic drugs, such as pitocin, are administered to
    a. increase urine output and reduce edema in body tissues.
    b. prevent and treat venous thrombosis and pulmonary embolism.
    c. reduce tissue and joint inflammation following orthopedic surgery.
    d. increase the force and rate of uterine contractions during childbirth.

18. (806) In surgery, the drug heparin
    a. helps coagulate blood.
    b. provides anti-coagulation of blood.
    c. prolongs the effect of local anesthetics.
    d. constricts the uterus during a C-section.

19. (806) An osmotic diuretic agent that tends to crystallize at room temperature and reduces cerebral edema during neurosurgery is
    a. hyskon.
    b. dextran.
    c. albumin.
    d. mannitol.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Hemostasis

HEMOSTASIS IS STOPPING THE FREE-FLOW OF BLOOD OR HEMORRHAGE; it stops by coagulation, which is the formation of a blood clot. Without hemostasis, surgery would not be possible—our patients would bleed to death! Coagulation occurs naturally in the body (e.g., when a cut finger stops bleeding and heals) or the coagulation can be induced. When we refer to hemostasis in the operating room, we are generally referring to induced coagulation. The methods we use to achieve hemostasis fall into three general categories—thermal, chemical, and mechanical.

2–1. Electrosurgery and Laser Surgery

Electrosurgery (commonly known as the "Bovie") and laser surgery are the two primary thermal methods we use to achieve hemostasis. Both methods involve using energy to produce intense heat. We start this lesson by concentrating on these methods and finish with a brief look at other thermal methods of hemostasis.

807. Electrosurgery

High-frequency (HF) electrical energy, called electrosurgery, is used extensively to cut tissue and coagulate bleeders in every modern operating room. Electrosurgery is the most common method of hemostasis used in surgery. Electrosurgical units are safe, reliable, and time-saving tools for the surgeon—when setup and used properly. As a surgical technician, you must know the basic operating principles, particularly the types and parts of the devices, and the common uses of electrosurgery.

Basic operating principles

Electrosurgical units use HF oscillating electrical current to cut or coagulate tissue. A generator within the electrosurgical unit (ESU) converts normal electrical current (110 or 220 volts alternating current) to HF oscillating current. This HF oscillating current can be localized and does not overly stimulate muscle and nerve tissue near the active electrode through, which the current is delivered to the patient. This current is delivered from the active electrode, cuts or coagulates the tissue, then follows the path of least resistance (usually the inactive electrode), and is returned to the ESU.

We use two basic methods to deliver electrosurgical energy—monopolar and bipolar. Some machines are specifically designed to operate using one method; other machines are capable of providing both.

Monopolar (unipolar) systems

The monopolar system is the one most commonly used in the operating room. This system generally uses a pencil-style active electrode (commonly called a Bovie handpiece), and a separate patient ground plate or pad that serves as the inactive electrode (commonly called a Bovie pad). The current flows from the active electrode, to the tissue, and acts on the tissue. The current then travels through the patient, following the path of least resistance, until it reaches the inactive electrode (grounding pad) that is in contact with a broad area of the patient's skin. The inactive electrode may be some distance from the active electrode, but should be placed as closely as possible to the surgical site. The current then flows from the ground pad, through a cable, and back to the ESU to complete its circuit.

Most modern-day electrosurgical devices use isolated generators; they have built-in electrical safeguards that prevent the unit from delivering monopolar current if any area of the electrical pathway is disrupted. For example, if the inactive electrode (grounding pad) is not attached to the patient, the return path is disrupted so the unit will not work. Some older ESUs use a grounded generator, which means the machine continues to emit electricity as long as the current can return to earth. Most ESUs have audible and visual ground cable fault indicators and alarms to warn the operator of operational or patient grounding problems. Some units measure the energy output delivered through the active electrode, and compare it to the energy returned through the inactive electrode (return energy monitoring); if the return energy does not equal the output, the ESU alarms and does not operate.

Bipolar systems

In a bipolar system, the instrument delivering the current must be a 2-pronged instrument, such as a thumb-forceps. One prong of the instrument serves as the active electrode, delivering the current; the other side serves as the inactive electrode, and conducts the current back to the ESU. The surgeon grasps the tissue between the prongs and activates the unit (usually with a foot switch). The current flows from the active side of the forceps, through the tissue, to the inactive side, and then back to the generator. A separate patient ground pad or plate is not generally needed when bipolar electrosurgery is used. Because the current flow is small compared to the monopolar system, only the tissue between the instrument prongs is usually affected. This gives the surgeon precise control over the amount and intensity of the desired action. This fine control makes bipolar electrosurgery ideally suited for delicate surgery, such as neurosurgery. The primary limitation to the instruments used for bipolar cautery is it must have two conductive sides capable of being insulated from each other—one side for active current, one side for return current.

Bipolar systems usually operate without fail; monopolar systems do as well, as long as the two most important parts—the active and inactive electrodes—are connected and used properly. As a surgery technician, you are often responsible for correctly preparing both electrodes.

Active electrode

The active electrode actually conducts the HF oscillating current from the ESU to the tissue chosen by the surgeon. Because this electrode is used in the patient's wound and on the sterile field, it too must be sterile. The active electrode is generally the tip of the instrument, and it comes in many different sizes and shapes. Monopolar systems usually use a pencil-shaped handpiece to control and activate the active electrode "tip;" this handpiece allows you to change just the tip rather than changing the entire instrument. The surgeon can choose between blade, ball-end, needle-point, or loop style tips. Sometimes, the surgeon uses an instrument as an extension of the active electrode. The surgeon uses a hemostat or forceps to grasp the tissue, and then touches the active electrode tip to the instrument. The current flows through the instrument to the tissue held in the jaws.

As stated previously, the active electrode of a bipolar system is one side of a two-pronged instrument. The most commonly used instrument is a pair of forceps with a plug-in top for the cord. These forceps come in different sizes and shapes, and may be insulated or non-insulated. The amount of insulation also varies. Some are fully insulated with only the very tip of the metal exposed, some are insulated with slightly more than the tip exposed, and others are insulated only where the instrument is normally held by the surgeon. Other instruments used for bipolar electrosurgery include grasping forceps with wire, loop, ball, or ring tips.

Inactive electrode

The inactive electrode of a bipolar system is built into the instrument. You do not need to worry about it because the instrument will not work if the current is not completing its circuit through the tips. The inactive electrode of a monopolar system is one you do have to worry about. This inactive electrode (patient ground) is designed to disperse the HF current flowing through the patient's body over a wide skin surface area, and then channel it back to the ESU. By dispersing the current across a wide area (the point of exit from the body), the risk of heat building up in the tissue and burning the patient is greatly reduced.

. Most dispersive ground electrodes are adhesive pads with a conductive gel. It is absolutely critical for you to remember to place an inactive electrode (grounding pad) on the patient before the start of any procedure requiring monopolar electrosurgery. If you forget, the least effect is a delay in surgery (and an irate surgeon) as someone crawls under the drapes to place the pad. More serious effects are possible, including the patient being burned or even electrocuted.

Uses of electrosurgery

Electrosurgery can be used to perform different functions based on the type of current and the tip used. Bipolar systems use coagulation, so this section applies primarily to monopolar use.

Coagulation

Electrosurgical coagulation stops bleeding by literally burning or "searing" the ends of vessels. The electrode tip is placed in direct contact with the vessel or tissue, power is activated, and the electricity generates intense heat in the tissue and seals the vessels it contacts. Coagulation is effective on small- to medium-sized vessels; using it on large vessels can cause extensive damage to surrounding tissues. (For the technically minded, coagulation uses damped current, which basically consists of applying short, very rapid, bursts of energy with pauses between.)

A form of extensive coagulation seldom used today is called dessication. Dessication involves deliberately destroying an area of tissue, such as a small tumor, by applying electrosurgery until the tissue cells are dehydrated and the tissue destroyed. The surgeon places the active electrode in direct contact with, or sticks it directly into, the area and applies the current until the tissue is charred (turns brownish-black). Laser ablation has virtually replaced this method of electrosurgery.

Cutting

Cutting via electrosurgery involves creating an arc (continuous spark) of electricity between the tissue and the active electrode. The surgeon holds the electrode slightly above the tissue, and the tissue is divided by the intense heat of the arc without coagulating the vessels in surrounding tissue. (Cutting uses undamped current, which, simply described, applies constant energy to the electrode.)

Blended coagulation and cutting

Blended coagulation and cutting is simply what it sounds like—combining the coagulation and cutting. As the active electrode cuts through the tissue, the current also coagulates the cells and vessels of nearby tissue. Most ESUs have controls that allow the user to set the amount of "cut" energy and the amount of "coagulation" energy delivered simultaneously to the electrode. This method blends undamped with damped current, and the level of cut or coagulation is determined by the amount of each type current delivered.

Fulguration

Fulguration uses spray coagulation, which is actually a form of the cutting energy, to char the surface of an area without destroying the deeper tissues. Fulguration involves holding the active electrode slightly away from the tissue, and then applying energy to create a "spray" of sparks to destroy the surface of the tissue. It is mainly used by urologists and gynecologists during endoscopic procedures.

808. Laser surgery

The invention of the surgical laser has revolutionized many areas of surgery. The laser offers precision application with excellent control of bleeding. It uses an intensely concentrated light beam to cause a localized increase in tissue temperature. Due to the continuing development and varied uses of lasers in surgery, we will discuss only general characteristics of surgical lasers.

Types of lasers

There are many types of surgical lasers commonly available—solid-state, gas, liquid/gas, excimer, and free-electron lasers. Most lasers are classified by the medium they use to generate their light beams. Each has different types and characteristics.

Solid-state lasers

Solid-state lasers use a solid material as the medium. Some common types of solid-state lasers are neodymium-yttrium aluminum garnet (Nd-YAG), laser holmium-YAG laser, and the potassium titanyl phosphate (KTP) laser.

Gas lasers

Gas lasers use various gases as their media; the most commonly used is the carbon dioxide (CO_2) laser. Other gas lasers include the argon laser, krypton laser, and helium-neon laser.

Other lasers

Liquid/dye lasers pass a laser beam (usually argon) through fluorescent dyes or vapors to create different colored beams for different applications. This laser is sometimes called a tunable dye laser. It is mainly used to destroy cancer cells by photodynamic therapy.

The excimer laser uses a halide medium to make a cool laser beam. It is used mainly in corrective eye surgery and some plastic surgery.

The free electron laser uses magnets and a particle accelerator to produce its beam. The beam color is adjustable throughout the entire light spectrum—visible and invisible. It is also in a developmental stage and not widely used at present.

Laser applications and advantages

For a laser beam to affect tissue it must be absorbed by the tissue and the color of the beam primarily determines how well specific tissues absorb it. Therefore, the color of the beam determines the effectiveness of the laser on the specific tissues. This absorption or reflection allows specific applications and offers some unique advantages.

Applications

Lasers are used by virtually all surgical specialties on various surgical procedures. When a laser is used, a smoke evacuator may also be used to remove the smoke and steam from the operative site.

The type of laser used is often determined by the desired application. As mentioned earlier, due to the ever changing uses of lasers in surgery, a complete list of applications and surgical procedures using lasers is beyond the scope of this CDC. However, the following table should give you a pretty clear picture of how the various lasers are used.

Surgical Specialty	Laser Type	Application
Urology	CO_2	• Ablation of bladder tumors. • Ablation of condylomata. • Repair of urethral strictures. • Treatment of bladder cancer.

Surgical Specialty	Laser Type	Application
	Nd-YAG	• Prostatectomy. • Renal surgery. • Removal of malignant lesions.
	Holmium-YAG	Lithotripsy.
Plastic	Argon	Removal of port-wine stains.
	CO_2	Cutaneous (skin) surgery.
	Nd-YAG	Eyelid surgery.
	Excimer	Wrinkle removal.
Orthopedic	CO_2	Arthroscopic surgery.
OB/GYN	CO_2	• Ablation of condylomata. • Removal of carcinomas. • Removal of neoplasia. • Treatment of endometriosis.
	Nd-YAG	Treatment of menorrhagia.
Eye (Ophthalmology)	Argon	• Ocular photocoagulation. • Repair of retinal tears. • Treatment of glaucoma.
	Nd-YAG	Lens capsule removal after cataract excision.
	Ruby (Xenon)	Retinal photocoagulation.
	Excimer	Vision correction.
ENT (Otolaryngology)	Argon	Correction of chronic epistaxis (from hemangioma).
	CO_2	Removal of tumors/lesions in the oral cavity, nasal cavity, and larynx.
	Nd-YAG	Endoscopic removal of lesions.
Neurosurgery	Argon	• Spinal cord surgery. • Coagulation of small vessels.
	CO_2	Removal of non-central-nervous-system tumors.
	Nd-YAG	Removing highly vascular lesions.
General Surgery	Argon	Removal of superficial lesions.
	CO_2	• Ablation/excision of masses, tumors, and neoplasias. • General coagulation.
	Nd-YAG	Large vessel hemostasis lesion removal.
Cardiovascular/Heart	Argon	Arterial recanalization.
	CO_2	• Valve surgery. • Myocardial revascularization.

Advantages

Lasers offer many advantages; most of which are related to the fact that different beams are absorbed by different tissues and other substances. The major advantages are:

- Lasers offer precision and accuracy. The laser beam used is selected for how it is absorbed or reflected by the tissue, how far it penetrates, and how precisely it focuses.
- Lasers provide a dry, bloodless field. The laser coagulates as it cuts, and the smoke evacuator suctions the vapors away. This affords the surgeon a clear view of the operative site.
- Lasers provide minimal damage to surrounding tissues. The beams are highly localized and fast. The beam often is done vaporizing the desired area before nearby tissue begins to warm. This can help reduce the patient's postoperative pain.
- Lasers reduce operating time and promote more rapid healing with less scarring.

In the next section, we will discuss additional thermal methods to maintain hemostasis during surgery.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

807. Electrosurgery

1. Which method or system of electrosurgery is most commonly used in the operating room?

2. Briefly describe an isolated electrosurgical generator.

3. How does current flow through a monopolar electrosurgical system? Bipolar electrosurgical system?

4. What is the role of the active electrode?

5. What is the purpose of the inactive, or patient ground, electrode?

6. List the electrosurgical application(s) that require the active electrode to directly contact the tissue.

808. Laser surgery

1. List two types of solid-state lasers.

2. Which gas laser is most commonly used in surgery?

3. What primarily determines the effectiveness of a laser on a specific tissue?

4. List three advantages offered by lasers.

2–2. Hemostatic Agents

We use hemostatic agents primarily to help speed up the natural clotting ability of the blood. Some agents are applied topically, some parenterally. Most of the hemostatic agents used in surgery are applied topically, directly to the areas of the wound where bleeding is occurring. Thermal and chemical are two additional methods used to help control blood loss in the surgical patient.

809. Thermal hemostatic methods

In addition to electrosurgery and lasers, we use other thermal methods to maintain hemostasis during surgery. Many of the methods listed below involve heat or cold in conjunction with electrosurgery or laser surgery. You should be able to identify with the methods used within your facility. Let’s discuss some frequently used methods so that you can become more familiar with their use.

Cryosurgery

Cryosurgery involves freezing the area to be excised. A probe, fully insulated except for the tip, is placed in contact with the desired area, and then the tip is made extremely cold by using a gas refrigerant (usually liquid nitrogen or CO_2). The tip is held in place until the area surrounding it freezes; the frozen tissue is then excised. There is very little bleeding either during or after surgery. Cryosurgery can also be used to alter or destroy the tissue cells without excising them.

The effect of the cryosurgical unit on the tissue is rapid; exactly how fast it works and how cold it gets depends on the type of machine and the tissue being frozen. The extent of the area affected is controlled by the surgeon; variables include:

- The size and type of tip used.
- The temperature setting.
- How long the surgeon keeps the probe in contact with the area.
- How vascular or fluid-containing the tissue is.
- The expertise, preferences, and experience of the surgeon.

Speed of effect is not its only advantage. It offers minimal trauma to surrounding tissue, is nearly bloodless, and is virtually painless postoperatively. The following table shows some examples of cryosurgical use:

Surgical Specialty	Use
Ophthalmology	Removal of fragile or dislocated cataracts
Neurosurgery	To destroy certain brain and spinal tumors
Otolaryngology	To remove cancerous tumors in the nasal passages
Plastic Surgery	To remove superficial skin tumors
Urology	Prostatectomy
General Surgery	Removal of liver tumors/ tumors from other highly vascular organs
OB/GYN	Excision of cervical lesions

Hypothermia

Hypothermia also uses cold temperatures, but, unlike cryosurgery, we cool the tissue rather than freeze it. You should recall, from our discussion of hypothermia as an anesthetic adjunct, cooling the body slows the metabolic and oxygen needs of the body. This, in turn, decreases the blood pressure and slows the circulation. Slowing the circulation decreases bleeding. Hypothermia is often used to cool the entire body, but may be used locally, such as by using "slush" solution in cardiac surgery.

Diathermy

Diathermy, sometimes called electrocoagulation, is applied and used similarly to cryosurgery; except, it uses heat rather than cold. It uses very high-frequency electric current, which very rapidly generates temperatures that coagulate blood vessels. It is applied in very short bursts to avoid affecting areas close to the operative site. It is useful to coagulate very small blood vessels, and was once the method of choice to repair retinal detachments of the eye. Other methods and procedures, including cryosurgery and lasers, have all but replaced diathermy, but it is still used for unique procedures.

Electrocautery

This term is sometimes used to refer to electrosurgery, but it is not technically correct. Electrosurgery uses current to heat the tissue; electrocautery uses current to heat the instrument. The electrocautery device you will most likely see in surgery is a small, battery-operated, disposable device. It has a handle like a small flashlight, but where the lamp would be is a small wire loop. When you press the button on the handle, the current heats the loop, and the hot wire sears and seals the blood vessels.

Argon beam coagulator

The argon beam uses a handpiece (similar to the standard electrosurgical handpiece) that blows a stream of radio-frequency current and ionized argon gas to the site, thus cauterizing the tissue. It can cauterize broad areas of tissue more rapidly, and produces less charring, than electrosurgery does. It also results in less smoke. Initial tests show this to be a very safe and effective tool; it is suitable for conventional and endoscopic surgery. Because the argon beam coagulator is monopolar, an inactive electrode (grounding pad) must be used with it. The same safety rules for applying the electrosurgical pad must be followed.

Hemostatic scalpels

Another hemostatic device is the hemostatic scalpel. It essentially uses a standard scalpel blade attached to a handle with an electric cord attached. As the blade cuts, thermal energy cauterizes. It has a variable temperature setting, and can also be used cold as a standard scalpel. Its most promising application is for incisions in highly vascular areas, such as the scalp.

There are other thermal hemostatic methods, and microcircuitry is helping to develop new ones continuously.

810. Chemical hemostatic agents

Most chemical agents are used only when thermal or mechanical methods either fail or are not practical. Topical hemostatic agents come in several different forms, including liquids, powders, and solids. To be effective, all chemical hemostatic agents must be stored, handled, and used properly. Ensure you follow the manufacturer's directions when dealing with any chemical agent. We briefly look at the more commonly used agents.

Thrombin

Pharmaceutical thrombin is a protein substance derived from bovine (beef) blood plasma; it mimics the body's own thrombin (an enzyme). Thrombin aids the clotting process by converting the fibrinogen (a protein) in human blood plasma to fibrin. Fibrin is the thread-like material that appears in the blood, forming a tangled web that traps platelets and red blood cells to form blood clots.

Thrombin may be used topically as a powder; it is sprinkled over an oozing area. More frequently, thrombin is used as a liquid. It may be packaged as a powder that must be reconstituted with injectable saline, may be already in liquid form, or may be a topical spray. Thrombin is applied directly to tissues to achieve hemostasis whenever oozing blood from capillaries and small venules is accessible. It is also often used to saturate pieces of absorbable gelatin sponge, which are used as hemostatic mini-packs in hard to reach areas. This chemical hemostatic combination is used extensively in neurosurgery and orthopedic surgery, particularly for spinal operations. Because thrombin speeds up the chemical reactions of the normal blood clotting process, it should never be injected intravenously or allowed to enter large blood vessels; extensive blood clotting and even death may result.

Absorbable gelatin sponge

Absorbable gelatin sponge (gelfoam) is a sterile, pliable, surgical sponge prepared from specially treated, purified gelatin solution. It aids in controlling bleeding by absorbing and holding several times its weight in blood, allowing the body's own clotting mechanism time to clot the blood. In a sense, it acts as an adjunct to the fibrin "net" we just talked about, helping trap the blood cells and platelets that form the clots. When left in the body, the gelatin sponge is completely absorbed in 4 to 6 weeks.

Like thrombin, the absorbable gelatin sponge controls oozing of blood from capillaries and venules in hard-to-reach areas of a wound. The sponge is usually cut into various sized pieces before use, and then an appropriately sized piece is applied to the oozing area. It can be used dry, but is often moistened with saline or thrombin. When used dry, the pieces of the sponge should be compressed before being placed in the wound, then should be held directly against the bleeding tissue for at least 10 to 15 seconds. When moistened with saline or thrombin, the sponge pieces should be thoroughly saturated, then squeezed to remove the air trapped in the pores. The compressed, saturated pieces should then be placed back in the solution until they are needed. After they are immersed in the solution, the compressed pieces should resume their original shape and size. If they do not, try squeezing them again to remove the air, and then re-immerse them. Absorbable gelatin sponge should be used as soon as possible after the package is opened, and any unused pieces must be discarded.

Oxidized cellulose

Oxidized cellulose is available as a specially treated knitted fabric, or as a cotton-like pad prepared from regenerated cellulose. Like the other topical hemostatic agents, it controls capillary or moderate venous oozing in areas where other means are impractical or impossible. Oxidized cellulose aids the clotting process by acting as a matrix or net for clots to form (much like the action of absorbable gelatin sponge). Although oxidized cellulose is absorbed by the body, it is usually removed after hemostasis has been achieved to reduce chances of abscess formation or foreign body reaction.

Oxidized cellulose is used dry, and is laid over, sutured to, wrapped around, or otherwise held in direct contact with the bleeding surface. When the blood contacts the fabric, the fabric swells and a gel is formed. Because it swells significantly, oxidized cellulose is not used to "pack" a wound, except in extreme emergencies. If packed in a confined area, the cellulose can cause pressure on nearby nerves, blood vessels, and tissues.

Several pharmaceutical companies supply oxidized cellulose under different trade names. The most common are Surgi-Cel, a loosely-knit fabric; Surgi-Cel Nu-Knit, a more tightly knit fabric; and Oxycel, a cotton-like pad. These products are yellow-gold colored, and come in various sizes that are cut to meet the specific need. Once opened, oxidized cellulose should be used as soon as possible, and unused portions must be discarded.

Microfibrillar collagen hemostat

Microfibrillar collagen hemostat (MCH) is an absorbable topical hemostatic agent made from purified bovine collagen. It is supplied in a dry, powder-like fibrous form, or in nonwoven, web-like sheets applied directly to the bleeding site. It controls bleeding by attracting platelets that become trapped in the fibers of the material.

MCH should never be moistened with saline or thrombin because moisture impairs its hemostatic action. MCH tends to stick to moist surgical gloves, instruments, and tissues, so you should handle the sheets with clean, dry forceps. After handing the MCH to the surgeon, you must be prepared to hand a clean, dry, sponge (sponge-stick if necessary). MCH must be held in place with pressure to keep it from absorbing the blood’s moisture and becoming ineffective. As with the other topical hemostatic agents, unused portions should be discarded and never resterilized. MCH is most often supplied under the trade name Avitene.

Absorbable collagen

Absorbable collagen is available as sponges, pads, or felt. It is almost identical to MCH in action, handling, and use. Common trade names are Superstat (sponges), Helistat (pads), and Lyostypt (felt).

Silver nitrate

Silver nitrate is a topically applied styptic. A styptic is an agent that aids in hemostasis by vasoconstriction (epinephrine is sometimes classified as a parenteral styptic). Silver nitrate is available as a solution, but, in surgery, silver nitrate is usually applied by using a silver nitrate “stick.” The silver nitrate is molded onto the end of the stick, and then the stick topically applies the agent directly to the bleeding area. A common use of silver nitrate is to stop the bleeding from the uterine punctures caused by a tenaculum.

Bone wax

Bone wax is a sterile, refined mixture of beeswax and a softening agent, primarily used to control blood oozing from bony surfaces. It actually falls into the next category of hemostatic devices because it works as a mechanical barrier rather than a chemical reaction. We are covering it here because most people think of it as a chemical hemostatic agent. Bone wax is simply spread and compressed over the oozing bone and forms a “wax wall” the blood cannot penetrate. It is not very absorbable and some studies indicate it may inhibit bone growth, so it should always be used sparingly.

Bone wax usually comes packaged in a foil wrapper contained in the same sized peel-pack as suture. (In fact, it is usually packaged and sold by suture manufacturers.) It is opened on the field just like suture. Before use, you should warm the wax by either immersing the unopened foil in warm saline, or by holding it tightly in your (gloved) hand. To prepare bone wax, you usually break-off small “pea-sized” pieces and roll them into balls. You can place the rolled wax around the rim of a basin or cup when not in use. To pass the bone wax, most surgeons prefer you stick it on the end of a small periosteal elevator, such as a Freer. This minimizes the risk of dropping the wax ball off the sterile field or into the wound, and gives the surgeon an applicator to spread it on the bone.

Other chemical hemostatic agents are being researched and developed, but these are the ones you will probably use.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

809. Thermal hemostatic methods

1. Briefly describe cryosurgery.

2. What thermal hemostatic method is similar to cryosurgery, but uses heat instead of cold?

3. Describe the basic difference between electrocautery and electrosurgery.

810. Chemical hemostatic agents

1. List three chemical agents commonly used when thermal or mechanical methods either fail or are not practical.

2. How does pharmaceutical thrombin help control bleeding?

3. Which topical hemostatic agent is often saturated with thrombin before use?

4. Why is oxidized cellulose usually removed from the body after hemostasis has been achieved?

5. Which topical hemostatic agent should never be moistened with saline or thrombin prior to use? Why?

6. What chemical hemostatic agent is sometimes used to stop the bleeding from the uterine punctures caused by a tenaculum, and how is it applied?

7. Briefly describe how bone wax stops bleeding.

2–3. Mechanical Hemostatic Devices

Mechanical hemostatic devices work by clamping or compressing the blood vessel(s) to stop the flow. We use several products and devices to ligate blood vessels and control bleeding. Suture ligatures can be used to achieve mechanical hemostasis, but, since we usually associate suture with wound closure, we cover it in the next unit. The devices we cover in this section include the various clips and stapling devices we use in surgery. Let's begin with a look at surgical clips.

811. Surgical clips

Though there are several kinds of surgical clips used in the OR, we use them for two basic purposes. We use scalp clips to control bleeding from superficial tissue during procedures such as craniotomies. We also use clips to "clamp-off" (ligate) vessels and small body structures during many other procedures.

Scalp clips

Scalp clips are used primarily during neurosurgical procedures involving the skull or brain. They are placed side-to-side along the edges of the highly-vascular scalp flap as the surgeon makes the incision. The clips are left in place throughout the procedure to maintain hemostasis, and then removed as the surgeon closes the wound.

Scalp clips may be metal or plastic, and, like all ligating clips, a specific applicator is used for the specific clip used. Most of the clips used today are disposable, but you may come across a surgeon who prefers the non-disposable silver or carbon-steel clips. Two of the more popular clips used are the Raney clip and the Leroy clip; a Leroy-Raney clip combines features of both. Figure 2–1 shows a Raney clip and applier.

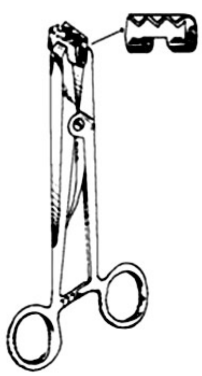

Figure 2–1. A Raney-type scalp clip and applier.

Most scalp clips are applied in a similar fashion. You load the clip on the end of the applying forceps, and then lock the instrument ratchet; locking the ratchet opens the jaws of the clip. Unless the surgeon prefers, otherwise, lock the applier to only the first notch. This prevents over-stretching the clip before it is applied; over-stretching it reduces its clamping tension, thereby reducing its effectiveness. You should have at least two appliers loaded at all times, preferably more, because the surgeon applies the clips as rapidly as possible. After the surgeon places all the clips, ensure you keep at least one applier loaded for back-up, and one empty. The surgeon will need an empty applier to remove the clips at closing. Disposable scalp clip appliers are also available; they usually contain 10–12 clips and allow the surgeon to rapidly apply them. A separate removal tool is required when the disposable applier is used.

Ligating clips

Ligating clips, commonly called Liga-clips or Hemo-clips, are most commonly used instead of individual suture free-ties or ligatures. Ligating clips have two "legs" that squeeze together when the clip is compressed; they literally "clamp off" small blood vessels, tubular structures (like the bile duct), and nerves. They are particularly useful for ligating major vessels in deep, hard-to-reach areas, where the surgeon's ability to see and maneuver needles and other instruments is limited. Ligating clips are also used on bleeders in more superficial tissues; they help "speed-up" the operation because the surgeon simply slides the clip over the desired area, and then squeezes the applier to clamp the area. Using conventional suture ligatures, the surgeon must clamp the area, maneuver the suture around the structure, tie the knot, and cut the loose ends. Metallic ligating clips can also serve as X-ray detectable "markers" in a wound. For example, a surgeon can place the clips in an area where tissue biopsies were removed, and then use the clips as postoperative markers to determine if a cancerous mass is spreading or shrinking under follow-on therapy. Ligating clips are either made from metal and are non-absorbable, or they are made from synthetic polymers and are absorbable. The two types are used similarly, but are different in design, so they deserve individual attention.

Nonabsorbable clips

Nonabsorbable ligating clips are usually made from stainless steel, titanium, or tantalum; these metals will not corrode and they produce very little tissue reaction when implanted in the body. Tantalum clips usually have a dull gray finish and are heavier than stainless steel or titanium clips; titanium clips usually have a metallic blue finish. As shown in figure 2–2, most metal ligating clips are usually a modified “V”-shape and have small serrations on the inside surface. The serrations keep the clip from slipping after application. Most clips are pre-packaged sterile. Some clips come pre-loaded in a disposable “multi-fire” applicator, but most are packaged in plastic cartridges in groups of six or more. Some ligating clip cartridges come unsterile from the manufacturer (in which case, they must be wrapped and sterilized). The clips come in different sizes for different applications, and each type and size clip requires a specific applicator.

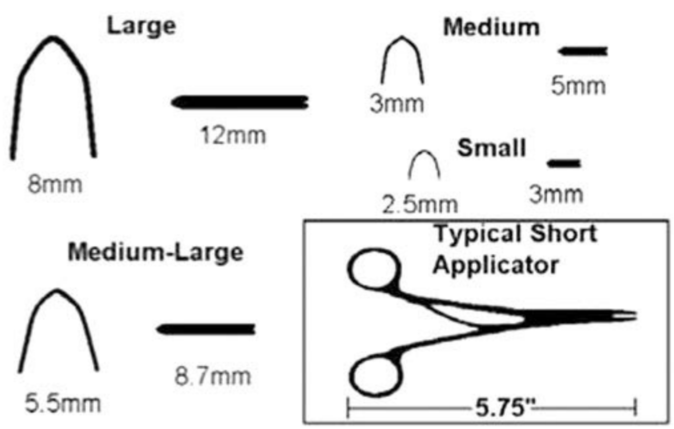

Figure 2–2. Metal, nonabsorbable ligating clips.

The applicators used with each sized clip come in different styles, with different shaped tips, and in various lengths. There are even “double-clip” applicators that apply two clips simultaneously. Labeling and terminology is sometimes confusing. One accurate method is to label and call the applier by its overall length, by its style and tip shape, and by the type and size clip it applies. For example, the label “5-inch, alligator, right-angled tip, small Liga-clip applier” tells the user exactly what instrument is in the package. The label “short-small clip applier” is ambiguous and could refer to numerous applier types.

When loading a metal ligating clip, grasp the applier by the box lock with its jaws pointed down. Insert the tips in a loaded slot on the cartridge until the tips touch the base of the groove. Ensure you slide the applier tip straight down over the clip, this means you may have to tilt the instrument to load its tip. Do not use excessive force and do not “rock” the applier as you insert the clips; you may damage the tip. After the clip is loaded, pull the applier straight out of the cartridge to withdraw it. Do not handle the loaded applier by its ring handles; hold it only by the box lock. If you hold it by the handles, you may accidentally squeeze them, and even a small compression will bend the clip and make it fall out of the jaws.

Absorbable clips

Absorbable ligating clips are made from synthetic polymers, such as polydioxanone—the same slow-dissolving chemical compound used in some absorbable sutures. Unlike the metal clips, which are designed to remain permanently clamped around a structure, absorbable clips eventually dissolve. They are not used when a secure, permanent ligation is required. The absorbable clips are usually dyed violet to enhance their visibility in the tissues and, because they contain no metals, are X-ray transparent. As shown in figure 2–3, the clips are also shaped in a modified "V", but, unlike metal clips, they have projections at the end of each "leg" to lock together and secure the clip. Absorbable clips come in pre-sterilized cartridges designed for use with reusable appliers, or in disposable multiple clip appliers. Loading and handling of the absorbable clip appliers is basically the same as for the metal clip appliers.

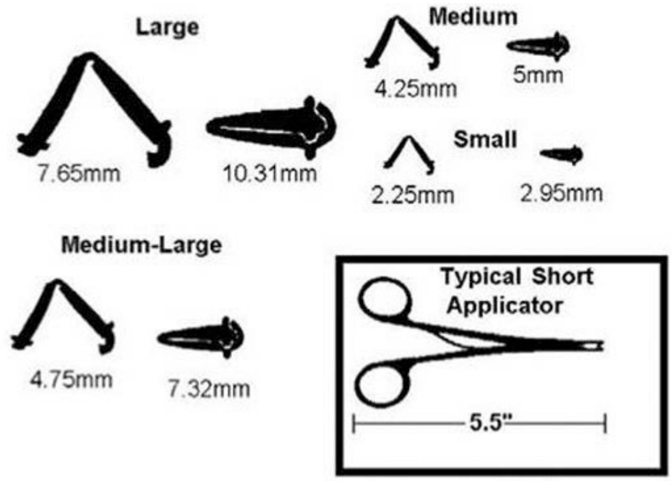

Figure 2–3. Absorbable ligating clips.

812. Tamponade

In surgery, tamponade is the use of packs or pads (surgical sponges) in surgical cases to control hemorrhage or absorb secretions. We can think of it as a direct pressure with a sponge to control bleeding. The most common forms of tamponade are holding direct pressure with a sponge stick or packing an area with sponges. Many times, you as the surgical technician may be required to hold pressure on the site of the bleeders while the surgeon performs other tasks. When using sponges to control bleeding the main "trick" is to use direct pressure or blotting to keep the operative site clear of blood for the surgeon to be able to see what he or she is doing. If you use a wiping motion, you can disturb clots already in place and increase bleeding and reduce the surgeon's visibility of the operative site.

Remember to be careful when you remove the sponges and pull them away from the tissue instead of using a wiping motion, as we have already mentioned, so that you don't disturb the clot that has formed and start the bleeding again. Never use a dry sponge inside of a patient; only use sponges moistened in saline or with hemostatic agent. Do this to avoid tissue damage to the patient. Of course the most important things are to use only radiopaque sponges and to know exactly how many sponges you placed in a cavity to pack the area. Another common method of hemostasis involves using surgical clips to control bleeding.

813. Surgical stapling devices

Surgical stapling devices have revolutionized wound closure and the methods used to perform certain surgical procedures. Most surgeons now use disposable stapling devices for a variety of procedures.

General information

Surgical stapling devices come in many sizes, shapes, and configurations. Some devices are multi-purpose; others are designed for use in specific body areas or on certain types of tissues. General surgeons most commonly use stapling devices, especially for procedures involving structures of the gastrointestinal (GI) tract. They are also routinely used for many thoracic and gynecological surgical procedures.

The pattern, length, and type of staple line vary with each specific type of stapler. Some place a parallel double row of staples in the tissue; others implant a double circle of staples. The length of each staple depends on the pattern of the staple line and the tissue it is designed to be used in. Some staplers not only place staples, but also cut the tissue between the rows. Ligator-dividers place two staples and cut between them. Skin and fascia staplers replace sutures by approximating the wound edges with a series of individually applied single staples.

Most staplers use non-absorbable staples; the staples are made from thin surgical stainless steel wire. The most commonly used double-row stapler contains staggered puncturing "legs." The rows of staples are staggered so a staple in one row is positioned between two staples in the other row. This forms a leak-proof approximation, which is very important in gastrointestinal and lung surgery. The shape, size, and length of the staples vary with the thickness and type of tissue the stapler is designed for. Most staplers bend the staples into a noncrushing "B" shape after the staple passes through the tissue. This shape provides a secure approximation while preserving the blood supply to the stapled tissues. Skin staples are the primary exception; they bend the staples into a rectangular or D-shaped pattern.

Most stapling devices used today are completely disposable units; though there are still a few reusable stainless steel units that use disposable cartridges. Regardless of the type your OR uses, ensure you are thoroughly trained in their assembly, preparation, use, and care. Always use a new cartridge and anvil when using any unit with reusable parts. A used anvil may misalign and misshape the staples, causing the staple line to leak (or even rupture). Disposable staplers are designed for single patient use. Because they require no reprocessing and are used on only one patient, they help lower the risk of cross-contamination. Regardless of the type stapling devices your surgeons use, you must be familiar with preparing and handling them properly. Fumbling to prepare them not only wastes valuable operative time, but can compromise patient safety. Always read and follow the manufacturers' operating instructions before scrubbing a procedure where stapling devices are used.

Advantages of surgical stapling

Staplers offer several advantages over sutures. Probably the most noticeable advantage is the amount of time they save. When using the right stapler, surgeons can ligate, approximate, and anastomose tissue in one or two simple steps. Using suture requires individual placement, tying, and cutting of each stitch; plus resecting and reanastomosing the tissue. Staplers also require less preparation and handling than multiple sutures, so the scrub can set up the case quicker and devote more attention to anticipating the surgeon's needs during the operation. Surgeons ultimately choose staplers becaue they reduce tissue manipulation and handling, which in turn reduces postoperative inflammation and risk of infection.

As mentioned earlier, the use of disposable staplers further reduces the risk of wound infection by eliminating the need for reprocessing. By using staples, particularly those positioned in double-row patterns, the surgeon can create a leak-proof seal between tissues. This is very critical in GI surgery, where leaking stomach or bowel contents could cause peritonitis. It is also very important during thoracic surgery involving the lungs or bronchial tree because a leaking lung can cause air to enter the pleural space, a condition that can lead to impaired breathing and a collapsed lung. The noncrushing seal created by the B-shaped staples also accelerates wound healing and prevents tissue necrosis. The staples are made from an inert metal and cause little, if any, tissue reaction after implantation. Using surgical staplers reduces the number of, thereby the risk of losing, needles in a wound, and makes needle counts faster and easier. Finally, skin staples are easier to remove postoperatively than are nonabsorbable skin sutures.

Disadvantages of stapling

The primary disadvantage of surgical staplers is their cost; they are not cheap. A single-use stapler can cost more than ten times as much as a box of sutures. Because they are so expensive, all personnel who handle these devices must be intimately familiar with them to prevent waste caused by accidental contamination, premature staple firing, or physical damage due to improper handling. The surgeons must also be well-trained in their proper use. If the device is improperly placed, tissue approximation may be poor or leaks may develop. Incorrectly placed sutures can be cut, removed, and replaced with minimal difficulty. Not so with malpositioned staples. Correcting a stapling error may require excision of healthy tissue, subjecting the patient to unnecessary surgery, greater risk of infection, and prolonged anesthesia.

The use of surgical stapling devices requires more training for all surgical personnel, including the surgeons, than the use and handling of suture materials. Most manufacturers offer in-service and other type training. Technicians and nurses not only need to learn the basic applications of staplers but also how to properly prepare, handle, and maintain them to ensure they are ready when needed.

Types and uses of stapling devices

As we said earlier, there are many types of surgical staplers. We will briefly cover the ones most frequently used.

Ligating and dividing staplers

These staplers save the surgeon and scrub technician a lot of time and effort because they take the place of hemostats, ligatures, and scissors (both tissue and suture) when ligating and dividing vessels, and other small tubular structures. Figure 2–4 shows the most popular type ligator-divider. It fires two single staples side-by-side, and then uses a single straight knife blade to cut the tissue between the staples. These staplers are most often used for rapid ligation and division of blood vessels supplying the omentum during GI surgery. They are also used by gynecologists and thoracic surgeons.

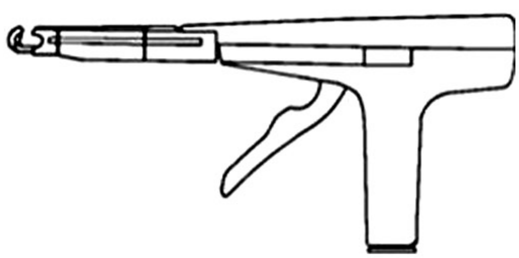

Figure 2–4. A ligator-divider stapling device.

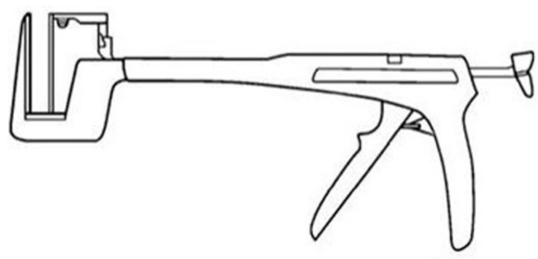

Figure 2–5. A common-type rigid linear stapling device.

Linear staplers

Linear staplers place a double, staggered row of staples in the tissue. As previously described, the staples are bent into a capital B-shape, which gives a leak-proof closure without crushing the tissue. Linear staplers are widely used in lung and GI surgery. The staplers vary in size and jaw length, depending on the desired staple line length and the thickness of the tissue to be stapled. The three most common jaw lengths are 30 millimeters (mm), 55mm, and 90mm. These staplers are used by nearly all surgical specialties, especially in the chest and abdomen, for stapling and resecting a variety of tissues and structures. Many linear staplers are rigid, pistol-like instruments (fig. 2–5). Some are similar to the one in the figure, but their heads rotate, tilt, or both. One manufacturer even offers a disposable linear stapler with a flexible “goose neck” to allow the surgeon to staple tissues in hard-to-reach areas.

Gastrointestinal anastomosis staplers

There are two types of staplers designed primarily to perform various intestinal and gastrointestinal anastomoses. The first is a device known as a gastrointestinal anastomosis (GIA) instrument (fig. 2–6). It has two halves that are separated, and then rejoined after the tissue is clamped between the jaws. The jaw on one half of the stapler holds a staple cartridge that has two double rows of linear staples; the other half holds a metal anvil that bends the staples into the noncrushing B-shape after they pass through the tissue. The third part of the assembly is an extremely sharp double-bladed knife. After the two double staple lines are in place, the knife slides into the unit and cuts a swath of tissue out from between the two lines. The GIA is used for transection of the small and large intestines, and for numerous intestinal and gastric anastomoses. It is particularly useful for side-to-side anastomoses.

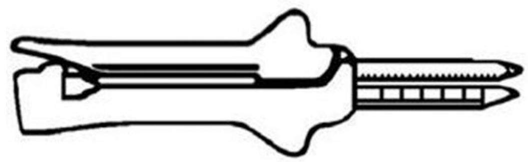

Figure 2–6. A gastrointestinal anastomosis instrument.

The other gastrointestinal anastomosis (GIA) stapler design (fig. 2–7) is primarily used for end-to-end anastomosis. Depending on the manufacturer, they may be called intraluminal staplers (ILS) or end-to-end anastomosis (EEA) staplers. These stapling devices are almost identical in design and function. They may have rigid shafts, either straight or curved, or flexible shafts. These staplers are primarily designed to join two tubular hollow structures within the alimentary tract, such as the rectum or colon. These staplers have a circular cartridge that fires a double staggered row of the B-shaped staples in a circular pattern.

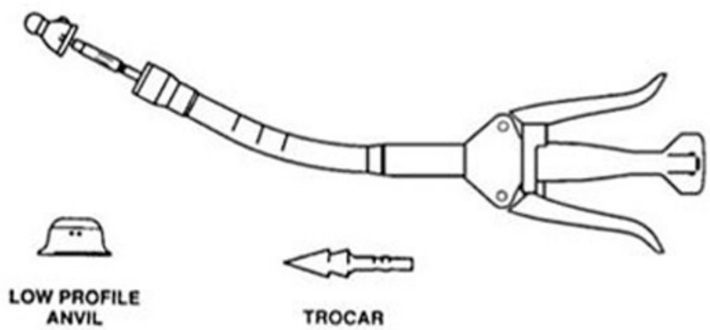

Figure 2–7. An end-to-end anastomosis instrument.

To understand how this stapler works, we'll look at how it rejoins a resected colon. The surgeon makes an incision in the side of one of the two sections to be reanastomosed, and then passes the stapler through the incision until the end of the stapler protrudes from the end of the colon. The end of the other section of colon is then slid over the end of the stapler, and the "doughnut-shaped" staple cartridge and the similar-shaped anvil is screwed together. The surgeon then fires the stapler and a double row of staples join the two sections of colon together. A built-in "cookie-cutter" knife trims the excess tissue around the inside of the anastomosis. The stapler is then opened and removed. A GIA can then be used to close the incision in the side of the colon.

The staple cartridges of these devices are available in different diameters for use on the different structures within the GI tract. The surgeon usually determines the size cartridge or disposable stapling device to use by first "sizing" the tubular structure with a special sizing instrument. In addition to the end-to-end colon anastomosis described, these stapling devices are used for end-to-side and side-to-side anastomosis of the esophagus, small intestine, and colon. They may also be inserted rectally for low anterior resections.

There are other types of stapling devices available and there are also absorbable staples available, but the ones we just covered are the most commonly used. Of course, we also use staples in routine wound closure, but we will cover them in the next unit.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

811. Surgical clips

1. Describe how scalp clips are used during neurosurgical procedures involving the skull.

2. Why is a loaded scalp clip applier locked to only the first notch on the ratchet?

3. How do ligating clips work?

4. What are nonabsorbable ligating clips usually made from? Why?

5. Briefly describe the feature that locks and secures absorbable ligating clips.

812. Tamponade

1. What is tamponade?

2. Why are only moistened sponges used inside of a patient?

813. Surgical stapling devices

1. Why are the staples forming the double-row implanted by most surgical staplers staggered?

2. What shape do most staplers bend the staples into? Why?

3. Why should you always use a new cartridge and anvil when using any stapling unit with reusable parts?

4. List five advantages of surgical stapling.

5. What is the primary disadvantage of surgical staplers?

6. What are the three most common jaw lengths of linear staplers?

7. What type of stapler has two separate halves that are joined together after the tissue is clamped between the jaws?

8. What type of stapler is primarily designed to join two tubular hollow structures within the alimentary tract?

Answers to Self-Test Questions

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1. Monopolar (unipolar).
2. Isolated generators have built-in electrical safeguards that prevent the unit from delivering monopolar current if any area of the electrical pathway is disrupted.
3. (1) The monopolar system uses a pencil-style active electrode, and a separate patient ground plate or pad that serves as the inactive electrode. The current flows from the active electrode, through the patient, following the path of least resistance, until it reaches the inactive electrode. The inactive electrode may be some distance from the active electrode, but should be placed as closely as possible to the surgical site. The current then flows from the ground pad back to the ESU.

   (2) In a bipolar system, the instrument delivering the current must be a 2-pronged instrument, such as a thumb-forceps. One prong of the instrument serves as the active electrode, delivering the current; the other side serves as the inactive electrode, and conducts the current back to the ESU. A separate patient ground pad or plate is not generally needed when a bipolar is used.
4. Actually conducts the HF oscillating current from the ESU to the tissue chosen by the surgeon.
5. To disperse the HF current flowing through the patient’s body over a wide skin surface area, and then channel it back to the ESU.
6. Coagulation and dessication.

808

1. Any two of the following:
   (1) Nd-YAG.
   (2) Holmium-YAG.
   (3) KTP.
2. The CO_2 laser.
3. The color of the beam.

4. Any three of the following:
   (1) Offer precision and accuracy.
   (2) Provide a dry, bloodless field.
   (3) Provide minimal damage to surrounding tissues.
   (4) Reduce operating time and promote more rapid healing with less scarring.

809

1. It involves freezing the area to be excised. A probe, fully insulated except for the tip, is placed in contact with the desired area, and then the tip is made extremely cold by using a gas refrigerant (usually liquid nitrogen or CO2). The tip is held in place until the area surrounding it freezes; the frozen tissue is then excised. There is very little bleeding either during or after surgery. Cryosurgery can also alter or destroy tissue without excising it.
2. Diathermy.
3. Electrosurgery uses current to heat the tissue; electrocautery uses current to heat the instrument.

810

1. Any three of the following:
   (1) Thrombin.
   (2) Absorbable gelatin sponge.
   (3) Oxidized cellulose.
   (4) MCH.
   (5) Absorbable collagen.
   (6) Silver nitrate.
2. By converting the fibrinogen (a protein) in human blood plasma to fibrin.
3. Absorbable gelatin sponge.
4. To reduce chances of abscess formation or foreign body reaction.
5. MCH; moisture impairs its hemostatic action.
6. Silver nitrate; using a stick with silver nitrate molded on the tip.
7. Bone wax—forms a mechanical barrier. It is spread and compressed over the oozing bone and forms a "waxwall" the blood cannot penetrate.

811

1. They are placed side-to-side along the edges of the highly-vascular scalp flap as the surgeon makes the incision. The clips are left in place throughout the procedure to maintain hemostasis, and then removed as the surgeon closes the wound.
2. To prevent over-stretching the clip before it is applied.
3. Ligating clips have two "legs" that squeeze together when the clip is compressed; they literally "clamp off" small blood vessels, tubular structures (like the bile duct), and nerves.
4. Metals such as stainless steel, titanium, or tantalum; these metals will not corrode and they produce very little tissue reaction when implanted in the body.
5. They have projections at the end of each "leg" to lock together and secure the clip.

812

1. The use of packs or pads (surgical sponges) in surgical cases to control hemorrhage or absorb secretions.
2. To avoid tissue damage to the patient.

813

1. It forms a leak-proof approximation.
2. A noncrushing B-shape. This shape provides a secure approximation while preserving the blood supply to the stapled tissues.
3. A used anvil may misalign and misshape the staples, causing the staple line to leak (or even rupture).
4. Any five of the following:

(1) The amount of time they save.

(2) When using the right stapler, surgeons can ligate, approximate, and anastomose tissue in one or two simple steps.

(3) Staplers require less preparation and handling than multiple sutures.

(4) Using staplers reduces tissue manipulation and handling that, in turn, reduces postoperative inflammation and risk of infection.

(5) By using staples, particularly those positioned in double-row patterns, the surgeon can create a leakproof seal between tissues.

(6) The noncrushing seal created by the B-shaped staples accelerates wound healing and prevents tissue necrosis.

(7) The staples are made from an inert metal and cause little, if any, tissue reaction after implantation.

(8) Using surgical staplers reduces the number of, thereby the risk of losing, needles in a wound and makes needle counts faster and easier.

(9) Skin staples are easier to remove postoperatively than are nonabsorbable skin sutures.

5. Their cost.
6. 30mm, 55mm, and 90mm.
7. A GIA stapler.
8. ILS or EEA stapler.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

20. (807) Which thermal hemostasis method is *most* commonly used in the operating room?
    a. Laser.
    b. Electrocautery.
    c. Bipolar electrosurgery.
    d. Monopolar electrosurgery.

21. (807) In a monopolar system, the inactive electrode is usually
    a. a separate patient ground plate or pad.
    b. at the tip of a pencil-like handpiece.
    c. one side of a pair of forceps.
    d. not necessary.

22. (808) What primarily determines how well specific tissues absorb a laser's beam?
    a. Color of the beam.
    b. Shape of the beam.
    c. Voltage of the beam.
    d. Amperage of the beam.

23. (808) Which of these is an advantage to using surgical lasers?
    a. They promote rapid healing with less scarring.
    b. Lasers generate no smoke to block the surgeon's view.
    c. They generate wide beams that warm extensive areas of tissue.
    d. The gas blows blood and fluid out of the way to keep the surgeon's view clear.

24. (809) Which method of hemostasis involves freezing the tissue to be excised?
    a. Diathermy.
    b. Cryosurgery.
    c. Hypothermia.
    d. Argon coagulation.

25. (810) Silver nitrate is
    a. a styptic.
    b. a thermal hemostatic agent.
    c. prepared from regenerated cellulose.
    d. used to control bleeding from bony surfaces.

26. (810) A topical hemostatic agent often saturated with normal saline or thrombin before use is
    a. protamine sulfate.
    b. oxidized cellulose.
    c. absorbable gelatin.
    d. microfibrillar collagen.

27. (811) When, if ever, are scalp clips (such as Raney or Leroy clips) usually removed?
    a. As the surgeon closes the wound.
    b. After the surgeon enters the skull.
    c. They are left in the wound to absorb.
    d. They are left in the wound to permanently ligate the vessels.

28. (811) Some ligating clips have small serrations on the inside surface to
    a. lock the ends of the two legs together.
    b. keep the clip from slipping after application.
    c. prevent the clip from falling out of the applicator.
    d. allow the tissue to granulate and encapsulate the clips.

29. (811) When passing a loaded ligating clip applier to the surgeon, how should you hold the applier to prevent the clip from bending and falling out of the jaws?
    a. Hold the applier by one of the shafts, above the ring handle.
    b. Hold the applier by the box lock and avoid squeezing the handles.
    c. Hold the index finger of the passing hand over the tip of the applier jaw.
    d. Put your thumb and fingers through the ring handles to hold the jaw open.

30. (812) What type of sponges should be used inside of a patient?
    a. Dry sponges.
    b. Non-radiopaque sponges.
    c. Sponges moistened with saline.
    d. Sponges moistened with water.

31. (813) What is the main advantage of the capital B shape that *most* surgical staples are bent into after passing through tissues?
    a. Prevent eversion of approximated tissues.
    b. Prevent inversion of approximated tissues.
    c. Preserve blood supply to the stapled tissues.
    d. Eliminate the flow of blood to wound edges, stopping hemorrhage.

32. (813) The *most* noticeable advantage of surgical staplers is that they
    a. save much time.
    b. save much money.
    c. are easy to use and require no special training.
    d. allow misplaced staples to be easily removed and replaced.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Wound Closure

EFFECTIVE WOUND CLOSURE is one of the most important aspects of any surgical procedure. For wounds to heal properly, the wound edges must be held together until the body's natural healing process can restore enough strength to withstand stress without additional support. We use a number of products to approximate wounds, including sutures, surgical staples, and non-suture wound closure products. The surgeon chooses the wound closure materials, and how these materials are used. As a surgical technician, one of your most important jobs is to assist the surgeon with wound closure. To anticipate the surgeon's needs and contribute to the smooth flow of an operation, you need to understand why and when the different types of wound closure materials are used. Since your main role is to supply the surgeon with the necessary materials, you must also know how to properly prepare and handle the different types of wound closure materials.

The purpose of this unit is to provide you with basic knowledge of wound closure materials and techniques. The lessons in this unit will discuss the different types, characteristics, and uses of sutures, suture needles, and nonsuture wound closure products. We'll also look at how these materials are selected, how you should prepare and handle them on the sterile field, and common suturing techniques used for tissue approximation.

3–1. Suture and Other Wound Closure Materials

The use of linen and animal gut fibers to tie off severed blood vessels and close wounds dates back several centuries; their use is even recorded on ancient Egyptian documents. However, it was not until the early nineteenth century that physicians truly began to investigate the mechanism of wound healing and began experimenting with various materials for wound closure. Since then, advances in science and surgical technology have revolutionized the development of suture materials and wound closure techniques. Now, surgeons have a broad variety of suture materials to choose from, each designed for a particular type of tissue and purpose. As a scrub or circulator, you need to know the types and characteristics of commonly used suture materials, the factors that determine which materials the surgeon will select, and how different sutures are used in the body.

814. General suture terms, characteristics, and selection factors

We start with the basic suture terms, general characteristics, and selection factors.

Suture terms

Like many other aspects of your job, there is a special "language" you must learn to fully understand the lessons in this text and to effectively communicate with other surgical team members.

Suture

Suture is a multi-purpose word. We use it to describe the strands of material used to sew wounds closed, or to ligate (tie) blood vessels or other tubular structures. We refer to a suture-needle combination as a suture. We also use it to describe the action of sewing the wound together.

No matter what type of material is used, suture is a foreign body when implanted in human tissue. The body responds to the introduction of this foreign substance by secreting enzymes, which attack and attempt to breakdown the suture material. Sutures that are dissolved or digested by these enzymes and other chemical processes are called absorbable sutures. Since absorbable sutures will break down and be absorbed, they are considered temporary sutures.

Some suture materials are not digested by tissue enzymes. These are referred to as nonabsorbable sutures. When implanted in body tissue, the body usually encapsulates, or walls-off, nonabsorbable sutures until they are physically removed. When used for skin closure, nonabsorbable sutures are removed postoperatively. Because nonabsorbable sutures are not broken down in the body, they are considered permanent. Absorbable and nonabsorbable sutures are also classified as either monofilament or multifilament.

A monofilament suture is made of a single strand of material; it usually resembles common fishing line. Monofilament sutures resist harboring microorganisms and are frequently used to close infected wounds. They also tie down smoothly and provide a strong knot. Because of their construction, monofilament sutures are more susceptible to damage than multifilament sutures. Crimping or crushing the strand causes a weak spot that can lead to suture breakage.

Multifilament sutures consist of several filaments twisted or braided together. This type of suture is usually easier to handle and tie than monofilament suture, but the variations in the twisting or braiding process used during manufacture causes knot strength to fluctuate. Because multifilament sutures are composed of many filaments, the microscopic spaces between the filaments can provide a breeding ground for microorganisms and act like a "lamp wick," allowing infected body fluids a pathway to travel between tissue layers. This "wicking" action is referred to as capillarity (or capillary action). All multifilament sutures exhibit some capillarity, though many are specially treated or coated to reduce it.

Size and tensile strength

The size of a suture refers to its diameter. Sutures are sized according to a numerical scale with zero as a starting point. Whole numbers above zero are used to denote the size of large diameter sutures. Small diameter sutures (below size 0) are identified using a series of zeros (0s). The larger the whole number above zero, the larger the diameter of the suture strand. Therefore, a #5 suture is larger in diameter than a #1 suture. On the other end of the sizing scale, a suture smaller than 0 (we say "size oh") is identified by multiple 0s; the more 0s in the series, the smaller the diameter of the suture. The series of 0s can be represented in two ways: by writing out the 0s in a chain or by using a hyphenated number to abbreviate this chain. For example, a size 0000 suture can be abbreviated 4–0 (we say "four-oh"); it is much smaller in diameter than a suture that is size 0.

If you are still confused, the simple sizing scale illustrated in the following table should help clear up the mystery:

Suture Sizing Scale

Smaller									Larger
5–0	4–0	3–0	2–0	0	#1	#2	#3	#4	#5

The largest diameter suture usually found in the operating room (OR) is #5 (which is closer to rope than suture). Heavy sutures such as these are generally nonabsorbable, and are only used when significant strength is required to combat the stress put on the wound postoperatively. Sutures can also be as thin and wispy as the filaments of a cobweb. Some sutures used by ophthalmologists and microsurgeons are as small as 11–0 or 12–0; we use them under a microscope, as they are barely visible to the naked eye. These sutures are so small they will actually float in the air currents within the OR.

Tensile strength of a suture refers to the measured force in pounds (tension) the suture will withstand before it breaks when knotted. Generally, the smaller the diameter, the less tensile strength a strand of the same type suture has. Surgeons generally try to use a suture with the same relative tensile strength as the tissue in which it is used. That is why smaller diameter sutures are used on delicate tissues, such as the peritoneum, intestinal walls, and blood vessels. In other words, surgeons use the smallest diameter suture possible that provides sufficient strength to hold the tissues together until they heal. The smaller the suture used, the less tissue trauma caused by the passage of the suture through the tissue, and the less foreign body introduced into the body to trigger a response. Using smaller diameter sutures placed closely together decreases the possibility of dead spaces in the wound. This decrease, in turn, reduces the incidence of abscess formation and serious wound infections.

Absorption rate

Absorption rate applies exclusively to absorbable sutures. It refers to the length of time it takes the body to breakdown and completely absorb the suture. The absorption rate and how long the suture retains its tensile strength are two factors used to gauge the performance of absorbable sutures *in vivo* (in the living body). The rate an absorbable suture loses its tensile strength is not the same as its absorption rate. A suture may lose its tensile strength after only a few weeks, but it may take months for it to be absorbed. Ideally, it retains enough tensile strength to hold the wound together during the vital first stages of the healing process, and then is rapidly absorbed.

Characteristics of an ideal suture

No suture material, whether absorbable or nonabsorbable, can satisfy all the surgeon’s needs. However, if you know the characteristics and “ideal suture,” you can better understand why the surgeon selects a particular suture material for a particular operation. The “all-purpose suture” would have the following qualities:

- Could be used on any type of surgical procedure. The only variable would be the size, which would depend on the tensile strength required to hold the wound edges together effectively.
- Would be sterile.
- Would be noncapillary (nonwicking), nonallergenic, noncarcinogenic, nonmagnetic, and nonelectrolytic.
- Would be easy to handle and tie.
- Would cause minimal to no tissue reaction. It would not harbor or serve to aid microbial growth.

- Won't cut into the tissue or fray when knotted.
- Would not shrink after implantation.
- Would be absorbed after serving its purpose, and would cause minimal tissue reaction during absorption.

Minimum suture characteristics

Because the ideal suture material does not exist, the surgeon selects one to meet as many of the ideal qualities as possible. The selection must have the following minimum characteristics:

- Any suture used to approximate wound edges must have a high-uniform tensile strength, which allows for use of smaller sizes.
- The suture strands must be consistently uniform in size.
- The suture must be pliable enough to allow for ease of handling and good knot security.
- The performance of the suture *in vivo* must be predictable. In other words, the absorption rate and decline in tensile strength, over a given period of time, must be consistent enough to allow the surgeon to estimate how long the suture will serve its purpose after implantation.
- The suture must also be free of impurities and irritating substances, and must be made of a material that will cause the least amount of tissue reaction.
- The suture must be sterile and packaged in a ready-to-use form.

Selection of an appropriate suture material for use on a particular surgical procedure involves careful consideration of several factors.

Factors determining suture selection

The type of suture a surgeon selects will be the one that best promotes healing of the wound after numerous factors are taken into consideration. These factors include, but are not limited to:

- The biological characteristics of the material in relation to the wound healing process. This takes into consideration such things as absorbability versus nonabsorbability, the wicking properties of the material, and the potential reactivity of the suture once it is implanted in the tissue.
- The healing properties of various tissues. If the surgeon is going to approximate tissues that are permanently weakened by surgery or that heal slowly (i.e., the skin and fascia), a nonabsorbable suture will most likely be chosen to provide adequate support until the tissue regains enough strength to hold the wound edges together without mechanical support. If the suture will be placed in rapidly healing tissue (i.e., the bladder, colon, or stomach), an absorbable suture will probably be used because the material will lose its tensile strength at approximately the same rate the healing tissue gains strength.
- The presence of an active infection, wound contamination, or drainage. Implanting foreign bodies, such as sutures, in an infected, contaminated, or draining wound can result in the formation of tissue granulomas (tumor-like masses of hardened scar tissue), rejection of the suture material, and formation of sinus tracts between tissue layers.
- The overall physical condition and health of the patient. Patients, who are elderly or overweight, or who have chronic illnesses (such as diabetes) or other debilitating conditions, will heal more slowly. Thus, the suture materials selected must be able to support the wound longer to compensate for the additional healing time.
- The physical characteristics of the suture material. The surgeon will consider the potential trauma caused by the suture as it is drawn through the tissue, the ease of handling, and the suture's ability to hold a secure knot.
- The size and location of the incisions or wounds. If a surgeon is concerned with obtaining a cosmetic closure, this will definitely affect his or her choice of sutures. For example, a plastic

surgeon performing small wound repairs on the face or legs of a patient would definitely want to use a suture that would result in minimal scarring. On the other hand, postoperative scarring would be a relatively minor concern during closure of an abdominal wound on an elderly patient because that area is normally covered by clothing. Larger wounds generally require the use of sutures that are larger in diameter and retain their tensile strength longer because of the additional physical stress placed on the approximated tissues.

- The training and experience of the surgeon.
- Most surgeons, especially when they first enter practice, will use the same basic suture materials and techniques they were taught during their residencies. As they gain more experience using various suture materials, read more scientific literature, and compare the advantages, disadvantages, and performance of various materials; they will most likely begin to change their suture preferences.
- The availability and cost of suture material. Sutures are extremely expensive and are too often wasted. Do your part for fraud, waste, and abuse control, and help your doctors develop "conservative" habits and attitudes. At the same time, be careful not to open any more sutures than the surgeon actually needs to complete the operation, and handle them properly so you'll not have to throw them out before they are used.

Now that we have covered some of the basic background material, it's time to take a look at some specific types of suture material.

815. Absorbable sutures

As we mentioned earlier, absorbable sutures are those that are dissolved, digested, and eventually absorbed in the body as the result of the action of tissue enzymes and other chemical processes. There are several different kinds of absorbable sutures widely used today. These absorbable suture materials can be broken down into two basic categories—natural and synthetic.

Natural absorbable sutures

Natural absorbable sutures are made from processed animal collagen (a protein substance found in white fibers of connective tissue). They can be used in all types of tissue and in the presence of an infection. The rate of absorption varies depending on the factors we previously discussed: the type and condition of the tissue the suture is used in, the type and biological properties of the suture material, and the overall physical condition of the patient. Natural absorbable sutures are usually packaged in a chemical solution that is mostly alcohol. This packing solution keeps the suture moist and pliable. To retain the pliability of these sutures before implantation, the sutures should be used as soon as possible after removal from the package. If the suture has been exposed to the air for an extended period, pliability can be restored by dipping the suture material in warm sterile saline or water before use. Rinsing the sutures to remove the alcohol packing solution is not necessary, except when these sutures are used in the eye. Natural absorbable sutures include plain surgical gut, fast absorbing plain gut, chromic, and collagen sutures.

Plain surgical gut (catgut)

Absorbable plain gut consists of processed ribbons of highly purified collagen derived from the submucosal layer of sheep intestine or the serosal layer of beef intestine. These ribbons are electronically spun and polished into a monofilament-like strand of uniform diameter. Plain gut suture is yellowish-tan and usually comes packaged as a single 54-inch strand designed to be cut into usable lengths. It is also packaged as a 54-inch strand wound on a disposable plastic reel, and in packages containing multiple precut strands.

Plain gut causes moderate tissue reaction when implanted in the body and is absorbed fairly quickly. On an average, it loses tensile strength within 7–10 days after implantation and is completely absorbed within 70 days. Because plain gut loses its tensile strength so quickly, it is used mainly in rapidly healing tissues and in areas of the body not subjected to postoperative physical stress. It is most commonly used to approximate the subcutaneous fat layer during abdominal wound closure and for tying off superficial subcutaneous bleeders during the initial incision. Plain gut is also used to suture mucous membranes in the nose and to suture the conjunctival tissue in the eye during ophthalmological surgery.

Fast absorbing plain gut

This type of surgical gut is specially heat-treated, plain "catgut." The heat treatment speeds up the loss of tensile strength and reduces the time it takes for this type of suture to be absorbed. Fast-absorbing gut is used primarily for epidermal (skin) suturing where sutures are needed to hold the tissues together for only 5 – 7 days. When this type of suture is used, the surgeon places several interrupted sutures in the skin and covers the closed wound with a strip of skin closure tape placed lengthwise over the incision. When the tape is removed 5–7 days later, the underlying suture is sufficiently dissolved so the knots and suture on the outside of the skin will lift off with the tape. Fast absorbing gut has less tensile strength than plain gut suture of comparable size. As a result, this type of suture should never be used internally because it will not hold tissue together long enough to allow them to heal properly.

Chromic gut

Chromic gut is simply plain surgical gut that has been specially treated with a chromium salt solution. This treatment conditions the suture to resist breakdown by tissue enzymes and, subsequently, prolongs the absorption rate to over 90 days. The chromic treatment process alters the color of the gut suture from a yellowish-tan to a dark brown and makes it less inflammatory than plain gut. Chromic gut suture retains its tensile strength anywhere from 10 to 14 days, with some tensile strength remaining up to 21 days after implantation in tissue. Because this type of gut retains its tensile strength longer than plain gut, surgeons use it in tissues that heal relatively slowly and need support for a longer period of time. You'll see chromic gut routinely used to suture the fascia and peritoneum during abdominal wound closure. It is also used to ligate vessels and suture uterine tissues during hysterectomy procedures and to suture tissues in and around the kidneys and ureters during urological surgery. Chromic gut sutures are most often packaged as single, 54-inch-long strands and as individual sutures with swaged-on surgical needles. One major drawback of chromic gut suture is its tendency to fray when tied or handled excessively.

Collagen suture

Collagen suture is a type of surgical gut manufactured from the pure collagen fibrils found in the flexor tendons of beef cattle. Collagen suture may be manufactured as plain, untreated strands or as chromic-treated strands. Both the plain and chromic collagen sutures look very much like their surgical gut counterparts, except the strands are sometimes dyed blue to enhance their visibility. The beef tendons used to make the strands are chemically treated and purified to remove noncollagenous materials. This treatment results in a suture that has physical properties superior to plain or chromic surgical gut suture. Because collagen suture is made from a material that is pure protein, it tends to flatten out when tied into a knot. This makes it particularly suited for use in eye surgery because the surgeon does not want to leave large, bulky knots that can cause excessive irritation in the delicate eye tissues. Collagen suture produces minimal tissue irritation, is absorbed at a uniform rate over a 56-day period, and holds a secure knot up to 10 days. After 10 days, the suture retains only about 10 percent of its original tensile strength.

Although natural absorbable sutures are still used for a wide variety of applications, synthetic absorbable sutures are becoming more popular among surgeons from many different specialties.

Synthetic absorbable sutures

These absorbable sutures are manufactured from polymers (chemical compounds formed from many molecules) of lactic acid, glycolic acid, or polyester poly (p-dioxanone). Synthetic absorbable sutures are extruded into strands of uniform diameter, and may be either dyed or undyed (most are dyed to enhance visibility). Manufacturers supply synthetic absorbable sutures in monofilament or braided strands.

Synthetic absorbables retain a high-tensile strength during the critical early stages of the healing process, and they are then rapidly absorbed. They are broken down by a chemical process known as hydrolysis, in which water molecules present in the tissue fluid penetrate and split the chemical bonds between the molecules of the polymer. Enzymes are not required to break down the polymer chains; only water is required. Consequently, synthetic absorbable sutures exhibit a lower degree of tissue reaction than surgical gut sutures. They are commonly used for suturing or ligating tissues where an absorbable suture is desirable, but they are not used for prolonged approximation of tissues subject to continual postoperative stress. They can be used on virtually any kind of tissue, and they may be used in the presence of infection.

One of the major disadvantages of using synthetic absorbable sutures is they tend to drag as they pass through tissues, making suturing more difficult. Because of this, manufacturers coat some types of synthetic absorbable suture with chemical compounds that reduce the drag. Another disadvantage is the tendency for knot slippage, which necessitates special tying techniques. Synthetic absorbable sutures are packaged dry and should always be used dry. They should never be soaked in saline or water before use because this reduces the suture material’s tensile strength. Remember, water initiates the breakdown of the material.

Polyglycolic acid

Polyglycolic acid suture (Dexon), a synthetic absorbable suture made from a polymer of glycolic acid, was the first synthetic absorbable suture. It is a braided suture material that comes either dyed green or in an undyed tan color. Strands of polyglycolic acid suture are smaller in diameter than gut sutures of comparable tensile strength. A special chemical coating is placed on the surface of certain types of polyglycolic acid suture to reduce the friction as the suture is drawn through the tissue. This surface coating becomes slippery when it contacts body fluid and almost completely disappears from the tissues within 7 hours. When the coated sutures are used, the surgeon must put additional “throws” (half knots) in the suture and must cut the ends above the knot longer than those normally left on the uncoated suture to ensure the knot will not slip. Polyglycolic acid suture loses nearly 50 percent of its original tensile strength after 14 days in the tissue and is almost completely absorbed after 30 days. It comes packaged in various forms, including single long strands, multiple precut strands, reels, and strands with swaged-on surgical needles.

Polyglactin 910

This synthetic absorbable suture is made from polymers of lactic and glycolic acid. Both of these acids occur naturally in the human body as by-products of normal metabolic processes and are excreted in the urine. Polyglactin 910 (commercially known as Vicryl) retains its tensile strength longer than plain surgical gut and polyglycolic acid suture. After 14 days *in vivo*, polyglactin retains approximately 60 percent of its original tensile strength and 30 percent of its strength after 21 days. Absorption of this suture material is minimal until about the 40th day, and absorption is essentially complete within 60 to 90 days. Polyglactin sutures are usually dyed violet to enhance visibility in the tissues, but they also come in an undyed tan color. They are manufactured as uncoated monofilament strands or as braided strands coated with a special chemical compound designed to reduce drag through the tissue.

The coating used on polyglactin 910 suture is different from that used on polyglycolic acid suture. It is a mixture composed of equal parts of polyglactin 370 (another polymer containing lactic and glycolic acid) and calcium stearate. This coating combination produces an excellent absorbable, adherent, non-flaking lubricant. The lubricating property of the coating provides for smooth passage through the tissue, precise knot placement, and smooth tie-down. The absorption rate and tensile strength of the polyglactin 910 suture is unaffected by the coating, which is absorbed into the tissue with the suture material. Coated polyglactin sutures may be used in the presence of infection because of their monofilament-like construction. The suture material comes packaged in a variety of lengths and configurations, with or without attached needles. The uncoated, violet-colored, monofilament polyglactin 910 suture material is most often used in ophthalmic surgery. The coated, braided suture is used for a wide variety of purposes, including eye surgery.

Polydioxanone suture

Polydioxanone suture (PDS) is a synthetic monofilament absorbable suture material prepared from the polyester poly (p-dioxanone). It is extremely useful where the combination of an absorbable suture and extended wound support is desired. PDS retains approximately 70 percent of its original tensile strength 14 days after implantation, 50 percent of its strength after 28 days, and 25 percent of its strength after 42 days. This type of synthetic absorbable suture provides wound support nearly twice as long as the other synthetic absorbables. Absorption is minimal until about the 90th postoperative day and is essentially complete within 6 months.

PDS causes very little tissue reaction and, because of its monofilament construction, may be used in the presence of infection. It is often used for abdominal and thoracic wound closures, colon and rectal surgery, plastic surgery wound closures, and approximating subcutaneous tissue. PDS suture is available as clear strands and as strands dyed violet to enhance visibility in tissues. It comes in many sizes, shapes, and configurations, just like the other sutures we have discussed.

Poliglecaprone 25 (Monocryl)

Like PDS, Monocryl is a synthetic absorbable monofilament suture. It is particularly useful when the surgeon wants strong wound support for a short period of time. Monocryl maintains 50%–60% of its initial strength for the first 7 days, but rapidly weakens; all strength is gone in about 21 days. Monocryl causes almost no tissue reaction because it is essentially made from an inert substance. It is used primarily for soft tissue closure, such as subcutaneous closure. It is not usually used in cardiac, vascular, neuro, or microsurgical procedures.

816. Nonabsorbable sutures

Nonabsorbable sutures include any suture material not absorbed or digested by tissue enzymes, and that does not hydrolyze in body tissues. Because of this, when placed in exposed superficial tissues (i.e., the skin or the eye), nonabsorbable sutures must be removed postoperatively after healing is nearly complete. When placed in deeper body tissues, nonabsorbable sutures become encapsulated or permanently surrounded by tissue. Nonabsorbable sutures are available in single or multifilament strands formed by spinning, twisting, or braiding. They can be dyed or undyed, and coated or uncoated; they may be treated with chemical substances to reduce their capillarity (wicking) properties.

Nonabsorbable sutures are used in tissues that heal slowly and require additional support during the healing process to resist the physical stress placed on them. Like the absorbable sutures, nonabsorbable suture materials can be divided into two categories—natural and synthetic. The most common nonabsorbable suture materials are silk, cotton, stainless steel, nylon, polyester, and polypropylene.

Natural nonabsorbable sutures

Natural nonabsorbable sutures are made from organic fibers or minerals. They include those made from refined silk, cotton, and surgical stainless steel.

Surgical silk

Of the natural nonabsorbable sutures, silk is by far the most widely used. Surgical silk is manufactured from the filaments spun by the silkworm larva in making its cocoon. The filaments, which are cream- or orange-colored in their raw state, are processed to remove the natural gums and waxes. The silk fibers are then twisted or braided into multifilament strands, dyed, scoured, stretched, and impregnated with special waxes to reduce their drag. Braided strands are preferred by most surgeons because of their ease of handling, increased tensile strength, and knot-holding ability. Since untreated silk has capillary action, it is chemically treated to reduce this property. Although most surgical silk sutures are dyed black to enhance their visibility in tissues, some are dyed white. Surgical silk loses tensile strength when moistened, so it should always be used dry.

Silk is not a true nonabsorbable suture. Studies have shown that implanted silk sutures lose most of their tensile strength after 1 year and that they usually break down and are completely absorbed after 2 years. Silk sutures cause moderate tissue reaction, give excellent support to wounds during the early stages of the healing process, and can be used in many different tissues. Silk sutures are commonly used for ligating and suturing in general, and for ophthalmic and plastic surgery, but they are not recommended for use on tissues of the biliary or urinary tract because they can cause the production of stones. Two of the most common uses of silk are approximation of the serosal layer of the intestines and closure of the fascia.

Silk sutures come in a variety of lengths, sizes, and packaging configurations. The most common configurations are 18- and 30-inch strands packaged in multi-strand packs, continuous reels, and multi-suture packs with swaged-on gastrointestinal (GI) needles. The most frequently used sizes are 0, 3–0, and 4–0. Since silk sutures are multifilament sutures; they are not used in the presence of infection.

Virgin silk

Virgin silk sutures consist of natural silk fibers drawn together and twisted to form delicate, small-diameter strands (8–0 and 9–0) for use in ophthalmic surgery. The natural gum on the raw silk fibers is not removed, as it is during the processing of braided silk sutures, and serves to hold the twisted fibers together. Virgin silk sutures are usually white, so the eye surgeon may ask for some methylene blue dye on the sterile field to temporarily dye the suture to make it more visible in the tissue. You dye the suture by placing a drop of methylene blue in the suture pack before removing the suture.

Cotton

Surgical cotton is made from individual Egyptian cotton fibers that are combed, aligned, and twisted into a strand. Before the strands can be used, they must be chemically purified and processed to remove natural waxes, gums, vegetable protein matter, pigments, and foreign mineral matter (sand). The final bleaching process produces white strands. The strands are coated to produce a smooth surface over the cotton fibers; this makes them easier to handle, reduces fraying, and lowers the drag through the tissues.

Cotton sutures are the weakest nonabsorbable sutures. Unlike silk sutures, cotton sutures gain tensile strength when moistened; therefore, they should always be moistened prior to use. Cotton sutures handle and tie much like silk sutures, and they can be used in most body tissues. However, they are not used as much as silk sutures because the strands tend to fray and separate, and they have a lower tensile strength than similarly sized silk sutures. After implantation in tissue, cotton loses approximately 50 percent of its tensile strength within 6 months, but it retains 30 to 40 percent of its strength at the end of 2 years. Cotton sutures cause minimal tissue reaction and will remain encapsulated within the tissue after the healing process is completed. Very few surgeons use cotton sutures anymore.

Surgical stainless steel

Surgical stainless steel sutures are the most inert (nonreactive) and strongest suture available. They are made from 316L (“L” for low carbon) stainless steel alloy, which is compatible with stainless steel implants and prostheses. Stainless steel sutures are available in monofilament or twisted multifilament strands. Even though they have a very high-tensile strength and cause no tissue reaction, surgical stainless steel sutures are not often used because they are very difficult to handle. Stainless steel sutures tend to kink and bend very easily. When steel sutures are kinked, bent, twisted, or knotted, metal fatigue may develop and cause the suture to weaken and perhaps break. Because the sutures are stiff and “springy,” they are easily contaminated when passed to the surgeon or during suturing. Sharp ends and barbs on the sutures will easily puncture or tear surgical gloves, causing contamination of the suture and possible injury to members of the surgical team. Steel sutures will tend to “saw” through the tissue. This action damages the tissue and may result in poor approximation of wound edges due to the loosening of the sutures.

Steel sutures hold knots very well. Because they are inert and have high-tensile strength, wire sutures are useful for closure of infected wounds and for approximating tissues subject to great postoperative stress. Wire sutures are often used for closure of the fascia and retention sutures in large abdominal incisions, particularly when the patient is obese. In chest and cardiovascular surgery, steel sutures are used to approximate the cut edges of the sternum and wire ribs together. Stainless steel sutures are also used in orthopedic surgery to wire bone fragments together and repair the torn or severed ends of tendons; these sutures minimize scarring, which could inhibit tendon function. Fine wire sutures can be used for skin closure, especially if the wound is infected or contaminated.

Wire sutures are packaged and sized differently than other sutures. Because kinking and bending can cause metal fatigue and weaken the sutures, large diameter steel sutures are packaged in long cardboard or tubular plastic containers. Smaller diameter sutures are usually packaged in a loose coil. Stainless steel wire sutures are sized by two different systems. One system is the same USP sizing scale used for all other sutures. The other system is the Browne and Sharpe (B&S) scale. On the B&S scale, wire is sized by gauge: the smallest diameter wire is 40 gauge and the largest diameter is 18 gauge. Suture manufacturers usually label all surgical stainless steel suture packages with both the B&S gauge and the USP diameter size classifications. The following table shows the USP and B&S equivalents:

Surgical Stainless Steel Wire Gauge Equivalents

Diameter (inch)	USP	B&S
.0031	6–0	40
.0040	6–0	38
.0056	5–0	35
.0063	4–0	34
.0080	4–0	32
.0100	3–0	30
.0126	2–0	28
.0159	0	26
.0179	1	25
.0201	2	24
.0226	3	23
.0253	4	22
.0320	5	20
.0360	6	19
.0400	7	18

Synthetic nonabsorbable sutures

Synthetic nonabsorbable sutures are made from several different chemical polymers and are available in monofilament and multifilament strands. Many are coated with special compounds that facilitate handling and lessen the suture’s drag through the tissue. Synthetic nonabsorbable sutures are often used by surgeons instead of natural nonabsorbable sutures, such as silk, because they offer certain advantages. For example, synthetic nonabsorbable sutures cause less tissue reaction and have a higher tensile strength than comparably sized silk sutures. They will not lose tensile strength when implanted in tissue as do silk or cotton. Because they are nonreactive and easier to handle than stainless steel wire sutures, synthetic nonabsorbables often are used in place of wire to approximate tissues in infected wounds and in high stress areas of the body.

Even though there are definite advantages associated with the use of synthetic nonabsorbable sutures, there are also some disadvantages. When compared with silk sutures, synthetic nonabsorbables are more difficult to handle. They usually require more throws in knots to ensure knot security, and the monofilament strands have a tendency to return to their original coiled packaging configuration. This is known as “memory” and is basically the same characteristic exhibited by some disposable wrapping materials. The materials most commonly used in the manufacture of synthetic nonabsorbable sutures are nylon, polyester fibers, and polypropylene.

Surgical nylon

Most nylon sutures are extruded into noncapillary monofilament strands (Ethilon and Dermalon). Nylon sutures are also available as braided multifilament strands (Nurolon and Surgilon), which either are uncoated or are coated with *silicone* to reduce drag through tissues. Sutures made of nylon have very high-tensile strength and cause very little tissue reaction. Although considered nonabsorbable, nylon sutures (monofilament and braided) gradually break down and lose tensile strength after implantation, at a rate of about 15 – 20 percent per year, due to slow hydrolysis. Nylon sutures are used for the same applications as silk sutures. They are not used where indefinite wound support is required due to their tensile strength degradation. The various types of nylon sutures (uncoated monofilament, and coated and uncoated multifilament) have distinct characteristics and uses. Monofilament nylon, like many other synthetic nonabsorbable sutures, is somewhat difficult to handle because of its “memory,” lack of pliability, and the tendency for knots to slip. Wetted monofilament nylon is more pliable and easier to handle than the dry strands right out of the package, so it’s a good idea to dip nylon sutures in warm saline before use. To prevent knots from coming apart, the surgeon uses additional throws and probably leaves the tails above the knots a little longer than with other types of suture. Monofilament nylon sutures are non-capillary and are available in strands that are clear, or dyed blue, black, or green. Small diameter sutures (the smallest is 11–0) are often used in ophthalmic surgery and microsurgery because of their strength and elasticity. Larger size monofilament nylon sutures are commonly used for skin closure, particularly in plastic surgery where cosmetic closures are desired. Heavy monofilament nylon (#1 and #2) is often used for retention sutures on large abdominal wounds.

Multifilament nylon is tightly braided, usually dyed black, and specially treated to reduce capillary action. It looks, feels, and handles much like braided silk, but it is stronger and causes less tissue reaction. It is used for ligating and suturing the same tissue that braided silk would be used on. Some braided nylon sutures are coated with silicone, which helps reduce the suture’s drag through tissue.

Polyester

This synthetic nonabsorbable suture is made from polyester fibers closely braided into a multifilament strand. The sutures are available in uncoated and coated strands that are white, or dyed green or blue. Polyester sutures are very flexible, pliable, and easy to handle, and they cause minimal tissue reaction. They have a high-tensile strength that will not decline after the sutures are implanted. Like silk, polyester sutures will become encapsulated in fibrous tissue. But unlike silk, they will not be absorbed, even after years in the body, and will not be weakened by wetting. Next to surgical stainless steel, polyester sutures are the strongest nonabsorbable sutures available. Because they retain their tensile strength, are easy to handle, and cause minimal tissue reaction, polyester sutures are frequently used on cardiovascular and thoracic surgical procedures.

Uncoated polyester sutures (Mersilene and Dacron) have a high friction coefficient and drags when passed through tissue, causing a “sawing” effect. Because of this, manufacturers have developed different coatings to make the suture easier to handle and reduce tissue damage. There are three chemical substances commonly used as coatings on polyester sutures: polybutilate, polytetrafluoroethylene (commonly known as Teflon), and silicone.

1. Polybutilate is a highly adherent, biologically inert, nonabsorbable compound that acts as a lubricant to ease passage of the suture through the tissues. Polybutilate was the first coating developed specifically as a surgical lubricant. It is a polyester material that strongly adheres to untreated polyester fibers. Sutures treated with this coating not only pass smoothly through tissues, but also tie very easily. Polybutilate-coated polyester suture is used mainly for vessel anastomosis and placement of prostheses in cardiovascular surgery.
2. Teflon coating is either bonded to the surface of polyester suture strands or impregnated in the spaces between the braided fibers. Unlike the polybutilate coating, Teflon tends to flake off the suture and, because it will not dissolve, may cause foreign body granulomas. Teflon-coated polyester suture is also primarily used in cardiovascular and thoracic surgery.
3. Although silicone provides a slippery coating, it does not bond very well to polyester suture. Consequently, the silicone can rub off on the tissue as the suture is tied. Polyester suture, coated with silicone, is available under the trade name Ti-Cron and, like the other coated sutures just discussed, is mainly used for heart, vascular, and chest surgery.

Polypropylene

This type of suture is made from polymers of propylene extruded into clear or blue-pigmented monofilament strands. The suture is not absorbed, nor is it subject to weakening or degradation by tissue enzymes. Like polyester, steel, and cotton sutures, polypropylene will become encapsulated after implantation in tissue. It is the most inert synthetic nonabsorbable suture and, next to surgical stainless steel, causes the least amount of tissue reaction of any suture material. Polypropylene sutures are easier to tie and they hold a knot better than most other synthetic monofilament sutures (such as nylon) because they are manufactured with a process that enhances pliability.

Polypropylene sutures will not adhere to tissue and are, therefore, often used as pull-out sutures for tendon repairs. Because polypropylene causes very little tissue reaction, it is recommended for use where the least possible tissue inflammation is desired. A true monofilament, polypropylene suture is ideally suited for use in infected or contaminated wounds to eliminate or minimize later sinus formation and suture extrusion from the tissues. Polypropylene sutures are manufactured under the trade names Prolene and Surgilene. They are used mainly for skin closure, blood vessel anastomosis, orthopedic and plastic wound closures, and in microsurgery. Polypropylene sutures are often used in place of stainless steel sutures where long-term support of healing tissues is required.

817. Suture needles

In this lesson, you'll learn about desirable needle characteristics, the materials surgical needles are made from, the various parts and design features of surgical needles, and the advantages of swaged-on needles.

Selecting the proper needles to use during surgical wound closure is just as critical to the success of an operation as the selection of the proper suture materials. Carelessness or casual selection of needles can prolong suturing efforts and increase operative and anesthesia time. It can also lead to unnecessary tissue damage, increase the risk of postoperative wound infection, and result in poor approximation of tissues. The primary purpose of the surgical needle is to carry sutures through tissues. Since needles must be able to do this in a variety of tissues and body areas, there are certain characteristics they should have.

Desirable needle characteristics

To approximate tissues effectively and enhance wound healing, all surgical needles, regardless of their specific design, must have the following characteristics:

- Be stable when clamped in a needle holder.
- Carry suture through tissues with minimal trauma.

- A smooth surface and designed to create the smallest diameter puncture wound possible. Ideally, the needle used to carry a given size suture should be as close to the diameter of the suture as possible.
- Be sharp enough to penetrate tissues with minimal resistance. The surgeon should never need to force the needle into and through tissue, no matter how heavy the tissue is.
- Be rigid enough to resist breaking, but flexible enough to bend before breaking.
- Be made of a corrosion-resistant material and sterile to prevent introduction of contaminants and microorganisms into the wound.

Now that you know what surgeons look for in a surgical needle, let's find out how manufacturers meet these requirements.

Needle composition

The best surgical needles are made from high-quality, heat-treated stainless steel. The use of carbon steel is avoided because it has a tendency to corrode, leaving pits that can harbor microorganisms. Heat treating the stainless steel adds strength to the metal and gives it flexibility or malleability (the ability to bend under a load without breaking). Despite the fact that good surgical needles are designed to bend before breaking, they will eventually break if too much force is applied. When a surgeon feels a needle bending, it should be a signal that excessive force is being used. So that needles will penetrate and pass smoothly though tissue, they are made with finely honed points and their surfaces are electropolished to remove imperfections. Some manufacturers apply a thin layer of silicone to the metal to further reduce the needle's drag through the tissue. Silicone coatings are not used on ophthalmic needles because they would leave residues in the cornea.

Parts of a surgical needle

Surgical needles come in many different shapes and sizes, each designed for a specific use. No matter what the intended use, all surgical needles have three basic components used in needle classification: the attachment end, body, and point.

Attachment end

The attachment end of surgical needles is designed to cause as little trauma as possible when drawn through tissue. Most suture needles are "swaged" or attached directly to the suture (fig. 3–1, C). Needles that are not swaged, often called free needles, attach to the suture by the needle's eye. The needle eyes are either closed or French (sometimes called spring or split eye). Closed eye needles (fig. 3–1, A) resemble common household sewing needles. They have round, oval, or square enclosed eyes. French eye needles (fig. 3–1, B) have a slit from inside the eye to the end of the needle that connects a series of V-shaped notches, which catch and hold the suture in place. Closed eye needles are threaded the same way you would thread a household needle—by pushing the end of the suture through the eye. French eye needles require the suture to be "snapped" into the V-shaped notches.

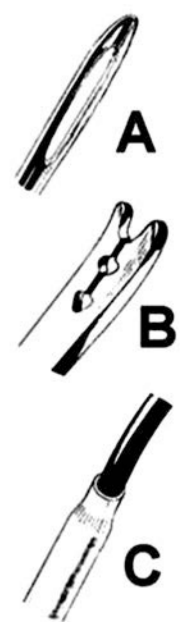


Figure 3–1. The attachment ends of suture needles.

Eyed needles, which must be threaded, present the disadvantage of having to pull a double strand of suture through the tissues. This double strand causes a great deal of trauma by creating a tract through the tissue that is considerably larger in diameter than a single suture strand. Another drawback to using eyed needles is the additional time required for scrub personnel to thread them. If you have ever worked with a surgeon who likes to use nothing but threaded sutures for a large abdominal wound closure, you can well appreciate how hard it is to thread needles fast enough to keep up with the surgeon and his or her assistant. Yet another disadvantage of eyed needles is their tendency to come unthreaded during passing and use. The scrub can minimize the chance that the suture comes unthreaded by tying or double-threading it, but this only increases the bulk of suture material that must be drawn through the tissue. To eliminate these disadvantages, suture manufacturers developed eyeless needles (fig. 3–1, C), which are attached (swaged) directly to the suture.

Today, most of the needles used in surgery are swaged onto sutures by the manufacturer. Most swaged or eyeless needles have a hole drilled in the end of the shaft opposite the point for insertion of the suture. Some swaged-on needles have a channel instead of a hole. The drilled hole (or channel) is closed around the end of the suture during the swaging process. Each hole or channel is specifically designed to accommodate the size suture swaged into it. By swaging needles directly onto the suture, a continuous unit is formed that is convenient to use and minimizes tissue trauma.

Swaged connections

There are two types of swaged-on needles:

1. The permanently swaged needle, which is firmly attached to the suture strand and must be cut off the suture before tying.
2. The semiswaged or controlled-release needle that is firmly attached to the suture strand, but can be removed from the suture with a sharp tug, straight back from the point of attachment. Before pulling the needle free from the suture, the surgeon grabs the strand just below the needle to prevent tearing the tissues the suture is implanted in. Controlled-release needles are commonly used in situations where the surgeon anticipates using several interrupted sutures of the same kind, in rapid sequence. They are often used to suture ends of the bowel together (when stapling devices are not used) and for suturing hernia defects.

Swaged-on needles are attached to sutures in either single-armed or double-armed configurations. As the name implies, a single-armed suture has a needle attached to one end of the strand. Double-armed sutures have a separate needle attached to each end of the strand. Some double-armed sutures have the same size and type needle swaged to each end, while some have a different size or type needle at each end. Double-armed sutures are commonly used in ophthalmic surgery, cardiovascular surgery, and microsurgery. They allow the surgeon to place a suture, and then approximate tissues on either side of the original suture. This suturing technique is often used during the anastomosis of two tubular structures.

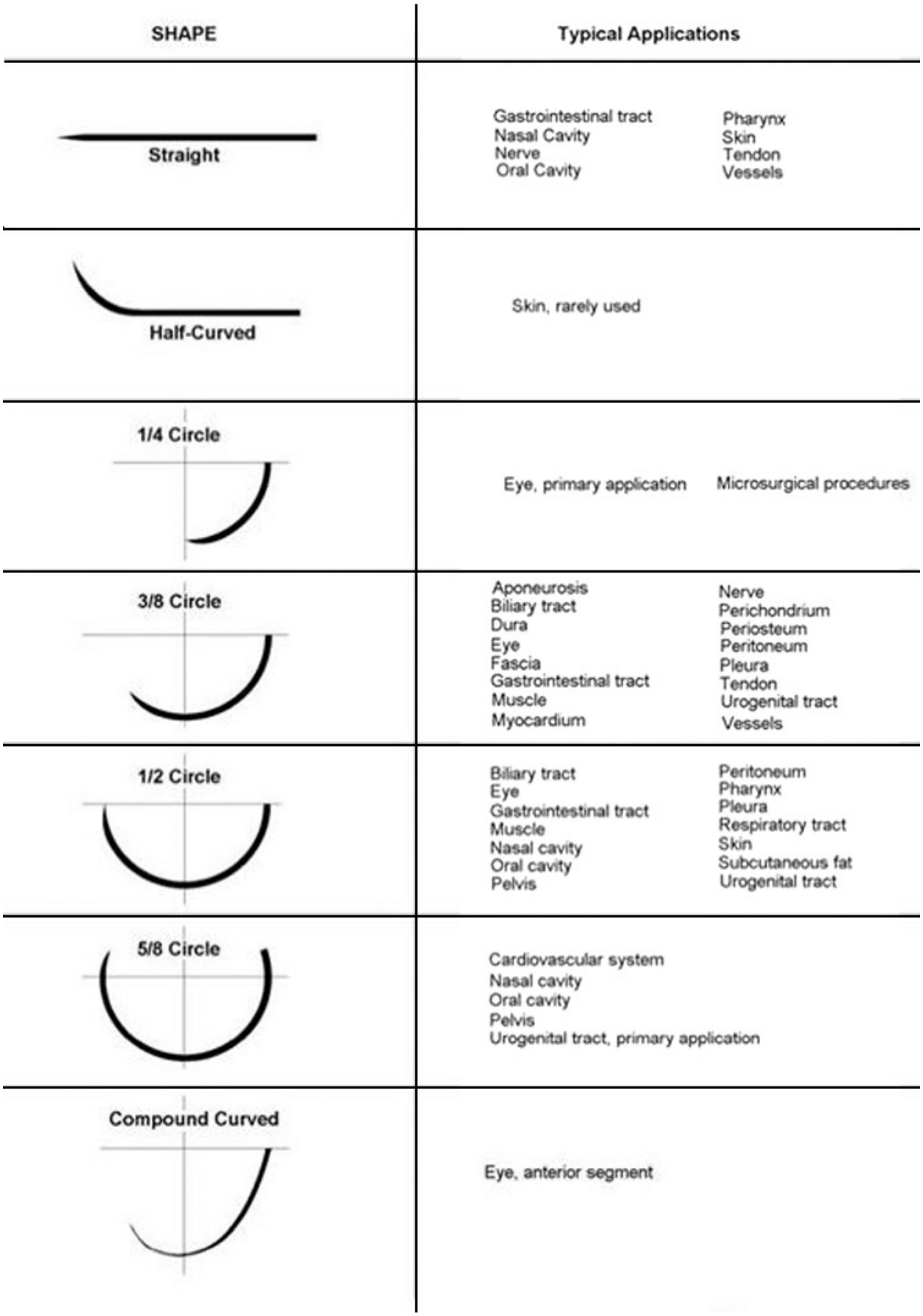
Body

The body or shaft of a surgical needle is the area where the needle is grasped. Needle shafts vary in wire gauge (diameter), shape, length, and finish, depending on the type, size, and location of the tissues they are designed to be used on. Generally, large gauge, thick-shafted needles are designed to be used for suturing heavy or tough tissue, such as muscle or fascia. Thinner needles are used on more delicate tissues, such as peritoneum, GI structures, and skin.

Needle shafts may be round, oval, side-flattened rectangular, triangular, or trapezoidal. Many needles are manufactured with special longitudinal ribs from the point to the eye or swaged-on end to improve the grip of a needle holder and to prevent the needle from twisting when it is passed through tissues. The longitudinal shape of the needle (from point to eye or suture attachment) may be straight, curved, half-curved, or compound-curved. These curves of the needles will vary depending on the types of tissue and anatomical location. Figure 3–2 illustrates basic needle body shapes and their typical applications in different body areas and tissues.

Straight needles

These needles may be used when the tissue is easily accessible. Most of these needles are designed to be finger-held and are used for suturing tissues on or near the surface of the body. The most common of the straight needles is the Keith needle. This needle is a straight, cutting edge needle primarily used to close the skin on abdominal wounds. Keith needles are also occasionally used to create purse string sutures for securing the ends of bowel to an intraluminal surgical stapling device during bowel resections and anastomoses. Taper point milliner needles may be used for placing interrupted sutures during GI surgery.Some microsurgeons prefer straight needles for nerve and blood vessel repair.



SHAPE	Typical Applications
Straight	Gastrointestinal tract, Nasal Cavity, Nerve, Oral Cavity, Pharynx, Skin, Tendon, Vessels
Half-Curved	Skin, rarely used
1/4 Circle	Eye, primary application; Microsurgical procedures
3/8 Circle	Aponeurosis, Biliary tract, Dura, Eye, Fascia, Gastrointestinal tract, Muscle, Myocardium, Nerve, Perichondrium, Periosteum, Peritoneum, Pleura, Tendon, Urogenital tract, Vessels
1/2 Circle	Biliary tract, Eye, Gastrointestinal tract, Muscle, Nasal cavity, Oral cavity, Pelvis, Peritoneum, Pharynx, Pleura, Respiratory tract, Skin, Subcutaneous fat, Urogenital tract
5/8 Circle	Cardiovascular system, Nasal cavity, Oral cavity, Pelvis, Urogenital tract, primary application
Compound Curved	Eye, anterior segment

Figure 3–2. Needle body shapes and typical applications.

Half-curved needles

These needles look like a straight needle with a bent or curved end (half the needle body is straight and the point half is curved, hence the name). Half-curved needles are primarily designed for skin closure. They are seldom used because they are difficult to handle and cause too much tissue trauma. The curved tip of the needle passes easily through the tissue, but the straight half is unable to follow the curved path of the tip without bending the needle body or enlarging the tract through the tissue.

Curved needles

Most of the needles you'll prepare and see used are classified as curved needles. Due to their curved shape, curved body needles can be used in smaller, tighter spaces than straight needles and require far less tissue manipulation during use. The curvature of the needle shaft may be 1/4, 3/8, 1/2, or 5/8 of a circle. The length of the arc in degrees determines the needle curvature. Needle holders must always be used for curved needles.

Use of needles with a curvature equal to 1/4 of a circle is limited to ophthalmic and microsurgery procedures. These needles are almost straight or flat, and are designed to take very shallow "bites" into the tissue.

The most commonly used curved needle is the 3/8 circle. These needles can be manipulated in relatively large and superficial wounds with only a slight twist of the wrist. However, because they require a larger arc of manipulation and do not penetrate as deeply into tissue as do similarly sized needles with greater curvatures, 3/8 circle needles are unsuited for use in deep cavities or confined areas. You'll see 3/8 circle needles used most often for suturing the skin.

A 1/2 circle needle is the needle of choice for use in deeper body tissues because the needle tip will turn out of the tissue in a more limited space (due to its shorter arc of manipulation). Use of a 1/2 circle needle requires a more exaggerated twisting of the wrist to push the needle through the tissue and expose the point. The majority of the needles used to suture internal body structures are 1/2 circle needles.

Sometimes, even a 1/2 circle needle will not provide a tight enough arc of manipulation to expose the point adequately once the needle is passed through the tissue. If not enough of the point is exposed, the surgeon will not be able to grasp it and pull the needle the rest of the way through the tissue. This may happen whenever the surgeon is trying to suture in deep body cavities or tight spaces, such as the bottom of the pelvic cavity or the back of the throat. In these instances, the use of a 5/8 circle needle (occasionally called a "horseshoe" needle because of its shape) normally provides the surgeon a smaller arc of manipulation and causes more of the needle point to be exposed. You'll probably see 5/8 circle "horseshoe" needles used most often on urogenital procedures, such as bladder suspensions and on intraoral/ENT procedures.

Compound-curved needles

Compound-curved needles have a very tight curvature at the point end of the needle that gradually lessens throughout the rest of the body. (They look a little bit like a common fish hook without the barbed point.) These needles were originally developed for ophthalmic surgery and are mainly used to suture the anterior portion of the eye, particularly the region where the cornea meets the sclera. This unusual needle shape allows precise, short, deep bites into the tissue, which enables the surgeon to place sutures equidistant from the wound edges. This is very important in cornea surgery because unequal spacing of the suture on either side of the wound could result in postoperative distortion of vision caused by the uneven pull of the sutures on the cornea.

Point

The point on a surgical needle extends from the extreme tip of the needle to the area of the body widest in diameter. The design and sharpness of the needle point are just as important to effective tissue approximation as the shape and size of the needle body; therefore, suture manufacturers make every effort to match needle points with a particular body shape.

Each point is designed and honed to the degree of sharpness required for smooth penetration of a particular type of tissue. There are three basic point designs: cutting, tapered, and blunt. Figure 3–3 shows point and body shape combinations, and their typical applications.

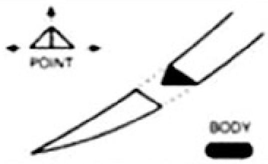
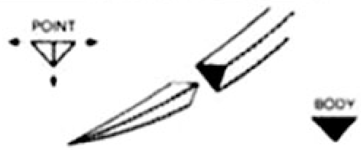
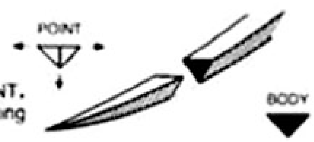
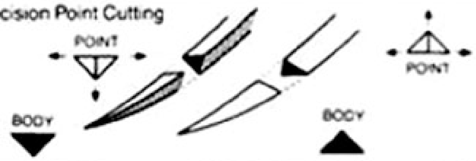
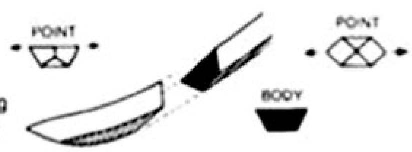
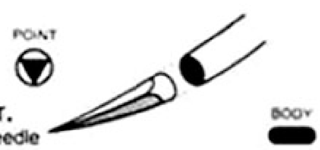
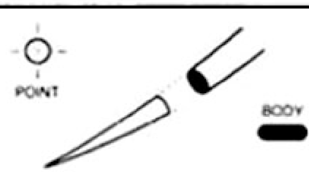
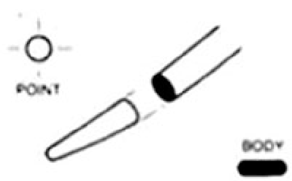
Needle Point and Body Shape		Typical Application
Conventional Cutting		Ligament Nasal cavity Oral cavity Pharynx Skin Tendon
Reverse Cutting		Fascia Ligament Nasal cavity Oral mucosa Skin Tendon sheath
MICRO-POINT. Reverse Cutting Needle		Eye
Precision Point Cutting		Plastic or cosmetic procedures Skin
Side-cutting Spatulated		Eye, primary application Microsurgical procedures Reconstructive ophthalmic procedures
TAPERCUT. Surgical Needle		Bronchus Calcified tissue Fascia Ligament Nasal cavity Oral cavity Ovary Perichondrium Periosteum Pharynx Tendon Trachea Uterus Vessels, sclerotic
Taper		Aponeurosis Biliary tract Dura Fascia Gastrointestinal tract Muscle Myocardium Nerve Peritoneum Pleura Subcutaneous fat Urogenital tract Vessels
Blunt		Blunt dissection through friable tissue Kidney Liver Spleen Uterine cervix for ligating incompetent cervix

Figure 3–3. Needle points and typical applications.

Cutting

All cutting needles have at least two opposing cutting edges. These edges are ground and polished so they will cut through tissue that is tough and difficult to penetrate, such as skin, muscle, tendons, cartilage, and the sclera of the eye. Cutting needles can be further subdivided into specific categories based on the configuration of the cutting surfaces:

Cutting Needles	
Categories	**Explanation**
Conventional cutting	These needles have two opposing cutting edges, along with a third cutting surface on the inside curvature of the triangular tip on curved needles. The triangular configuration of the tip changes to a flattened shape approximately one-third to one-half of the way back from the needle tip on curved and straight needles to allow for better grip with a needle holder or by the fingers. Curved conventional cutting needles are prone to cut out tissue since the inside cutting edge cuts toward the edges of the incision or wound.
Reverse cutting	These needles differ from conventional cutting needles in the third cutting edge is located on the outside portion of the curved needle body. In addition, the needle body is triangular shaped all the way from the sharpened tip to the eye. This design offers the advantage of having a flat surface closest to the wound edges as the needle passes through the tissue. This greatly reduces the chances of cutting the tissue between the needle and the wound edges, and leaves a wide margin of tissue between the needle holes and the wound edges to tie the suture against. Because a flat surface of the triangular body is on the inner (concave) curvature and the needle body cross-section does not flatten out beyond the tip, reverse cutting needles are stronger than similarly sized conventional cutting needles. They are better able to resist the force a surgeon places on the inner curvature of the needle when passing a needle through the tissue using a forehand twisting motion and are, therefore, less likely to bend or break. The flat base on the inner curvature also offers additional stability of the needle in the jaws of the needle holder. Many surgeons use reverse cutting needles to cut through extremely dense tissue, such as thick skin, tendon sheaths, fascia, and oral mucosa. Large reverse cutting needles are frequently used for placement of retention sutures (used to support extensive abdominal incisions).
Side cutting	These needle manufacturers have combined the characteristics of reverse cutting and taper tip needles. This design is commonly referred to as a trocar point (Ethicon Tapercut point). Three cutting edges extend back from the point approximately $_{1/32}$ of an inch and blend into a round, tapered body. This type of point readily penetrates tough, dense tissue, while the tapered round body provides smooth passage and eliminates the danger of a full cutting edge cutting further into the surrounding tissue. Trocar tip needles were originally designed for use in cardiovascular surgery to suture sclerotic, calcified tissue. They are now used by many surgeons for suturing dense, fibrous connective tissue, such as fascia, periosteum, and tendons.

Taper

Taper tip needles are sometimes referred to as round needles although in reality they are round only in the portion just behind the tip. The round portion of the body tapers to a very sharp point at the tip. The remainder of the body, beyond the rounded portion extending to the eye, flattens into an oval shape. Flattening out the needle body and increasing the cross-sectional width enables the needle to be gripped more firmly in the jaws of a needle holder and helps prevent twisting of the needle as it passes through the tissue. Taper point needles are preferred when the smallest possible hole in the tissue and minimum tissue trauma are desired. Taper point needles leave a hole no larger than the diameter of the needle, so they are particularly useful for suturing intestinal anastomoses. (The small holes the taper point needles make help prevent leakage of bowel contents into the abdominal cavity.) Taper point needles are used primarily on soft, easily penetrated tissues, such as peritoneum, abdominal viscera, myocardium, dura, and subcutaneous fat. Heavy-duty taper tip needles are also commonly used to approximate fascia in abdominal wound closures, and specially designed heavy gauge taper needles are routinely used for closing dense tissue during gynecological surgery and hernia repairs.

Blunt

Blunt tip needles have a taper body with a rounded point that will not cut through tissue. They are designed for suturing delicate, friable (easily torn) tissues, such as those found in the liver, spleen, and kidneys. Rather than piercing tissues, the blunt tip needle actually dissects its way through the tissues. In addition to the uses already mentioned, large blunt tip needles are also used to pass heavy suture ligatures around the cervix during Shirodkar procedures (the operation designed to correct the condition of an incompetent, flaccid cervix).

Other features

As we mentioned before, surgical needles vary in size and wire gauge (diameter). What we did not mention was how needles were measured and sized; let’s cover all there is to know about needle sizing, along with a couple of other unique features you may see on some surgical needles. As we discuss these additional features, refer to figure 3–4. This figure provides an overall look at the anatomy of a needle and summarizes the features we previously discussed, along with the ones we are about to cover.

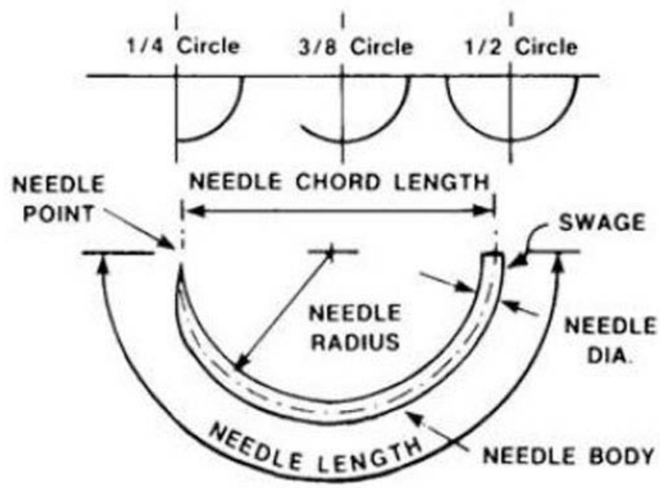


Figure 3–4. Anatomy of a suture needle.

Chord length

This is a measurement of the straight line distance from the point of a curved needle to the swage or top of the eye. This distance may vary from approximately 2mm to over 2 inches (50.8mm).

Needle length

The distance measured along the needle body, from point to swaged end or eye, is the actual needle length. Straight needles vary in length from 2mm to around 31/2 inches (88.9mm). Curved needles range from 2.5mm to 33/4 inches (95.25mm).

Radius

If the curvature of the needle was continued around to form a complete circle, the radius would be the distance from the center of the circle to the needle body. The radius of surgical needles varies from 1mm to 11/8 inches (28.5mm).

Diameter

The diameter of a needle is the thickness or gauge of the needle body. This can vary from approximately one-thousandth of an inch (.001 inches) to a little over one-twentieth of an inch (approximately .05 to .06 inches). Fine gauge needles are required for microsurgery. Large gauge needles are needed to penetrate the sternum and several layers of tissue during placement of retention sutures.

Ribbed needles

One of the biggest problems associated with using curved surgical needles is the tendency for them to twist, turn, or rock in the jaws of a needle holder as they are passed through tissue. To reduce this problem, some needle manufacturers have incorporated longitudinal ribs or grooves into the inside and outside curvatures of the needle body. These longitudinal ribs are situated perpendicular to the serrations found on many needle holders and provide a cross-locking action when the needle holder jaws are clamped firmly on the needle body. The use of ribbed needles allows for more versatility with regard to where the needle holder can be clamped on the needle shaft without fear of slipping. Ribbed needles can be positioned at almost any angle to the needle holder jaws for optimum maneuverability in different body areas. Small, heavy-gauge ribbed needles are often used in hernia repairs and orthopedic surgery.

Side-flattened needles

As you may have noticed, most needles are flattened in the area of the body where the needle holder is supposed to be positioned to improve the contact between the needle and the needle holder jaws. In addition to this, some needles also have flat sides, a condition that gives the needles a square cross-section. By flattening the sides, the strength of the needle can be increased without increasing the diameter of the needle. This process allows needle manufacturers to reduce the wire diameter (gauge) of the needles so they are even closer to the diameter of the suture. This provides two advantages. First, it allows the suture strand to fill the swage needle hole more easily than a rectangular or oval body needle. Second, it helps reduce the size of the hole created in the tissue by the passage of the needle, thereby reducing tissue trauma and necrosis.

Advantages of swaged-on needles

The following list is some of the more important reasons why atraumatic, swaged-on sutures have all but replaced the old eyed needles and threaded sutures:

- By using swaged-on needles, the scrub does not need to decide what needle to select from the needle book or rack because only certain needles are attached to certain suture materials by the manufacturers.
- Swaged-on sutures require minimal handling and preparation, which eliminates suture stretching, cutting, or threading that tended to compromise the physical integrity and strength of suture materials.
- Because the sutures do not need to be threaded into an eye on the needle, there is almost no chance they will separate from the needle during passing or use (i.e., unless you mishandle a controlled release suture and inadvertently pull the needle off!).
- If a swaged needle is dropped, either on or off the sterile field, it is easier to find and pick up due to the suture remnant attached to it.
- The use of swaged-on sutures has virtually eliminated the need to sharpen and resterilize surgical needles, skills that all surgical specialists had to perfect back in the “old days.”
- The use of the controlled release (semiswaged) needles facilitate rapid placement of interrupted sutures. This makes it easier for the scrub to keep up with the rapid pace of wound closure; it also reduces surgical and anesthesia time. The net effect lessens the risk to the the surgical patient

- The use of swaged-on needles reduces tissue trauma because there is no eye to make the hole in the tissue larger than the suture; there is no double strand of suture that must be pulled through the tissue; and a new, sharp needle is used nearly every time a suture is placed, so the risk of using a dull, burred, or corroded needle is eliminated.

818. Nonsuture wound closure materials

The staplers we covered in the last unit are often classified as nonsuture wound closure materials. We covered them in the last unit because they are most frequently used during the procedure, not while closing. Two types of stapling devices we touched on, however, are nearly exclusively used for wound closure, so we will cover them now in more detail.

Skin and fascia staplers

As we said in the previous unit, surgical staplers are designed to be used on specific types of tissue in specific areas of the body. One of the most frequently used types of staplers is the skin stapler.

Several companies manufacture disposable suture "guns" specifically designed for approximating skin edges. These devices have become so popular that surgeons seldom use "old-fashioned" suture for routine closures, especially abdominal closures. The guns are made primarily of plastic and are available in prepackaged, sterile units that contain anywhere from 15 to 55 staples. Staplers containing 25 to 35 staples are the most commonly used for medium size abdominal wounds. The staples are placed gently across the union of the skin edges that are held together and slightly elevated by an assistant. The assistant uses two pairs of fine-toothed forceps to hold the opposing skin edges together immediately in front of the spot the surgeon will apply each staple. Some assistants may use one forceps that "pinches" the skin edges together between the forceps jaws. A third method of approximating skin edges for stapling involves applying tension to either end of the incision so the edges actually come together by themselves. In this method, tension can be applied using an Allis clamp or a skin forceps.

As you should recall, and as figure 3–5 shows, skin staples bend into a rectangular shape after penetrating the tissue. This configuration holds the skin edges together and minimizes the rotation of the staples. It also minimizes the tissue compression, postoperative edema, and "railroad tracks" (skin crosshatching) that often result when sutures are used.

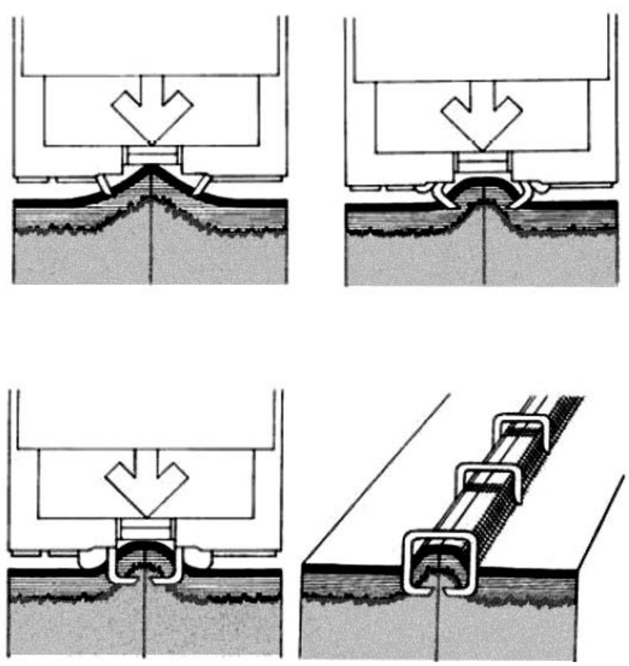


Figure 3–5. Application of skin staples.

One manufacturer offers a dual-purpose reusable stapler that uses cartridges designed for skin or fascia stapling. The skin staples for this device are basically the same as the ones on the disposable staplers, but the disposable cartridges do not hold as many staples as some of the disposable skin staplers. The fascia staples come in a special cartridge that bends the top part of the staple down against the tissue, forming a kind of figure-eight pattern instead of the rectangular pattern formed by the skin staples. This figure-eight shape keeps the tissue edges from everting and adds strength to the staple line.

After approximately seven to ten days, a patient's wound is considered to be sealed well enough for any sutures or staples to be removed. There may be times when you will be asked to remove sutures or staples whether in the clinic or in the OR. The guidelines below will prepare you for performing suture or staple removal:

- Wash your hands, open your suture or staple removal kit, and don clean gloves.
- If applicable, remove the dressings and properly dispose them.
- For suture removal, lift the knot of the suture away from the skin with a pair of forceps. Clip beneath the knot with scissors to release the suture (fig 3–6A and fig. 3–6B). *Use caution to avoid pinching or cutting the skin around the wound when clipping the suture.*
- After pulling the suture through the skin, inspect it to see that it appears whole; any parts of suture left under the skin can cause inflammation as it is considered a foreign body.
- If the skin stays well approximated, continue removing the remaining sutures.
- For staple removal, a staple removal device or a hemostat can be used for extraction (fig. 3–6).
- Place the lower jaw of the staple remover under the staple, making certain that the tip is all the way under the staple. Close the handles, causing the upper tip of the remover to depress the center of the staple and both ends of the staple to be bent upward simultaneously, exiting their insertion sites in the dermal layer.
- If using a hemostat, point the closed tips of the clamp upwards, slide it underneath the staple, and slowly open the tips until the skin is free.
- Lastly, separate any instrumentation requiring processing. Discard all disposable items, remove gloves and wash your hands.

As a reminder, regardless of in the clinic setting or in the OR, sterile technique must be applied to decrease the risk of infection.

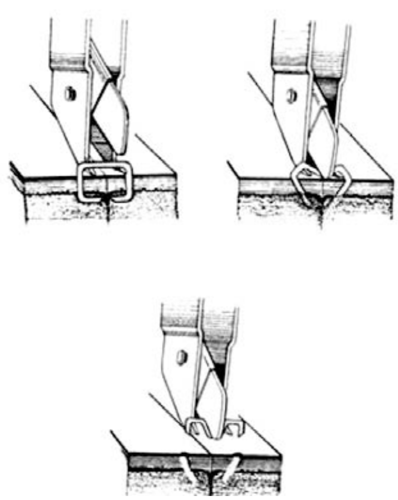


Figure 3–6. Removal of skin staples.

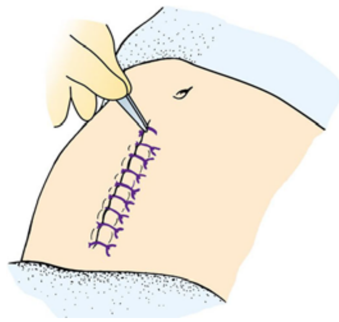


Figure 3–6A. Removal of suture.

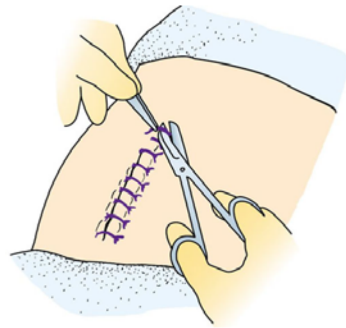


Figure 3–6B. Removal of suture.

Other nonsuture materials

In addition to the surgical stapling devices that we previously described, there are many other nonsuture devices and products used to facilitate wound closure. Among these devices and products are surgical meshes, skin closure strips, collodion, umbilical tapes, and bone cement.

Surgical meshes

Surgical meshes are used to reinforce or bridge defects in fascia and other body tissues. They are most often used to reinforce weakened areas of the abdominal wall in the inguinal area during repairs of recurring hernias. Surgical meshes can be easily cut to any shape the surgeon desires. They can be sutured in place under tissue edges to create a smooth, porous matrix that allows for ingrowth of tissue. The ingrowth of tissue creates a strong wound closure by increasing the tensile strength of the mesh. Surgical meshes are made from many different synthetic materials. The most commonly used meshes are made from polyester fiber, polypropylene, and, occasionally, stainless steel.

Polyester mesh

Polyester mesh is made from woven multifilament fibers of polyester fabric (the same material used in polyester sutures). It is very strong, pliable, and porous. The additional porosity afforded by the multifilament fibers provides an excellent matrix for ingrowth of tissue. Sheets of polyester mesh come in various sizes, and may be sterile or nonsterile. Nonsterile sheets should be cut to approximately the right size, and then sterilized according to the manufacturer’s directions (usually steam sterilization). Unused portions of the mesh should not be resterilized. Since this mesh is made from multifilament fibers that tend to wick fluids, it is not used to reinforce infected wounds.

Polypropylene mesh

This mesh material is made from knotted monofilament polypropylene fibers. It is elastic, very strong, causes minimal tissue reaction, and will not unravel when cut. Polypropylene mesh is available in precut, small sterile sheets or in larger unsterile sheets. Sheet sizes range from 21/2-by–4 to 9-by–14 inches. Polypropylene mesh should be sterilized using conventional gravity displacement sterilization. It should never be flash sterilized, and unused portions should not be resterilized more than once. High temperature or repeated sterilization of the mesh reduces its tensile strength. Because it is made from monofilament fibers, polypropylene mesh is ideally suited for reinforcing infected or grossly contaminated wounds.

Polytetrafluoroethylene mesh

This type of mesh is made from manmade materials and comes already sterile in a package. The mesh may be oval or square in shape. It is smooth on one side and ribbed on the other. This facilitates the grafting of muscle fibers or fascia on the ribbed side (providing stabilization to weak muscle tissue on hernia repairs), while the smooth side inhibits tissue attachment (helping to prevent unwanted adhesions on tissue such as the spermatic cord on a conventional hernia repair, or the intestines or peritoneum if used in a laparoscopic hernia repair). Because of these properties, this mesh is ideal for laparoscopic hernia repairs

Stainless steel mesh

This type of mesh looks like a sheet of window screening material. It is available as nonsterile 6-by–12-inch or 12-by–12-inch sheets. Stainless steel mesh is virtually nonreactive in tissue and may be used in the presence of infection. Because it is made from metal filaments, it is rather stiff and more inflexible than the other meshes available. The wire filaments that stick out from the edges of the mesh can easily puncture a glove, so wearing a second pair of gloves (double set) is advisable. Steel mesh should not be bent or folded because this weakens the metal filaments and may cause them to break after implantation. The broken filaments could then protrude into tissues surrounding the implant site and cause the patient postoperative pain and discomfort. Since the mesh is made from metal, wire scissors should always be used to cut the mesh to the desired shape. Do not pass the surgeon a regular pair of suture scissors! Cutting the mesh with these scissors dulls and scratches the cutting surfaces. Stainless steel mesh should be steam-sterilized.

Skin closure strips

Skin closure strips (Steri-strips, Ethistrips, etc.) are basically small strips of sterile, adhesive surgical tape mounted on a piece of cardboard. These strips are made from several different materials (including nylon, rayon, and polypropylene) and come in different widths and lengths. The most common size strips are 1/8-, 1/4-, or Y2-inch wide, and 1Y2 to 4-inches long. The strips are supplied in presterilized peel-back packages, a feature that allows for aseptic presentation on the sterile field.

Surgeons may use skin closure strips in place of sutures or staples to approximate the edges of skin to achieve a fine closure with minimal scarring. Skin closure strips are often used along with skin sutures or staples to close small gaps in the tissue between the sutures or staples. They are also often used to hold skin edges together after the surgeon removes the sutures or staples a few days postoperatively. You'll frequently see surgeons use skin closure strips to approximate skin over subcuticular skin closures (hidden skin stitches), approximate skin edges on minor lacerations, and close the skin on pediatric patients. Skin closure strips provide an excellent alternative to staples and sutures for closing the skin on low-stress areas of the body.

Before skin strips are applied, the surgeon may ask for some benzoin or adhesive spray to make the skin tacky and help the strips adhere better. The surgeon may also ask you to cut the strips in half. The simplest way to do this is to leave all the strips on the card they were packaged on and cut the card in half. Both ends of most packing cards have perforated tabs that can be removed to expose just the ends of the strips. Before passing the card to the surgeon, you should always remove at least one of these tabs to facilitate removal of the strips from the card. (Even if you cut the card and strips in half, you'll still have a perforated tab at one end of the card half).

Many surgeons like to use smooth pickups (forceps) to remove the strips from the card to prevent the strips from sticking to their gloves. Small-toothed forceps may also be required to hold the skin edges while the strips are applied. Figure 3–7 shows the steps to applying steri-strips. In instances where the strips are placed over a subcuticular stitch or are used as the primary means of holding skin edges together, the surgeon may request some collodion on the sterile field to paint over the closed wound and skin closure strips.

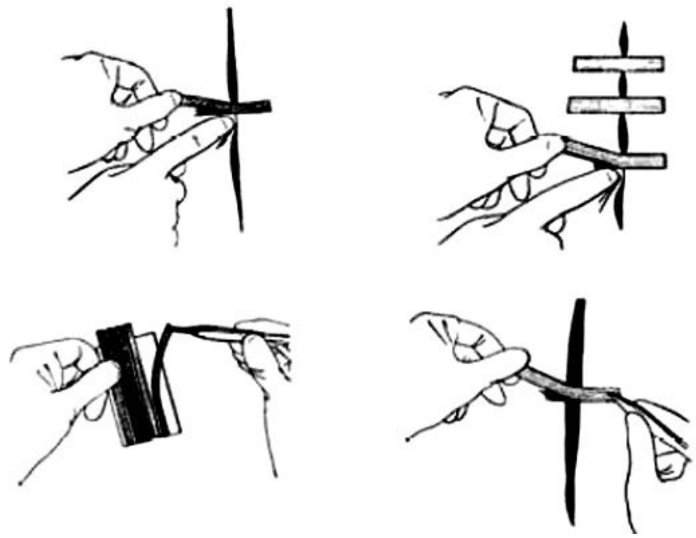


Figure 3–7. Applying steri-strips.

Collodion

Collodion is a thick, clear, volatile liquid that dries quickly to form a see-through protective seal over closed incisions and areas denuded of skin. Bowlers and runners use similar commercial products (Nu-skin, Tuff Skin, Cut Patch, etc.) to make patches over ruptured blisters. Using collodion can be messy if you are not careful; it sticks to almost everything!

To keep the folks in the decontamination room happy and prevent them from having to spend precious time trying to remove a sticky, plastic-like residue from instruments and medicine glasses (an impossible task!), you need to learn a simple way of receiving and handling collodion. Instead of having the circulator pour the collodion into a medicine glass, use an empty suture pack as a container. Cut the open end of the foil packet completely off and keep the sealed end. Clamp a forceps (a straight one is better) onto the sealed end of the package so the jaws are perpendicular to the package. If you do this right, the open end of the foil pouch should be upright when you lay the clamp flat on your Mayo tray. This makes a disposable foil pouch (with a stable base) to use as a receptacle for the collodion. (Ensure you open the end of the cut-off suture packet so the circulator has a big enough "target" to hit when pouring the collodion.) To apply the collodion, the surgeon needs some cotton-tipped applicators, so ensure you ask the circulator for them at the same time you ask for the collodion. There are also commercial plastic spray dressings the surgeon may use over the skin closure strips instead of collodion.

Umbilical tapes

Umbilical tapes are wide strands of white woven cotton that commonly come in 1/8- or 1/4-inch widths. They were originally used to tie off the umbilical cords on newborn infants. Umbilical tapes are also used in cardiovascular and pediatric surgery as traction ties to suspend small vessels and structures.

Umbilical tapes should always be wetted before they are passed to the surgeon. There are three reasons for this. First, the tapes are made from cotton and will become stronger when wetted. Second, the dry cotton fibers may stick to the tissue and cause damage, as well as, leave lint in the wound. Third, dry tapes tend to adhere to bloody surgical gloves, so wetting the tapes makes them easier to handle.

Because they are basically large, absorbent, multifilament sutures, umbilical tapes readily soak up blood and body fluids, and are very difficult to see in a wound. For this reason, all umbilical tapes should be counted, along with the sponges, needles, blades, and instruments. Umbilical tapes are available with a sewn-in radiopaque thread, which shows up on X-ray if the tape somehow gets lost or left in the wound. This is the type you should pass to the surgeon whenever possible.

Bone cement

Bone cement is a synthetic, glue-like substance commonly used to hold orthopedic prostheses (hip, knee, ankle, etc.) in place. It is also used in neurosurgery to fashion skull plates to replace bone destroyed by tissue or trauma (a procedure known as a cranioplasty).

Bone cement is made from a chemical compound called methyl methacrylate, which is formed by mixing two sterile chemical agents together. When combined, these agents form a white, doughy substance that hardens into a dense solid mass in a few minutes (a process similar to mixing the resin and hardener in epoxy cement). The chemical reaction that takes place when the two agents are mixed gives off considerable heat. (In scientific terms, this is called an exothermic reaction.) One of the agents is a clear, highly volatile, caustic liquid that can severely burn exposed tissues and, therefore, should be handled with extreme care. The other agent comes packaged as a white powder. The white powder contains barium sulfate that, as you may recall, is a metal-containing substance used in X-ray diagnostic tests. The two components are usually packaged together in a sterile peel-back wrapper, a feature that allows aseptic transfer to the sterile field. The liquid comes in a large glass ampule and the powder is usually contained in a plastic package.

The scrub technician, or nurse, is responsible for mixing the two chemicals together just before the surgeon is ready to use it. When mixed, methyl methacrylate gives off toxic fumes that are harmful if inhaled. To prevent these harmful fumes from being inhaled by the surgical team and the patient, special vented hoods, or special mixing bowls, are used on the sterile field when the bone cement is mixed.

The mixing bowls or hoods are connected to a suction unit off the sterile field via a sterile connecting tube. The fumes are contained within the hood or bowl, exhausted into the suction system, and vented to the air outside the hospital or into a special charcoal filter. This system is basically the same as the anesthesia machine's scavenging system that we described in the unit on anesthesia. An exhaust hood or similar vapor collection system should always be used when methyl methacrylate is used. The scrub should also wear protective eyewear (as always) and an extra set of gloves (double set) to prevent possible burns from the liquid agent if it should splash into an eye or penetrate a punctured glove. The extra set of gloves also insulates the scrub's hands from the heat generated by the chemical reaction and act as "work gloves" that can be removed after handling the bone cement. You should be prepared by having the extra gloves on the sterile field before they are needed.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

814. General suture terms, characteristics, and selection factors

1. What kind of sutures are dissolved or digested by body enzymes and other chemical processes?

2. What happens to nonabsorbable sutures implanted in body tissues?

3. What type of sutures exhibit capillarity?

4. Which suture has the smallest diameter, a 5–0 or #5 suture?

5. Define tensile strength as it applies to suture.

6. Which suture generally has the greater tensile strength, a 3–0 or 2–0 suture?

7. Define absorption rate.

8. List five characteristics of an ideal suture.

9. Name four characteristics all sutures must possess to be acceptable for use.

10. Identify six factors that determine the type of suture a surgeon selects for use.

815. Absorbable sutures

1. Why are natural absorbable sutures, such as plain surgical gut, packaged in a solution that is mostly alcohol?

2. What substance is plain surgical gut made from?

3. How long will it take a plain gut suture to be completely absorbed by the body?

4. What is fast-absorbing plain gut suture used for?

5. What is chromic gut suture?

6. Why are collagen sutures particularly suited for use in the eye?

7. What chemical process causes synthetic absorbable sutures, such as those made from polyglycolic acid or polydioxanone polymers, to dissolve?

8. Which sutures cause the lower amount of tissue reaction—surgical gut sutures or synthetic absorbable sutures?

9. Which synthetic absorbable suture material comes only in braided strands, loses roughly half of its tensile strength in 14 days, and was the first synthetic material used for absorbable sutures?

10. Which type of synthetic absorbable suture is available in uncoated monofilament or coated multifilament strands, and is completely absorbed after 60 to 90 days *in vivo*?

11. What chemical substances are used to make the coating put on braided polyglactin 910 sutures?

12. Under what circumstances would a surgeon most likely use sutures made from polydioxanone?

13. How long will it take a PDS to be completely absorbed?

816. Nonabsorbable sutures

1. In what types of tissue are nonabsorbable sutures used?

2. Which natural nonabsorbable suture material is the most widely used?

3. Why do surgeons avoid using silk sutures on tissues of the biliary and urinary tract?

4. Briefly describe the differences between regular surgical silk and virgin silk suture.

5. Which natural nonabsorbable sutures are the weakest?

6. What type of stainless steel alloy are wire sutures made from?

7. What may happen to stainless steel sutures that are kinked, bent, twisted, or knotted?

8. What type of wounds would a surgeon close with stainless steel wire suture?

9. Why are large diameter wire sutures packaged in long, straight containers?

10. In addition to the zero sizing scale, what other sizing system is used for wire suture?

11. When compared to silk sutures, why are synthetic nonabsorbable sutures more difficult to handle?

12. Why are nylon sutures sometimes coated with silicone?

13. Why are nylon sutures not used in situations where indefinite wound support is required?

14. What can you do to monofilament nylon sutures to make them more pliable and easier to handle?

15. For what purpose will surgeons often use heavy monofilament nylon sutures?

16. Next to stainless steel wire, which synthetic nonabsorbable suture material is the strongest?

17. Name three special coatings that suture manufacturers put on polyester sutures to reduce their drag through the tissues.

18. Which special coating put on polyester sutures flake off and cause foreign body granulomas?

19. Which synthetic nonabsorbable suture material is manufactured in monofilament strands that are easier to tie and hold a knot better than nylon?

817. Suture needles

1. What are four desirable suture needle characteristics?

2. What material are the best surgical needles made from?

3. What are the two categories of eyed needles?

4. List three disadvantages associated with the use of eyed needles during wound closure.

5. How are controlled release, swaged-on needles removed from a suture stand?

6. What is the difference between a single-armed and double-armed suture?

7. What part of a surgical needle is grasped during suturing?

8. Why do some needles have special longitudinal ribs?

9. What is the most commonly used type of straight needle?

10. In terms of degree of curvature, what is the most commonly used curved needle to suture the skin?

11. What type of curved needle would a surgeon normally use to suture deep body tissues?

12. List the three basic points found on surgical needles.

13. Which type of cutting needle reduces the chances of cutting tissue on the side of the needle hole towards the wound edges? Why?

14. Why do surgical needle manufacturers design taper tip needles with flattened-out oval bodies behind the round point, extending to the needle eye?

15. When would a surgeon most likely use a blunt tip needle with a taper body?

16. Specify five advantages that swaged-on needles have over eyed needles and threaded sutures.

818. Nonsuture wound closure materials

1. What shape are skin staples bent into after passing through the tissue?

2. Why do skin stapler manufacturers design the skin staples and stapling “guns” to bend the staples into a particular shape?

3. When performing suture removal on a patient, where should you clip the suture knot?

4. What instrument is sometimes used to remove skin staples?

5. How does a fascia stapler bend its staples? Why?

6. What are surgical meshes used for?

7. Why is benzoin applied to the skin prior to application of skin closure strips?

8. What should you use to contain collodion?

9. Cite three reasons why umbilical tapes should always be wetted before they are passed to the surgeon.

10. What holds orthopedic prostheses in place and is used to fashion skull plates during cranioplasties?

11. State three precautions you should take as a scrub specialist when handling bone cement on the sterile field.

3–2. Preparing and Handling Suture Materials

In the first section of this unit, we provided you with a great deal of information about various types of suture and suture needles. The purpose of those sections was to familiarize you with the basic characteristics and uses of the most common suture materials you'll encounter during your daily duty performance. Even though you may now have a better understanding of the suture materials you'll be using, you still need to learn how to prepare and handle these materials properly. Improper preparation and handling of wound closure materials can seriously delay an operation; jeopardize patient and surgical team members' safety; and waste valuable resources.

This section will round out your knowledge of suture materials by covering the basic guidelines for estimating suture requirements and procedures for preparing, handling, and passing sutures on the sterile field. A separate lesson discusses how to select, prepare, and pass surgical needles.

819. How to estimate suture requirements

The first subject we'll discuss is how to estimate the amount of suture your surgeons will require.

Sources of information

Before the operation, you can determine the amount and type of suture required for a particular procedure by referring to the preference card. This card should outline the specific types and amounts of suture a surgeon normally uses on a given procedure. It may also tell you which sutures are used as free ties, which sutures should be swaged-on rather than threaded, the types of surgical needles used (if threaded sutures are required), how long the suture strands should be cut, and on what tissues the different sutures are used. The scrub and circulator can also determine suture needs by asking the surgeon what he or she uses before the operation.

Amount of suture needed

The circulator is usually responsible for pulling the sutures needed for a procedure. When selecting sutures to be opened on the sterile field, the circulator should use discretion as to the number of individual suture packages initially given to the scrub. There should be enough sutures available on the sterile field that the surgeon will not be kept waiting (which usually means opening one or two packages of each suture listed on the surgeon's preference card). However, it is not always necessary to open every package that was originally pulled for the case. Often, it is possible to open additional sutures during the procedure as it becomes evident the surgeon needs them.

Anticipating intraoperative suture needs

The key to calculating suture needs during the procedure is for the scrub and circulator to pay attention to what the surgeon is doing. The scrub should look into the wound to see what type of tissue the surgeon is working on, how deep these tissues are in the wound, and whether or not the surgeon is encountering bleeding problems. By doing this, the scrub can anticipate not only what instruments to pass, but also what suture materials may be needed. This is where your knowledge of suture and suture needles pays off. If you know what types and sizes of suture and needles are used on different tissues, you'll be able to have the right materials ready well before the surgeon asks for them.

If you are scrubbing on a case where it is difficult for you to see what is going on, you can still anticipate suture requirements by listening to the conversation between the surgeon and assistants. Many times, an alert scrub can tell exactly what stage of the operation the surgeon has reached simply by picking up bits and pieces of conversations between the other sterile team members.

If other efforts at anticipating suture needs fail, simply ask the surgeon what sutures are needed next. Normally, surgeons will not mind if you ask because they understand you are asking so you can have the sutures ready before they need them. It is always better to ask than to remain silent and wait for the surgeon to demand a certain type of suture you do not have. If the surgeon must ask, you and the circulator have failed to do your jobs properly and, as a result, the operation will be delayed.

Two important guidelines all scrub technicians should remember when trying to anticipate suture needs are:

1. Don't wait until the last strand of a particular suture is used to ask the surgeon if more is needed (at the latest, ask when there is still one unused suture remaining on the sterile setup).
2. Always ensure you have at least one backup suture of each kind on the sterile field.

Even if the surgeon indicates no more sutures of a particular kind are needed, you should ask the circulator for an additional package if you do not have any on the field. You never know when an emergency situation may arise that requires the use of a certain tie or suture. Having at least one suture on the field may prevent the patient from losing a great deal of blood during a critical stage of the operation.

The circulator must also remain alert to determine both the scrub's and the surgeon's needs. If the circulator observes the activities of the sterile team and listens to their conversations, sutures and other supplies can be opened well before they are needed. It is the circulator's responsibility to ask the scrub what additional sutures are required and remind more inexperienced scrub specialists of the need to periodically check the level of sutures that remain on the field.

Factors influencing suture needs

There seems to be a reverse relationship between the scrub's level of experience and the amount of suture he or she prepares in advance. The more experience the scrub specialist or technician has, the less suture is opened and prepared in advance because the experienced scrub has learned how to anticipate the surgeon's needs accurately.

The same can be said of the circulator, whether nurse or technician. Because the amount of practical experience varies so much, particularly in Air Force ORs, it is vitally important the scrub and circulator work together as a close-knit team and constantly communicate with each other during a procedure. As your experience grows, you'll soon learn there are several factors to be taken into consideration when estimating suture requirements. The following table lists some of these factors:

Factor	Explanation
Size and Age of the Patient	Obese or large adult patients generally require more sutures to close their wounds. They also may require larger diameter sutures to support the wound adequately and bigger needles to pass through the thicker tissues. On the other hand, pediatric patients and small, skinny adults require not only fewer sutures than large adults, but also smaller sizes of suture and needles.
Physical Condition of the Patient	If the wound is infected or grossly contaminated, the surgeon may need to deviate from his or her normal suture routines. Where multifilament nonabsorbable sutures would normally be used, the surgeon may decide to use a monofilament suture to prevent the spread of infection through capillary action. If the patient is elderly or has a chronic disease, the surgeon knows wound healing usually is slower. As a result, nonabsorbable sutures may be substituted for absorbable sutures to provide for long-term wound support. Or, the surgeon may decide to use absorbable sutures that are absorbed more slowly than the ones normally used.
Urgency of the Surgery	Many more sutures may be required for suturing and bleeder ligation on a trauma case than on a routine elective procedure. The surgeon cannot tell the exact extent of the damage until the patient is "opened up."
Length of the Incision	Obviously, it takes more sutures close longer incisions than to close shorter incisions. In addition, if the incision is in the abdomen, the surgeon may want to put some additional reinforcing sutures (called retention sutures) at intervals along the length of the incision to help support the wound closure provided by the primary suture line.
Possible Complications	No matter how well-prepared the surgical team is for a given operation, there is always the possibility something will happen during the procedure that will dramatically alter normal surgery routines and require the opening of additional supplies, including suture materials. For instance, if a bridges surgeon is performing an abdominal hysterectomy and accidentally nicks one of the ureters, the scrub will need to obtain additional sutures to close the damaged ureter. If a surgeon plans to perform a routine cholecystectomy but discovers a cancerous tumor that may immediately threaten the patient's life, the surgeon may decide on-the-spot to remove the mass. This procedure would necessitate the opening of several additional supplies and sutures.
How the Suture are Packaged	Many sutures come packaged in multiple strand or multiple swaged-on suture configurations. You must become familiar with the packaging of the sutures available in your OR so you'll know how many strands are in a given pack of suture. This way, you'll be better able to estimate how many additional packages of suture must be opened if you need more suture in the middle of a case. For instance, suppose the surgeon is doing a hernia repair using 0 silk sutures with swaged-on needles that come packaged in multi-packs of eight sutures per pack. The surgeon uses all eight before finishing the repair and indicates four more sutures are required. You'll need to ask for more suture. If your OR has single suture packages of 0 silk with the same needle, it may be more economical to have the circulator open five single suture packages than to open one more eight-suture multi-pack. (The fifth suture is your backup.)

820. Preparing suture on the sterile field

After the suture materials have been transferred to the sterile field, the scrub should arrange an area on the instrument table to use for suture preparation.

Suture preparation area

The site reserved for suture preparation should be located where it will be most accessible to the scrub after the operation is underway (usually at the front of the table near the end of the table nearest to the foot of the OR bed). It should be big enough for a round bowl or other container to hold opened suture packs, a sterile sharps pad or other sharps container, at least two needle holders, and suture scissors.

Many scrub technicians organize the multiple strands of free ties inside of the fan folds of a cloth hand towel and place it on the Mayo stand for immediate access. Another technique is to place the free ties under a towel on the Mayo stand, leaving one end of the sutures projecting out toward the operative site. The instruments are placed on the Mayo after the suture and towel is prepared. This method can be used for free ties and multi-packs of swaged-on sutures. However, when sutures are placed on the Mayo tray, the scrub should take extra precautions to pad the sterile Mayo stand cover. This is necessary to prevent the suture strands from cutting through the cover as they are pulled out from under the towel. If the sutures cut through the cover during the procedure, you'll not be aware of it until the end of the case; you may have been passing contaminated sutures to the surgeon throughout the better part of the procedure, and they are now implanted in the patient's tissues. To pad the cover, place a cloth hand towel between the cover and the suture, lay the sutures out the way you want them, and then place another towel over them. Do this before you start putting instruments on the tray.

You may also use a small round basin, or the large single basin designated for soaking sponges, for rinsing off or soaking certain sutures with sterile normal saline. You should recall that surgical gut sutures are packaged in a preservative solution. This solution does not need to be rinsed off unless the sutures are to be used in the eye. If you rinse gut sutures, do so by just dipping the coiled strand briefly in the saline. Prolonged soaking of gut sutures can weaken the tensile strength of the strands. Gut sutures that have been exposed to the air for a long time should be moistened in saline before use to increase their flexibility. You should also remember that cotton sutures and umbilical tapes are always wetted before use to increase tensile strength, make them easier to handle, and make them less traumatic to the tissues.

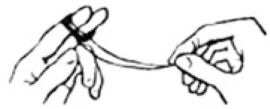
Preparing ligatures

Experienced scrub personnel prepare different sutures in the same sequence as the surgeon will use them. Most often, ligatures (ties) will be used in the subcutaneous tissue shortly after the incision is made unless the surgeon uses electrosurgery to cauterize bleeders. Because of this, the ties for subcutaneous bleeders are prepared first, and other ties for use in deeper tissues are prepared next. There are basically four different types of ligatures or ties: free ties, continuous ties, ties-on-a-passer, and stick ties.

Free ties

Free ties are strands of suture material tied around the ends of severed blood vessels. First, these bleeders are clamped with a hemostat, and then a tie is looped around the clamped stump. After the surgeon "throws" the first half-knot in the suture, the clamp is removed and the tie is securely knotted. The length of free ties will vary according to the depth of the wound. In subcutaneous tissue, quarter length strands (about 14-inches long) are usually long enough for the surgeon to use. As the surgeon progresses into the deeper tissues, longer free ties, varying in length from 18 to 30 inches, may be required. Sutures (without attached needles) used for ligating purposes may come as long, single strands, or in packages containing multiple precut strands.

Long, single strands are referred to as standard length sutures. These are commonly supplied in 54- and 60-inch lengths. Normally, the absorbable sutures will be 54 inches long, and the nonabsorbable sutures will be 60 inches long. Obviously, these standard length strands are too long for the surgeon to use right out of the package, so they must be cut into usable lengths. The surgeon may ask for half lengths (28 to 30 inches), third lengths (18 to 20 inches), or quarter lengths (131/2 to 15 inches). You were taught the proper procedures for cutting standard length strands into different lengths in technical school, so we'll not bore you with the step-by-step techniques in this text. Figure 3–8 will refresh your memory on how to cut a standard length suture into different lengths.

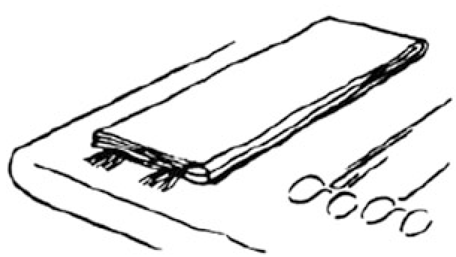


1. To prepare cut lengths of surgical gut, place standard length coil around fingers of left hand. Grasp two free ends with right hand and unwind to half length.

2. Maintain loop in left hand and two free ends in right hand. Gently pull surgical gut strand to straighten.

3. To make 1/3 lengths: Pass one free end of strand from right to left hand. Simultaneously, catch a loop around third finger of right hand. Make the strands equal in thirds and cut at loops with scissors.

4. To make ¼ lengths: Pass both free ends from right to left hand, simultaneously catching a double loop around the third finger of right hand. Cut the loops.



5. Place packets or strands in "suture book" with ends extended far enough for rapid extraction.

Figure 3–8. Preparing standard lengths of suture.

One key point regarding cutting standard length sutures was emphasized in technical school and is worth repeating here: when opening packages of standard length surgical gut, always hold the package over a basin to ensure the preservative solution inside the package does not squirt all over the sterile field. This could cause strike-through contamination or leave a potentially irritating residue on some of your instruments. To open the package properly, you should hold it over the basin with the notched peel-off end facing down and tear the package with an upward motion. This allows the solution to drain down into the basin and prevents the fluid from splashing up into your eyes.

Precut lengths of suture are available in many different packaging configurations. They usually come in either 18- or 30-inch lengths with a dozen individual strands packaged together. The packages may be designed so the sutures can be removed one at a time directly from the package, or totally removed from the package and placed in a suture book or under the Mayo tray. Nonabsorbable sutures, particularly silk, are commonly supplied in multiple strand packages. Although these precut multiple strand packages are convenient to use, some surgeons may prefer to use continuous ties over individual free ties.

Continuous ties

Some surgeons like to use suture material supplied on a disc-like plastic reel that is held in the palm of the hand as vessels are ligated. The reels are radiopaque so they can be seen on X-ray if they are accidentally "lost" in a wound. Some suture manufacturers also color code the reels (for quick identification) according to the type of suture they contain.

The size of the suture on the reel is plainly marked by numbers or by a series of holes that represent the size of the suture on the zero sizing scale. For example, three holes in a series would represent 3–0 suture. An absorbable suture reel will usually have a 54-inch strand wrapped around its hub, and a nonabsorbable suture reel will contain up to 12 feet of suture material. Suture reels are normally kept on the Mayo tray for easy access and passing. The steps for preparing and passing a suture reel are illustrated in figure 3–9.

Tie-on-a-passer

A tie-on-a-passer is simply a strand of suture material clamped in the jaw of a long ring-handled forceps. This type of tie is used to ligate structures in deep cavities and hard-to-reach areas where exposure and visibility are limited. A typical tie-on-a-passer consists of a medium-to-long, right-angle forceps with a single strand of suture clamped in the jaw. Most surgeons prefer the suture positioned in the forceps jaws so the end of the suture goes straight into the tip of the jaw rather than perpendicular to the jaws. This positioning of the suture makes it easier for the surgeon to pass the tie around the backside of various tubular structures. Whenever you hand a tie-on-a-passer to the surgeon, be ready to pass a long, smooth dressing forceps or Debakey thumb forceps (pickup). The forceps are used to grasp the end of the tie near the jaw of the right angle clamp after the surgeon passes the tie around the back of the structure. Sometimes, the surgeon may encounter a large blood vessel that has been severed and need to use a special ligature that will be more secure than a free tie or tie-on-a-passer. In this instance, the surgeon may request a stick tie.

Stick ties

Stick ties are nothing more than a suture on a needle that the surgeon passes through the end of a large severed blood vessel before tying the ends of the suture around the vessel stump. This is done to prevent the tied knot from slipping. This type of tie is also called a suture ligature or transfixion suture.

Stick ties can be either sutures with swaged-on needles or sutures that have been threaded on an eyed needle. If the surgeon asks you for a threaded stick tie when he or she is working on superficial tissues, common sense should tell you a short, quarter-length suture is needed. If the surgeon is working in a deep cavity, a 30-inch strand should be threaded. When swaged sutures are used, the surgeon will have little choice as to the lengths of the ties because these sutures are usually 30 inches long. Because these sutures are so long, the surgeon can use them more than once (as long as the tie is used on superficial tissues and enough suture is left attached to the needle after the first tie is placed). This is useful because the scrub will not need to open and arm a fresh suture in the event the first stick tie fails to achieve the desired result. The needle can be repositioned in the needle holder jaws, and the suture ligature can be immediately passed back to the surgeon.

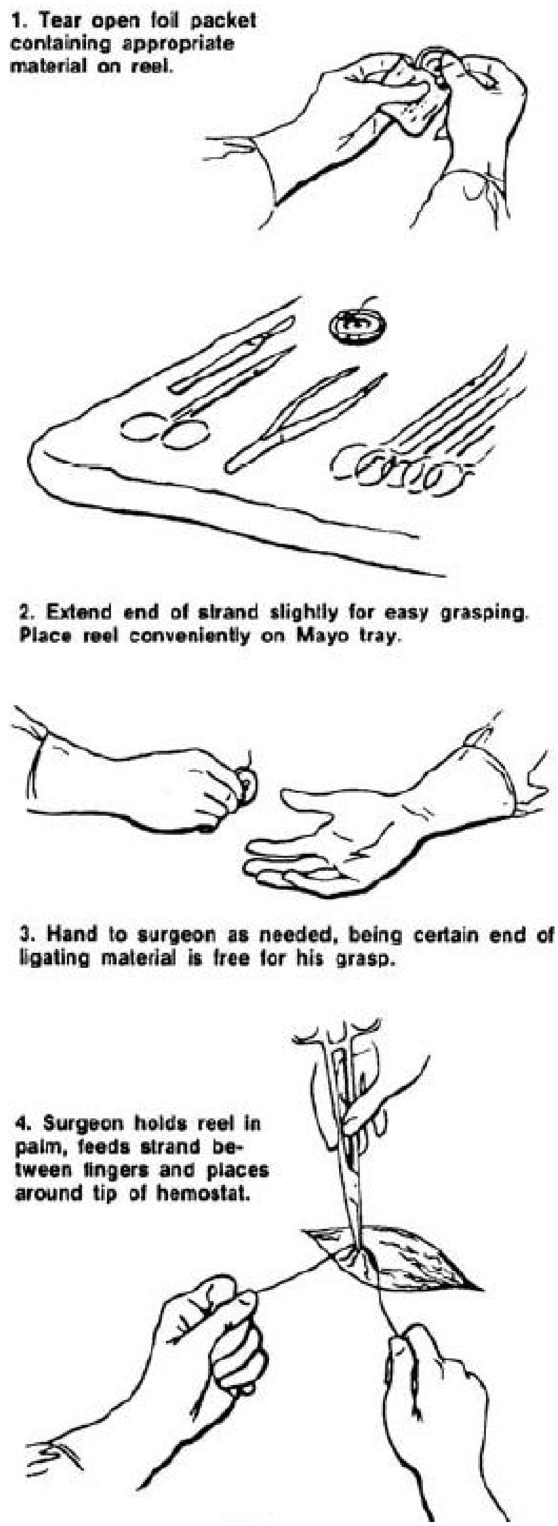


Figure 3–9. Passing a suture reel.

821. Guidelines for suture handling

It is essential all surgical service technicians learn to handle each suture material correctly to preserve its tensile strength. Since the patient's wound will have little or no strength of its own during the first few days postoperatively, the burden of holding the wound edges together will fall on the sutures or mechanical devices implanted in the tissues. These wound closure materials can provide the support essential to uneventful wound healing only if their quality and integrity are maintained during preparation and handling.

Preserving tensile strength

In our previous discussion of the different types of suture materials, we mentioned some characteristics of each specific kind of suture material that related to tensile strength. Now, we'll attempt to summarize all that material into some simple guidelines you can remember easily when handling sutures on and off the sterile field. The first type of suture material we'll cover is absorbable suture.

Absorbable sutures

The integrity and strength of absorbable sutures can be destroyed if they are subjected to extremes of heat and moisture, or if they are roughly handled during preparation. To preserve the tensile strength of absorbable suture, you should:

- Store suture packages at normal room temperature, ensuring they are not stored in hot, humid areas (i.e., near steam pipes or steam sterilizers).
- Avoid prolonged soaking of surgical gut sutures. Over-exposure to moisture greatly reduces the strength of gut sutures because of water absorption between the individual fibers in the strands. If gut sutures dry out after prolonged exposure to the air, dip them momentarily in saline. Do not routinely soak or rinse plain or chromic gut suture unless it will be used in the eye, or if specifically ordered by the surgeon.
- Keep synthetic absorbable sutures dry. Use the strands directly from the package whenever possible. If the strands must be removed from the package long before they are used, store them in a dry location. Never soak synthetic absorbable sutures or place them in a moist suture book. They will begin to dissolve by the process of hydrolysis before they are implanted in the tissues.
- Never re-sterilize sutures. Repeated sterilization may damage or weaken the suture.
- Limit contact between surgical gloves and gut suture strands. This should be limited to the minimum required for preparation (stretching, cutting, threading on needle, etc.). Excessive handling with rubber gloves can cause the strands to fray.
- Straighten coiled strands using a gentle, steady pull. Jerking or tugging on the strands will only weaken them. This is particularly true for surgical gut and collagen sutures.
- Do not test the strength of a suture strand by pulling on it. The suture may not break when you "test" it, but it may break in the wound because you reduced its tensile strength.

Nonabsorbable sutures

Since there are so many different types of nonabsorbable sutures, each with its own distinct characteristics relating to tensile strength, we'll talk about them individually:

- Braided silk—You should remember that dry silk is stronger than wet silk. Avoid wetting it.
- Cotton—This suture material is just the opposite of silk—it gains strength when wet. Always moisten strands before use. (This holds true for cotton umbilical tapes also.)
- Stainless steel wire—Avoid kinking and bending stainless steel wire to prevent weakening its strands. Discard kinked or bent wire strands. Do not sterilize wire on wooden spools. A toxic

substance known as lignin is leached from the wood by the high temperature in the sterilizer and will cling to the wire. This residue can cause a severe tissue reaction.

- Polyester—This material is unaffected by moisture, so it can be used wet or dry.
- Nylon—Avoid stretching strands to remove kinks or bends. Stretching reduces tensile strength. To remove the kinks, gently stroke the strands (with your gloved fingers) a few times.
- Polypropylene—This material can be used wet or dry because moisture will not affect tensile strength. To remove kinks and bends, use a strong, steady pull.

General suture handling guidelines

One of the first things you should do, as either a scrub or circulator, is to read the label on the suture package. This is necessary to ensure you have the correct sutures and do not waste them by opening the wrong package. Always check the size and type of suture and any attached needles. Also, look to see how many sutures or individual strands are in a single pack and to see if the needles are controlled release-type needles. The label also tells the scrub how to properly open the inner suture package without damaging the contents.

Suture is expensive! Open only the number and type of sutures specified on the surgeon's preference card or the number the surgeon specifies orally. Use proper aseptic technique to transfer suture to the sterile field. You may "flip" suture packs onto the field (once you master the technique), or you may present them for the scrub to grasp by peeling back the flaps on the outer package to expose the inner pack. When opening long suture packs, such as those for wire sutures, peel the flaps of the outer package down about six to eight inches and present the contents to the scrub. Do not attempt to project these big suture packages onto the field. If you do, you'll contaminate the suture and the sterile table.

Keep an adequate supply of the most commonly used sutures on hand in the OR so the circulator will not need to run out of the room every time the surgeon needs additional suture. Also, check for outdates on all suture packages, and rotate suture stocks using the good old first-in, first-out (FIFO) rule. This should be done in each OR and in the bulk storage area on at least a weekly basis.

When passing free ties to the surgeon, remember to keep the strands taut and push them into the surgeon's outstretched palm with an upward motion. This action is necessary so the surgeon can feel the suture and know when to close his or her fingers. If you are passing wire sutures, you should clamp a hemostat (usually Kellys or criles) to each end to prevent the "springy" strands from becoming contaminated and to give the surgeon "handles" with which to manipulate the wire (this prevents cuts and punctures in the surgeon's gloves). If the wire suture has a swaged-on needle, attach a clamp to the free end before passing it to the surgeon for the same reason.

Control the ends of all stick ties passed to the surgeon, especially on long swaged sutures. Pass the free end to the assistant or loop it under the surgeon's "pinky" finger in the manner you were taught in technical school. When passing any suture, remember to keep the free ends out of the surgeon's palm.

Handle all sutures as little as possible and avoid crushing or crimping suture strands, except for the ends of sutures used for a tie-on-a-passer. (It's alright to clamp the end of wire sutures as previously described, unless they are very delicate.) Foil suture packages should never be cut with scissors. It's too easy to cut the suture inside accidentally. The foil package should be torn at the notched end, in accordance with the instructions on the package. Usually, the end of the package is torn with an upward motion and slightly to the left to expose the end of the suture. Do not hold the suture package with your fingers over the center cavity because doing so may damage the needle or suture. Hold the package by the sealed edge when opening. Do the following things:

1. Count all needles, following local policy. Retain all suture packages on the sterile field until the end of the procedure to validate counts or to double-check after miscounts. (We discussed sponge, needle, and instrument counts in depth in volume 4.)
2. Cut sutures using suture scissors only. Always use wire scissors when cutting wire sutures to prevent dulling and damaging the cutting surface of the regular suture scissors.
3. When preparing a swaged suture, avoid pulling on the needle to straighten the strand. If you pull on the needle, it may be loosened from its attachment or may pop off, particularly if it is a controlled release needle.
4. Finally, always pay attention to what is happening at the surgical site so you can anticipate the surgeon’s suture needs and have the required sutures ready in advance.

822. Selecting, preparing, and handling surgical needles

Knowing how to properly handle sutures is only part of your role in wound closure. It is also necessary for you to learn the proper procedures for selecting, preparing, and handling the needles used with these sutures.

Needle selection

Although surgeons usually have definite preferences for the sutures and needles they use in certain instances, they may not tell you exactly which one they want for each layer or application. You must know enough to make the correct selection. When selecting surgical needles, you should:

- If using free needles, try to match the size of the needle to the size of the suture, as closely as possible, to prevent excessive tissue trauma. The use of swaged-on suture needles virtually eliminates this concern.
- Consider the depth and size of the surgeon’s working area when figuring out what needle length, diameter, and curvature are best. Always pay attention to what is going on at the operative site so you can anticipate the surgeon’s needs. If you are totally confused, ask the surgeon what needles he or she prefers, but try to pick a “lull point” during the procedure so you’ll not break the surgeon’s concentration.
- Know what tissues the surgeon is working on. If you recall, we said earlier that taper point needles are generally used to suture tissues that can be penetrated easily, such as the peritoneum, abdominal viscera, and subcutaneous fat. Cutting needles are used on tissues that are dense, tough, and very fibrous. They are most often used on the skin, thick muscle and fascia, tendons and tendon sheaths, and cartilage. If you are unsure whether to choose a cutting or taper needle for use on a particular tissue, the best choice is the taper needle because it is less traumatic to the tissues. There is one exception to this general rule—cutting needles are always used on the skin.
- Verify the surgeon’s suture requirements. When in doubt about specific suture needs, ask the surgeon. Do this at the same time you ask about suture preferences and any anticipated variation from standard routines. Once you have worked with a particular surgeon for a while, you’ll be able to memorize their normal routines. However, this should not stop you from asking questions about needle selection because each patient is different and standard routines will always need to be adapted to each operative situation.

Needle preparation and handling

To prepare and handle a variety of sutures with needles effectively, you need to know how to position needles properly in needle holders; thread and pass curved and straight-eyed needles; and prepare and pass sutures with swaged-on needles. You also need to know the basic guidelines to follow when handling all sutures with needles.

Positioning needles in needle holders

The position of a needle in a needle holder can have a significant effect on the surgeon's efficiency in placing sutures. The surgeon should not need to reposition each needle before making a stitch. You can eliminate many mistakes if you follow a few basic rules when you place the needles in the jaws of the needle holders.

The first thing you need to do is to select the right size needle holder for the needle to be used. Needles with heavy shafts require a heavy-duty needle holder with wider, heavier jaws that is not sprung when the needle is clamped in the jaws. Small, delicate needles require the use of fine-jawed, smaller needle holders. A special needle holder should be used for microsurgery needles. In most instances, the needle should be securely held in the jaws when the needle holder is clamped to the first or second ratchet. If the needle is held too tightly in a needle holder with sharp jaw serrations, or a hard jaw (like those with tungsten-carbide inserts), the needle may be damaged.

As shown in figure 3–10, when you position the needle in the needle holder jaw, clamp the needle holder about 1/4 to 1/3 of the distance along the shaft, away from the eye or swaged end. This lets enough of the shaft free so the surgeon can pass the needle easily through the tissue. It also ensures the pointed end of the needle emerges from the tissue far enough so the surgeon can grasp the needle shaft and finish pulling the needle through the tissue. Unless the surgeon tells you otherwise, always position the needle at a right angle to the needle holder jaw. Be careful when using a curved jaw needle holder, such as a Heaney needle holder (used in OB/GYN surgery). When positioning the needle in a curved jaw needle holder, ensure the needle is perpendicular to the curved tip, not the shaft of the needle holder. Clamp the needle far enough back in the jaw to leave about one-eighth inch of the needle holder jaw tip protruding beyond the shaft of the needle. This positions the needle far enough back in the jaw to ensure a firm grip without over stressing the instrument jaw.

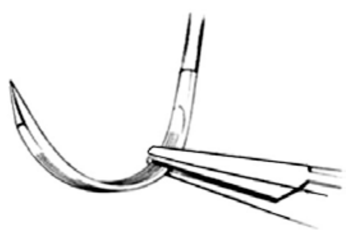


Figure 3–10. Arming a needle holder properly.

When preparing a suture for a right-handed surgeon, position the needle so the point faces towards the surgeon's left side when the needle holder is passed in the position of use. If you are right-handed, this is simple. Just hold the needle holder in your right hand (like the surgeon uses it) and the needle in your left hand with the eye of the needle facing towards your right. Clamp the needle holder one-fourth to one-third the distance along the shaft, and pass the suture in the position of use (fig. 3–11, A). For a left-handed surgeon, position the needle so the point faces towards the surgeon's right side when the needle holder is passed in the position of use. To make this easy on yourself, hold the needle holder in your left hand (just like the surgeon uses it) and the needle in your right hand with the eye of the needle facing towards your left. Clamp the needle holder one-fourth to one-third the distance along the shaft, and pass in the position of use as illustrated in figure 3–11, B. Never clamp the needle holder on the end of the needle where the suture is attached.

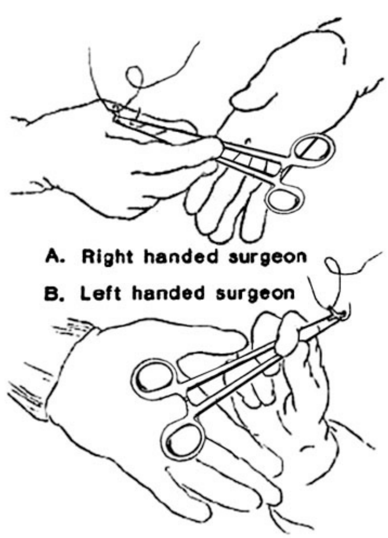


Figure 3–11. Passing an armed needle holder.

Threading needles

While most surgeons exclusively use swaged needles, there are instances when only a free needle will do the job; so, you must know how to thread suture needles. There are two basic methods of threading needles. One involves the use of a needle holder, and the other requires the needle be held in the fingers while it is being threaded. The former method is used for curved needles and the latter method is used for straight needles, such as Keith needles.

Many authorities recommend curved needles be threaded from within the curve so the short end of the suture is on the outside of the curve. This helps prevent the suture from pulling out of the needle as the stitches are placed. Threading a needle from the inside of the eye requires careful maneuvering to avoid pricking the gloved fingers on the point of the needle. To keep the suture from falling out of the needle, the end of the suture should be pulled through the eye approximately 2 – 3 inches. Pinch the short end and the longer part of the suture strand together, and “lock” them in the notch at the tip of the needle holder jaws. This further ensures the suture will not fall out of the needle when it is passed to the surgeon and passed through the tissues.

To thread a straight needle, hold the needle with your gloved fingers about halfway down the shaft with the eye of the needle facing up. Guide the suture through the eye until about 2 – 3 inches of the suture protrudes from the other side. Pinch the short and long parts of the strand together, and loosely twist them two to three times. This helps prevent the suture from pulling out of the eye. After the needle is threaded, stick it in a fan-folded towel. Several straight needles should be threaded in this manner and placed side-by-side on the towel. The towel is then placed on the Mayo tray so the surgeon can easily reach back and extract a threaded needle. When straight needles are used, the surgeon sticks the empty needle back in the towel so it is not misplaced on the sterile field.

Threading a French eye needle is a bit different from threading conventional eyed needles. To thread a French eye needle, secure the short end of the suture between the fingers of the hand holding the needle holder and the needle holder box lock. Hold the long end taut, pass it outside the curve of the needle, and pull it over the tip of the needle holder and across the V-slit in the top of the needle eye. Keep the strand taut and pull it down through the slits in the eye. Since French eye needles are very delicate and brittle, they are easily broken. You should always check the needle eye to ensure it is intact before threading a suture through it.

Passing threaded sutures

Once the needle is threaded, it can be passed to the surgeon. Since we already told you how straight needles are passed, we’ll now concentrate on passing threaded curved needles. You’ll pass a threaded suture on a needle holder in the same manner you pass a hemostat. Hold the needle holder by the box lock, with the ring handles facing the surgeon and the point of the needle facing in towards the surgeon’s midsection. This basic guideline holds true whether you are passing a suture to a right- or a left-handed surgeon. As you pass the needle holder, use a slight twisting motion of the wrist so the ring handles snap firmly into the palm of the surgeon’s outstretched hand. Hold onto the long end of the suture as you pass the needle holder to keep the suture from getting caught in the surgeon’s palm. Release the long suture tail after the surgeon has control of the needle holder so the tail falls over the back of the hand holding the needle holder. An alternative to this is to pass the long end of the suture to the first assistant after the surgeon has control of the needle holder.

Preparing and passing sutures with swaged-on needles

Sutures with swaged-on needles come in a variety of packaging configurations, including single sutures with single needles, single sutures with needles at both ends (double-armed), and multiple sutures with single- and double-armed needles. Regardless of the packaging, these suture-needle combinations require special handling to ensure the integrity of the suture-needle attachment is not destroyed. To illustrate the proper techniques for arming and passing a swaged suture, we’ll use a single-armed suture as an example.

Many swaged sutures come in foil packages just like the standard length and precut strands. This foil package should be opened in the same manner we described earlier for the ligature packs. The pack should be held by the side seam to avoid damaging the inner contents. The notched end should be torn in an upward motion to reveal the inner contents. Most swaged sutures are coiled inside a protective cardboard insert with the point end of the swaged-on needle inserted into the cardboard. The majority of the needle shaft is exposed, so you can easily grab it with your gloved fingers or the needle holder. Once the foil package is opened, the inner cardboard insert containing the suture should be removed and the foil package should be retained on the sterile field to validate the needle count. Pull the needle free of the cardboard, preferably with a needle holder to prevent puncturing your glove. Adjust the position of the needle in the jaw of the needle holder using the guidelines for positioning previously described for eyed needles.

After the needle is clamped in the proper position, slowly pull the coiled suture straight out of the package. To prevent tangling of the suture, hold the cardboard insert so the thumb and index finger of the hand holding the insert gently hold the suture strand as it emerges from the package. If you hold the insert in this fashion, you'll be able to grab and control the free end of the suture after the last coil is unwrapped. An alternative to this method of removal is to unfold the cardboard insert, remove the coiled suture, and grab onto the free end.

The next step is to get the "kinks" (if any) out of the suture. To do this, hold the suture a couple of inches back from the needle and, using the other hand to grip the free end, gently stretch the suture. If you pull too hard, you'll weaken the suture strand. Never pull directly on the needle when stretching a swaged suture. Otherwise, the needle may be loosened or pulled free from the swaged attachment. As we stated earlier, this is particularly crucial when arming controlled release needles. This method of stretching the suture applies whether you have already armed the needle on the needle holder or you wait to arm the needle until after stretching the suture.

General needle handling guidelines

The scrub specialist or technician bears the responsibility for properly handling and keeping track of all needles used on the sterile field. The following principles will guide you in fulfilling these responsibilities:

- Protect surgical needles from damage when opening packs and arming needle holders. Never use suture scissors to open a foil package containing a swaged suture, and avoid holding the packages in the middle. Clamp the needle holder onto the flat portion of the needle designed to accept the needle holder, and do not arm the needle too close to the eye or swaged end. Arming the needle holder too close to the eye or swaged end increases the likelihood the needle will bend or break when it is passed through the tissues.
- Inspect all needles before you load them or pass them to the surgeon. Check the edges and points for sharpness—look for burrs, nicks, and bends. Pay particular attention to the eye of a free needle because any burrs or defects can fray or cut into the suture. Discard defective needles in accordance with your local shop's disposal policy.
- Thread free needles at the Mayo stand so you can keep your attention focused on the operative site, and be very careful that you do not puncture your gloves. Remember to notify the circulating nurse and your supervisor (noncommissioned officer-in-charge (NCOIC)) if you accidentally stick yourself with a needle so proper measures can be taken. Do not forget to pass the contaminated needle off the sterile field and change gloves.
- Count all needles on the sterile field. Retain the packages on the sterile field for verifying counts.
- Control all needles during the procedure. Exchange needles with the surgeon on a one-for-one basis if possible. In other words, do not pass the surgeon another needle until he or she has returned the previously passed needle. Secure each needle to a needle holder after the surgeon has used it. Most surgeons re-clamp the empty needle in the needle holder after placing a stitch, but you need to ensure all needles are returned and not left

on the field. If the surgeon has finished using a particular needle, place it in a needle disposal pack or contain it in a medicine glass or other suitable container.

NOTE: Whenever possible, use a disposable needle count/disposal pad. Placing suture needles in a medicine glass, prep cup, or round bowl makes them more difficult to count and increases the risk of a needle stick due to the requirement to separate the needles during the count. Always keep needles well away from sponges so they are not dragged into the wound.

- If a needle breaks on the sterile field, all pieces must be accounted for. If the pieces cannot be found, the surgeon should be notified and a postoperative X-ray should be taken. The incident is logged on the operation report and the preoperative nursing record, and an incident report is filled out in accordance with local policies.

Each OR has different types of sutures and different guidelines on how to handle them; learn the ones appropriate for your facility. In addition, suture manufacturers are constantly coming up with new wound closure materials and modifications to their existing products. The only way you can keep up with all the changes is to stay motivated. Read the manufacturers' product literature. If you are fortunate to be in a facility with a medical library, go there and sign out books on wound closure. Talk to suture manufacturer sales representatives. Read professional journals such as those published by organizations such as the Association of Operating Room Nurses and The Association of Surgical Technologists. If you think this type of ongoing study program is unnecessary, you are dead wrong. Only by keeping up with the changes in your career field are you able to provide the surgeon the kind of assistance that is expected and required to ensure that all surgical patients receive the best care possible.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

819. How to estimate suture requirements

1. What information regarding suture materials may be found on the preference card?

2. What general guideline should a circulator follow when determining the amount of suture initially to open on the sterile field?

3. What is the key to calculating suture needs during the procedure?

4. Cite six factors that should be considered when estimating suture requirements.

820. Preparing suture on the sterile field

1. Where on the instrument table should the scrub create a space large enough for suture preparation and suture supplies?

2. Why should you place an opened cloth hand towel between the Mayo tray cover and the suture on the Mayo tray?

3. What are the four basic types of suture ligature?

4. How can you determine what size suture is wrapped on a suture reel if there is no number stamped or imprinted on the reel?

5. When would a surgeon most likely want a tie-on-a-passer instead of a free tie?

6. After passing a tie-on-a-passer to the surgeon, what should you be ready to pass next? Why?

7. What is a stick tie?

821. Guidelines for suture handling

1. Cite five guidelines you should follow to preserve the tensile strength of absorbable suture materials.

2. Why should you avoid wetting silk sutures?

3. Why should you avoid sterilizing steel wire on wooden spools?

4. How can you straighten a nylon suture without reducing its tensile strength?

5. Why is it important for you to read the label on a suture package?

6. Why should you attach a hemostat to the free end or ends of a wire suture before passing it to the surgeon?

7. Why should you avoid cutting a foil suture pack with a pair of scissors?

8. Why should you retain all suture packages on the sterile field until the end of a procedure?

9. Why should regular suture scissors not be used for cutting wire sutures?

822. Selecting, preparing, and handling surgical needles

1. Specify four steps you should take when selecting a surgical needle for use with a particular suture.

2. Describe the proper way to position a needle in a needle holder jaw.

3. What should you do to prevent a suture threaded through a curved, eyed needle from falling out when it is passed to the surgeon and used for suturing?

4. When threading a straight needle, what should you do to prevent the suture from slipping out of the eye during handling and use?

5. How can you ensure the long end of a threaded suture does not get trapped in the surgeon's palm when you pass a suture?

6. Why should you avoid arming a needle on a needle holder close to the eye or swaged end?

7. How should you exchange needles with the surgeon so they won't become misplaced on the sterile field or find their way into the wound?

8. What must be done if a needle breaks on the sterile field?

3–3. Basic Wound Closure Techniques

There are numerous suturing techniques used by surgeons to approximate tissues. It is important that you be familiar with some of the more common techniques so you can better anticipate the surgeon's suture requirements during a surgical procedure. Understanding basic suturing techniques also enables you to assist the surgeons more effectively with wound closure if and when you are called upon first to assist on minor procedures.

In this section, we begin with a discussion of how a wound heals, and then discuss the characteristics and uses of some of the more common interrupted and continuous suturing techniques. The last lesson in this section provides you with the information you need to know to assist with one of the most common types of wound closures—an abdominal wound closure.

823. Care of the wound

A wound is described as an abnormal break in the continuity of normal tissue pattern by physical means. It follows, then, that wound healing is the restoration of the tissue.

Wounds vary in severity from the simple, clean wound, to the more serious deep, contaminated wound. The severity of the wound determines how long it will take for the wound to heal, how much postoperative pain the patient will have, probability of wound complications, and whether tubes, drains, or suction devices will be used.

Knowledge of the fundamental principles of wound healing is very important.

Classification of wounds

Wounds are classified as incised, contused, lacerated, or puncture, according to the manner in which they were made:

- Incised wounds are made by a clean cut with a sharp instrument, such as a surgeon's incision with a scalpel.
- Contused wounds are made by blunt force, do not puncture the skin, and cause considerable soft tissue damage, hemorrhage, and swelling.
- Lacerated wounds are made by an object (i.e., piece of glass or barbed wire) that tears the tissue and produces jagged, irregular edges.
- Puncture wounds are made by a pointed object (i.e., bullet, ice pick, knife point) and cause a small opening in the skin.

Wounds also have one of three surgical classifications:

1. Clean wounds are nontraumatic and uninfected, and do not enter the respiratory, alimentary or genitourinary tracts, or oropharyngeal cavity. They are closed after all bleeding vessels have been carefully ligated and are not usually drained. There is no known break in aseptic surgical technique.
2. Contaminated wounds are not grossly infected, but have been exposed to bacteria because the incision is placed through contaminated skin or placed in a contaminated part of the body. When there has been a break in aseptic surgical technique, the wound is considered to be contaminated. Contaminated wounds have a higher risk of infection.
3. Infected wounds contain infected or devitalized material. These wounds are left partially or completely open to encourage drainage and minimize sepsis. Debridement is done to thoroughly wash and irrigate an infected wound. Necrotic and devitalized tissue is removed because it acts as a culture medium (a nutrient source for bacteria). The wound is also thoroughly irrigated with saline or an antibiotic solution.

Mechanisms of wound healing

As soon as the surgeon makes the initial skin incision, the body's defense mechanisms begin the healing process. There are three stages of wound healing: first intention, second intention, and third intention. Each stage has a significant role in the healing process.

First intention

All surgeons would like their wounds to heal by first intention following primary union. An incision that heals by first intention shows no postoperative swelling, no serious discharge or local infection, no separation of wound edges, and minimal scar formation.

The pattern and rate of wound healing differ in different tissues. In general, first-intention wound healing consists of three distinct phases that overlap considerably.

1. Lag or substrate phase of acute inflammatory response—from day zero to day five. During this phase, blood cells and blood serum form a network of fibrin in the wound. At the surface, fibrin and other proteins dry, forming a scab that protects the wound from microbial invasion and further fluid loss. The wound has no tensile strength and wound edges would fall apart if the sutures were removed.
2. Healing phase of fibroplasias—from day five to day 14. This phase is characterized by the growth of fibroblasts (fibrous tissue germ cells) in and along the fibrin network. These fibroblasts and accompanying small blood vessels are called granulation tissue. The granulation tissue grows to restore the continuity of the injured tissue. It is soft and light red in color, and very friable. Epithelial cells begin to grow from the edges to cover the wound. Depending on the size of the wound, the connective tissue cells fill in the area and form a scar, which is considerably stronger than the granulation tissue. The wound has approximately 5 percent of its original skin strength by the time the skin sutures are removed; after 1 month, 35 to 50 percent of its original strength; and after 3 months, a maximum strength of 70 to 80 percent of its preoperative strength.
3. Maturation phase—from day 14 until the wound is fully healed. During this phase, the small blood vessels in the new tissue disappear and the scar becomes smaller. Tensile strength continues to increase up to 1 year postoperatively.

Second intention

This stage of healing occurs when infection is present. The healing process is also prolonged. Usually there is extensive tissue injury and pus, and approximation of the wound edges is difficult or impossible. The wound may be left open and allowed to granulate (heal from the bottom toward the outer surface).

Third intention

This stage of healing is also referred to as delayed primary closure and occurs when two surfaces of granulation tissue are brought together. This is a safe method of repair of contaminated, dirty, or infected traumatic wounds, where tissue loss may be extensive. These types of wounds usually result from traffic accidents, gunshot, and deep penetrating knife wounds. These wounds are initially treated by debridement and/or drainage.

Delayed closure is usually done 4 to 6 days post-injury. The skin edges and underlying tissues must be accurately and securely approximated. A deeper and wider scar usually results.

Complications in wound healing

The patient is immediately at risk whenever the integrity of tissue is violated. No matter how many precautions are taken in observing surgical principles and proper techniques, complications will occur in a few patients. Some complications that could arise during the healing process are hemorrhage, hematoma, infection, hernia, and wound disruption and keloid. We'll discuss the two most common complications—postoperative infection and wound disruption.

Postoperative infection

After a patient is diagnosed as having a postoperative wound infection, a specimen of the purulent drainage or tissue culture should be obtained. Surgical infections are produced by a variety of bacteria—anaerobic, aerobic, Gram-positive and Gram-negative. Staphyloccus aureus accounts for many postoperative infections. Antibiotic therapy is initiated after the invasive organism is identified and sensitivity tested. It is important adequate irrigation and debridement be performed on the infected area. Without adequate debridement, antibiotic therapy will not succeed.

Wound disruption (dehiscence)

Disruption, or dehiscence, is defined as a forcible splitting open of the wound. It occurs when the pressure or stress on the wound exceeds the strength of the tissue or the suture. A partial dehiscence involves one or more layers, and is usually in the superficial tissues. In a total dehiscence, the entire wound opens and the underlying structures protrude. The location and direction of the incision are considered to be important factors in wound disruption. Dehiscence occurs mostly in incisions in the upper part of the abdomen. The relative tenseness of the muscles and fascia in this area, due to attachment to the thoracic cage, is a major factor. Hematomas, infection, excessive coughing, retching, distention, or poor nutrition often underlie this catastrophe. Inadequate sutures or excessively tight closures are also offenders because they cause the blood supply to be compromised.

Wound disruption usually occurs more frequently in older patients, but it may occur at any age. It also occurs more frequently in males than females. It is most common between the fifth and twelfth postoperative day.

The first sign is usually a gush of serosanguineous peritoneal fluid from the wound. The rupture may occur suddenly with coils of intestine escaping through the abdominal wall (evisceration). This rupture causes considerable pain and is often associated with vomiting. When the wound edges part slowly, the intestines may protrude gradually or not at all.

After a diagnosis of wound disruption is made, the patient is usually returned to the operating room where the wound is cleaned and reclosed using very heavy sutures and binders over the sutures.

824. Interrupted suturing techniques

Meticulous approximation of tissues is required to ensure wound edges heal rapidly and without complications. Sutures placed with the main intent of holding wound edges together until they are healed are referred to as the primary suture line. The surgeon can use two basic techniques with several variations to establish a primary suture line, each with its distinct advantages and disadvantages. One basic technique commonly used to approximate nearly all tissues in the past, and still widely used in certain instances, is the interrupted technique.

Characteristics of interrupted sutures

When interrupted sutures are used, each stitch is placed, tied, and cut separately. This type of suturing takes more time than continuous suturing techniques, but it offers two important advantages over continuous suturing. First, interrupted sutures provide better security for the wound. If one suture breaks, the wound edges will not completely separate because the other interrupted sutures are still there to hold the wound together. Second, if a wound is infected or grossly contaminated, placement of interrupted sutures helps prevent the spread of infection along the primary suture line.

You should know something about the basic and special interrupted suturing techniques you'll see surgeons use in different situations.

Basic interrupted suturing techniques

The most commonly used interrupted suturing techniques involve placement of simple sutures, vertical mattress sutures, and horizontal mattress sutures.

Simple sutures

Simple sutures are sometimes called over-and-over sutures because the suture makes a single loop down through, between, and over the top of the tissue edges on either side of the wound. When using this technique, the surgeon ensures the suture needle is inserted and brought out of the tissues equidistant from the wound edges. In surgical terms, this is called taking equal “bites” on either side of the wound. After the needle is removed from the suture, the two free ends of the suture strand are tied so the knot rests to one side of the incision line. The knots are tied off to one side so they will not become incorporated into the healing wound.

Simple sutures allow for close approximation of wound edges without excessive eversion (pushing wound edges up and out) or inversion (pushing wound edges down and in). Simple interrupted sutures are often used to approximate deep tissues where strength of the closure is critical. For example, surgeons will often use interrupted sutures on fascia and muscle layers during closure of large abdominal wounds because these tissues must be closely approximated and supported during healing to prevent the wound from rupturing when the patient moves postoperatively. Simple interrupted sutures placed closely together are also frequently used by plastic surgeons to sew skin grafts and flaps in place so scarring can be minimized. Figure 3–12 illustrates the placement of simple interrupted sutures.

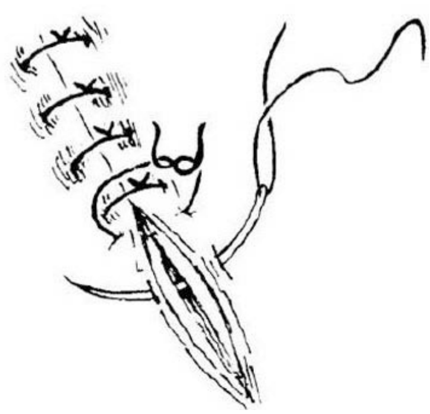


Figure 3–12. Simple interrupted sutures.

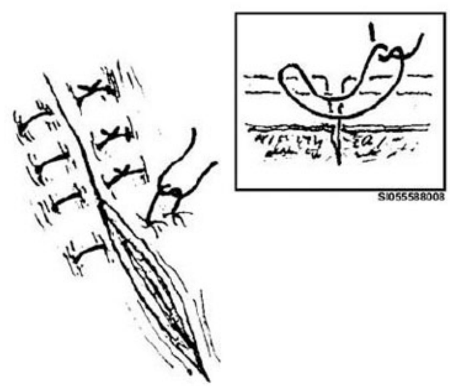


Figure 3–13. Vertical mattress sutures.

Vertical mattress sutures

Interrupted vertical mattress sutures are placed as a combination of vertical superficial and deep needle bites taken equidistant from the wound edges. The surgeon begins by taking a deep bite in the tissue, ensuring the needle goes into and emerges at approximately the same distance from the wound edges. After the deep bite is taken, the surgeon takes a superficial bite in the tissue, inserting the needle in the direction opposite from the direction in which the first bite was taken. Once again, the surgeon ensures the needle enters and emerges the same distance from the edges of the wound. The needle is removed and the free suture ends are tied uniformly on one side of the incision line.

Interrupted vertical mattress sutures are frequently used for skin closure. The additional superficial bite allows for more exact approximation of skin edges without eversion or inversion. This suturing technique provides the most cosmetic skin closure with the possible exception of closely spaced interrupted simple sutures. Figure 3–13 shows how interrupted vertical mattress sutures are placed and what the sutures look like in a cross-sectional view.

Horizontal mattress sutures

Interrupted horizontal mattress sutures are placed horizontally instead of vertically. The surgeon places these sutures by making a shallow bite through both sides of the tissue, and then reverses direction to make the second shallow bite parallel to the first bite (fig. 3–14). Since the implanted suture ends are parallel to each other and are brought out of the tissue at different points along the incision, one interrupted horizontal mattress suture can take the place of two interrupted simple or vertical mattress sutures. Like the other sutures we have talked about, the free ends of the sutures are tied so all knots are on one side of the wound.

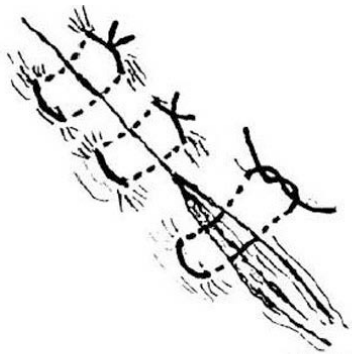


Figure 3–14. Horizontal mattress sutures.

Horizontal mattress sutures evert the edges of the wound and, as a result, causes more scarring when used for skin closure. They are used for skin closure when suture economy is desired and cosmetic closure is unnecessary. Some surgeons will also use interrupted horizontal mattress sutures for EEA of blood vessels.

In addition to the basic interrupted suturing techniques we just outlined, surgeons also use some special interrupted suturing techniques to achieve hemostasis.

Special purpose interrupted suturing techniques

Two special interrupted suturing techniques you need to know are the ones most often used by surgeons to control bleeding. One of these techniques involves the placement of a simple interrupted stitch in the end of a large blood vessel before the suture ends are tied around the vessel. This, as you may recall, is referred to as a stick tie, suture ligature, or transfixion suture. When the surgeon places a suture ligature, he or she will pass the suture through the middle of the vessel, tie the suture, then pass the free ends of the suture around the vessel proximal to the first tie, and tie them again. This second tie not only prevents the suture ligature from slipping, it also prevents the first tie, which passes through the middle of the vessel, from bleeding and tearing the vessel wall.

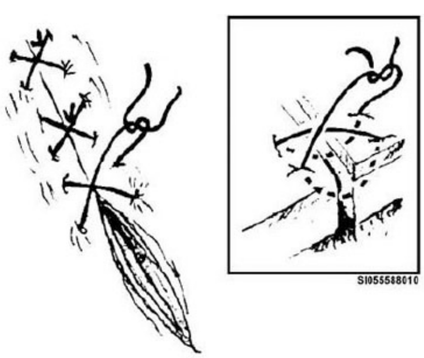


Figure 3–15. Figure of “8” sutures.

The other special interrupted suture is called a figure-of-eight suture (fig. 3–15). This suture gets its name from the crossed, figure-of-eight pattern the suture makes in the tissues. This stitch squeezes the tissue edges tightly together and distributes the pressure almost equally across the surfaces of the tissue approximated by the suture. Figure-of-eight stitches are frequently used by OB/GYN surgeons to suture the cut ends of uterine ligaments during hysterectomy procedures, and they may be used to stop profuse bleeding from the incised wall of the uterus following Cesarean deliveries.

825. Continuous suturing techniques

Another group of suturing techniques that have become more prevalent since the advent of swaged-on suture needles is the continuous suturing techniques.

Characteristics of continuous sutures

Unlike interrupted sutures, continuous sutures are a series of stitches taken with a strand of suture tied only at each end of the strand. These suturing techniques are often called running stitches. Continuous sutures can be placed much faster than interrupted sutures and provide a strong closure because tension is evenly distributed along the entire suture line. With interrupted sutures, uniformity of tension along the primary suture line depends on the surgeon’s ability to tie the individual sutures with the same tension each time. Another advantage to using continuous suturing technique is less foreign material is left in the wound, so there is less likelihood that a severe foreign body reaction occurs postoperatively.

Continuous suturing techniques have two major drawbacks. First, if one area along the implanted suture strand breaks, the whole primary suture line is disrupted and unravels. This can lead to partial or complete wound dehiscence (separation of the layers of a surgical wound) and, in the case of an abdominal incision, evisceration (protrusion of the internal organs through the abdominal wall). The other disadvantage is one we previously mentioned. If continuous sutures are used in the presence of infection, microorganisms can travel down the length of the suture line, transferring infection from one area to another. Infection along a continuous suture line can lead to the formation of draining tracts and sinuses in the tissues.

Basic continuous suturing techniques

Surgeons can use many different continuous suturing techniques in particular situations. The most common ones are the over-and-over, horizontal mattress, and subcuticular stitches.

Over-and-over sutures

The continuous over-and-over stitch is similar to the interrupted version. Like the interrupted over-and-over stitch (simple suture), the continuous stitch uses needle bites placed at equal distances from both wound edges. However, with the continuous over-and-over stitch, the only points along the suture line where the suture loops over the top of the tissue layer at a right angle to the incision are at the very start and end of the suture line (where the first and last stitches are taken). At all other points along the incision, the part of the suture that can be seen on top of the approximated tissue edges appears to be diagonal to the incision line (fig. 3–16). The part of the suture buried in the tissue is perpendicular to the wound edges, just like in the interrupted over-and-over stitch.

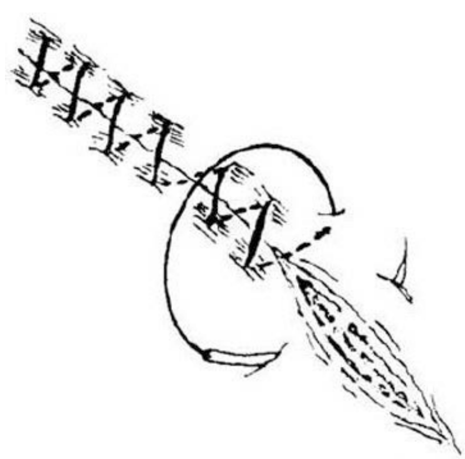


Figure 3–16. Over-and-over continuous suture.

Continuous over-and-over stitches are mainly used on the skin, but they can also be used to approximate delicate tissue layers where strength of the closed wound layer is not a major concern. An example of this is the continuous over-and-over technique routinely used for approximating the peritoneum during routine abdominal wound closure. Some surgeons may also use this type of closure for approximating heavier tissue (fascia, intercostal muscles, etc.), as long as larger diameter, stronger suture materials are used.

Horizontal mattress sutures

A continuous horizontal mattress stitch is much the same as an interrupted horizontal mattress stitch. The surgeon begins by making a stitch, which looks a bit like a simple suture, perpendicular to the end of the wound edges. After this initial stitch is made, the end of the suture farthest from the needle is tied and the excess suture is trimmed off. The stitches are then made horizontal and parallel to the wound edges where they emerge on top of the tissue, and perpendicular beneath the tissue where the two edges are joined together (fig. 3–17). This pattern is continued to the other end of the incision, where the last stitch is made in the same fashion as the first stitch (the exposed suture crosses ove0r the incision like a simple suture). The needle is cut off, and the free end of the suture thus created is tied to an adjacent loop of the continuous suture. The excess suture is then trimmed off.

Figure 3–17. Continuous horizontal mattress suture.

Continuous horizontal mattress sutures cause eversion of the approximated tissue edges and are most often used as an alternate method of suturing skin. Because this type of suture technique causes more scarring than noneverting techniques, it is used in areas of the body where cosmetic closure is not critical (areas that would normally be covered by clothing, such as the abdomen, back, flank, etc.).

Subcuticular stitch

This is a very popular type of continuous closure used to approximate skin. It is used when the surgeon wishes to achieve good cosmetic results (minimal scarring). A subcuticular running closure involves placing stitches in the subcutaneous tissue, just beneath the epithelial layer, in a line parallel to the wound. The stitch is started by inserting the suture needle in a direct line with the incision, just beyond the end. The free end of the suture (end opposite the needle) is either tied in a knot or anchored with a lead split shot (just like the small split shot sinkers used in fishing). The suture is then loosely “woven” back and forth between the subcutaneous tissue on both sides of the wound using short lateral needle bites (fig. 3– 18). Unlike the other continuous suturing techniques, the subcuticular stitch is not pulled taut after every progressive bite. Instead, the tissues are left loosely approximated until the last stitch has been brought out of the skin in line with the other end of the incision. Once the last stitch is placed, the surgeon cuts off the needle and gently draws the suture taut, straightening out wrinkles in the skin edges with a pair of fine-toothed forceps. The end is then secured in the same fashion as the opposite end, using either lead shot or a knot.

Because this type of closure creates a hairline scar without the “railroad tracks” associated with other types of skin stitches, it is often used during pediatric surgery, in plastic surgery, and in all types of surgery on women where incisions are made in potentially visible areas of the body (face, neck, legs, upper and lower back, and mid to lower abdomen).

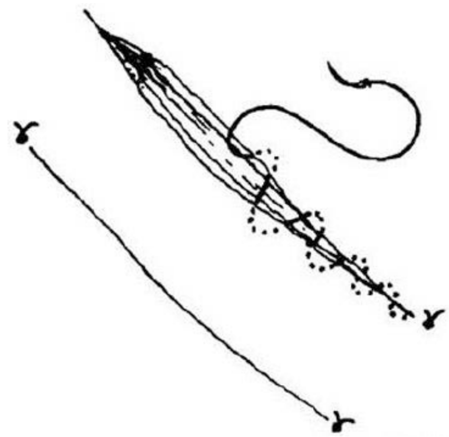


Figure 3–18. Continuous subcuticular suture.

Special purpose continuous suturing techniques

Although there are many variations on the basic over-and-over continuous suturing technique, three techniques warrant further study because of their frequency of use. The special continuous suturing techniques we’ll look at are the purse string suture, Cushing continuous inverting stitch, and locking over-and-over stitch.

Purse string suture

A purse string suture is a continuous strand stitched around an opening, and then tightened in a drawstring manner to invert the edges of the opening (fig. 3–19). The most common use of a purse string suture is to invert the stump of an appendix within the bowel. Purse string sutures are also used to suture around the openings created in organs and other body structures for insertion of drainage tubes. Once the drainage tube is inserted, the purse string suture is pulled tight to create a seal around the tube. The suture ends are then tied around the tube to hold it in place.

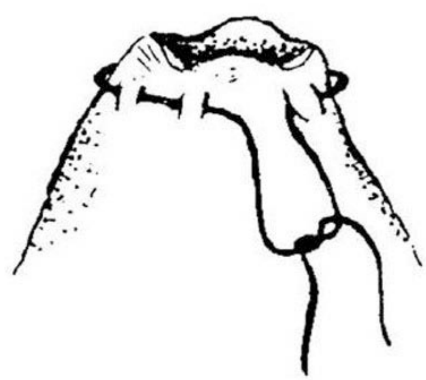


Figure 3–19. A purse string suture.

Cushing inverting continuous stitch

This special suturing technique is used solely for closing the outer layer of a gastrointestinal anastomosis (GIA) (fig. 3–20). The needle is inserted about 2 – 3mm back from the end of the resected intestine and parallel to the incision (bowel end). The stitch is then passed through the outer fibrous coat of the bowel (serosal layer), through the middle smooth muscle layer, and back out again. The suture is crossed over the tissue edges at right angles, and the needle is inserted on the other severed end of the bowel directly opposite the site where the needle emerged from the tissue on the first side of the anastomosis. The stitches are alternated back and forth in this manner around the entire circumference of the GIA. In effect, this stitch does the same thing the EEA and ILS stapling guns do. By starting the stitch 2 – 3mm back from the edges of the two bowel ends, the surgeon inverts the serosal layer into the lumen of the bowel to about the same degree as the tissue left in the lumen after the circular scalpel in the stapler trims away the excess tissue.

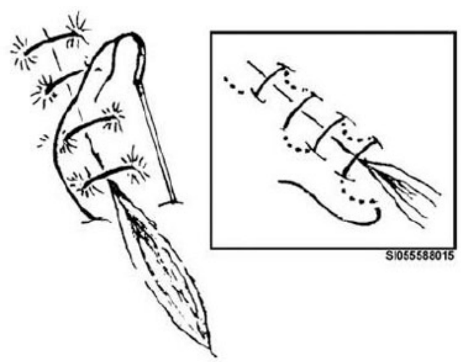


Figure 3–20. Cushing inverting continuous stitch.

Locking over-and-over stitch

This stitch is a basic over-and-over continuous stitch with a slight modification (fig. 3–21). Instead of bringing the needle outside the previous loops of suture created as the needle is passed through the tissue on both sides of the wound, the needle is brought inside the previous loops. This creates a chain of self-locking loops that hold securely when the suture is pulled taut after each stitch is taken. Unlike the basic over-and-over continuous suturing technique that relies on the suture to hold tension on the suture at all times during the placement of stitches, this technique keeps tension on the previously placed stitches without having to pull steadily on the suture. Since constant tension is maintained on the placed stitches, the locking continuous suturing technique is commonly used for GIA. When used for this purpose, the stitches are placed through all three layers of the intestine (serosa, muscle, and mucosa). The main purpose of this stitch is to achieve hemostasis along with a secure closure. You may see some surgeons use this same locking stitch for skin closure.

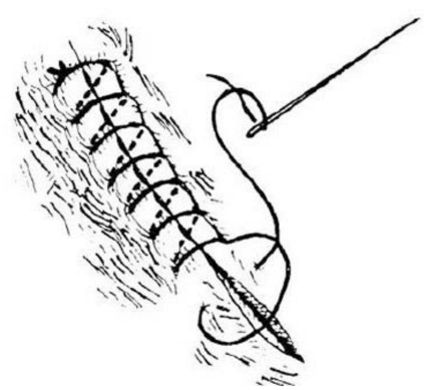


Figure 3–21. Locking over-and-over stitch.

826. A typical layered abdominal wound closure

If you recall, you learned a little bit about a typical abdominal wound closure back in technical school. In fact, you had to arm and pass sutures for a simulated abdominal closure during your major operative procedure performance. You should remember that your instructors closed the simulated abdominal wound in separate layers, which were designed to resemble the various tissue layers in the abdominal wall. Why is a layered closure necessary?

Purpose of a layered closure

Remember the main function of all suture and nonsuture wound closure devices is to hold the edges of a wound closely together until the tissues heal naturally enough that they no longer require artificial support. In the abdominal wall, there are several different layers of tissue, each with very different characteristics. One tissue is very thin and easily torn; other layers are very tough and fibrous. Each layer must be closed separately with different combinations of suture, needles, and staples to ensure the wound edges within each tissue layer line up with each other properly. If this is not done, dead spaces, which may collect body fluids and blood, may be created between the tissue edges. These fluid-filled spaces would then become ideal breeding grounds for microorganisms, and nasty infected abscesses would develop. If left untreated, the infection could become a systemic infection that could kill the patient. Another primary reason for closing the various layers of the abdomen separately is to ensure the wound heals strong enough to withstand the day-to-day stresses and strains the body is put through, without rupturing and causing an evisceration to occur.

Layers of the abdomen and closure materials

Layers of the abdomen that must be closed individually are from inside out the peritoneum, fascia, abdominal muscles, subcutaneous fat, and skin.

Peritoneum

The peritoneum is the first layer of the abdominal wall the surgeon usually closes. It is the thin serous membrane that lines the abdominal cavity and lies directly beneath the posterior fascia in the anterior abdominal wall. The peritoneum heals very quickly, and many surgeons will argue over whether or not this layer needs to be closed at all as long as the posterior fascia is adequately approximated. If the peritoneum is closed, the surgeon will most likely use a 3–0 or 4–0 chromic gut suture with a swaged-on, fine shaft, taper point, or GI needle. A running, continuous sewing technique is usually used to approximate the peritoneum.

Fascia

The fascia is the next layer the surgeon encounters during abdominal wound closure. It is a layer of firm connective tissue that covers and supports muscles throughout the body. It is the strongest tissue in the abdominal wall and heals very slowly. Once cut, fascia will never regain its original strength and takes over a year to heal enough to withstand the normal stresses placed on it. Fascia, therefore, needs to be closed with a suture material that retains its tensile strength for a long period of time.

A medium size multifilament or monofilament nonabsorbable suture that will last indefinitely, or monofilament slow-absorbing suture, should be used. As we mentioned earlier in this unit, a monofilament suture should be used in the presence of infection, and multifilament sutures may be used if the wound is clean. The most commonly used nonabsorbable monofilament suture materials are size 0 or 2–0 polypropylene (Prolene) or stainless steel. Nonabsorbable multifilament sutures, such as 0 and 2–0 silk or polyester (Mersilene), are also frequently used for fascia closure. The most frequently used absorbable sutures are the synthetic absorbables, such as size 0 or 2–0 polydioxanone (PDS), polyglactin 910 (Vicryl), and polyglycolic acid (Dexon). Occasionally, surgeons will also use #1 or 0 chromic gut to close fascia on smaller abdominal wounds.

The needle of choice for fascia closure is a medium size and medium diameter, half-circle taper needle, such as a Mayo needle. (Manufacturers of swaged-on sutures have different names and number codes for their needles; so, until you learn them, look at the pictures on the suture boxes to get a rough idea of the size.) Special staples may also be used for fascia closure.

A layer of fascia lies over and under abdominal muscles. The layer that lies under the muscles, closest to the peritoneum, is the posterior fascia. The layer that lies above the muscles is the anterior fascia. The posterior fascia is always closed during abdominal wound closure; the anterior fascia is seldom closed. Most of the time, the surgeon will use an interrupted suturing technique to close the posterior fascia. This technique ensures the closure remains secure in the event that one or more of the sutures break after the wound is completely closed.

Muscles

During abdominal surgery, the surgeon usually tries to make an incision that splits the muscles along the length of their fibers rather than cut across them. This is done to allow the muscles to heal quickly after surgery. If the muscles are cut across the "grain," they are forever weakened, and there is a much greater chance that a major artery or nerve will also be cut in the process. (The nerves and blood vessels that feed the muscles normally run in the same direction as the muscle fibers.) The surgeon may also try to make an incision that allows retraction of the muscles toward their nerve supply, thereby eliminating the need to incise them and preventing damage to the nerves.

When abdominal muscles are split or retracted, there is no need to suture them during wound closure. Suturing a muscle inhibits normal movement, so the surgeon normally chooses to suture the surrounding fascia layers instead. This provides the necessary wound support and still allows the muscles to move freely within the fascial layers. If a muscle-cutting incision is used, the muscles will need to be sutured together during wound closure. In this instance, the surgeon normally uses the same size and type of sutures and suturing techniques used to close the fascia.

Subcutaneous fat

The subcutaneous fat layer may or may not be closed, depending on the surgeon's preferences and the thickness of the fat layer. Most surgeons will place a few plain gut sutures in a thick fat layer on an obese patient to prevent the formation of dead spaces, which, as we indicated earlier, can lead to a wound infection and abscess formation. If the patient is exceedingly fat, you'll need to cut your closure sutures longer than normal (either in half or third lengths) and use the largest size taper needles available. Closure of the subcutaneous fat layer is usually not necessary in average or thin adults, and in pediatric patients. The most frequently used suture and needle combination for closure of subcutaneous fat in an adult is 3–0 or 4–0 plain gut on a large taper needle.

Skin

Placement of a suture through the skin creates a wound or tract along which epithelial cells migrate into the deeper skin layers. When the suture is removed, a tract lined with epithelial cells remains. Even though most of these cells will eventually disappear, some remain in the tract and form keratin (an insoluble protein that is the main component in epidermis, hair, and nails). This material is what is seen as a scar on the skin. These scars can be avoided through the use of careful subcuticular closure or by avoiding excessive tension on skin sutures and removing them within 7 days postoperatively. Most skin sutures are removed between 3 and 10 days postoperatively.

As we stated previously, skin closure can be done using interrupted or continuous suturing techniques. Whenever practical, interrupted techniques are preferred to prevent the passage of the same suture strand repeatedly through the tissue. Either absorbable or nonabsorbable suture may be used, though the use of nonabsorbable monofilament sutures is generally preferred by most surgeons because they are inert and do not have capillary action. Since skin is a tough, superficial tissue, a 3/8 circle reverse cutting needle is usually used. Synthetic nonabsorbable monofilament sutures, such as nylon or polypropylene (Prolene), in sizes 3–0 or 4–0, are the sutures used most often for adult skin closure. As you already know, surgical skin staples have virtually replaced sutures for skin approximation in most routine abdominal wound closures.

Retention sutures

All the sutures we have discussed for a layered abdominal closure up to this point have been those used in the primary suture line (fig. 3–22, A). Occasionally, the surgeon may decide to use a secondary suture line to help support the primary closure and help eliminate potential dead spaces in the wound. The secondary sutures, more commonly called retention or stay sutures, are placed at intervals along and around the primary suture line. They are used when the surgeon feels the postoperative strain on the wound (caused by coughing, retching, abdominal distention, and even normal movement) greatly increase the risk of wound dehiscence in certain patients. For example, retention sutures are often used to help support the primary closure in obese or chronically ill patients whose wound healing capabilities are significantly diminished.

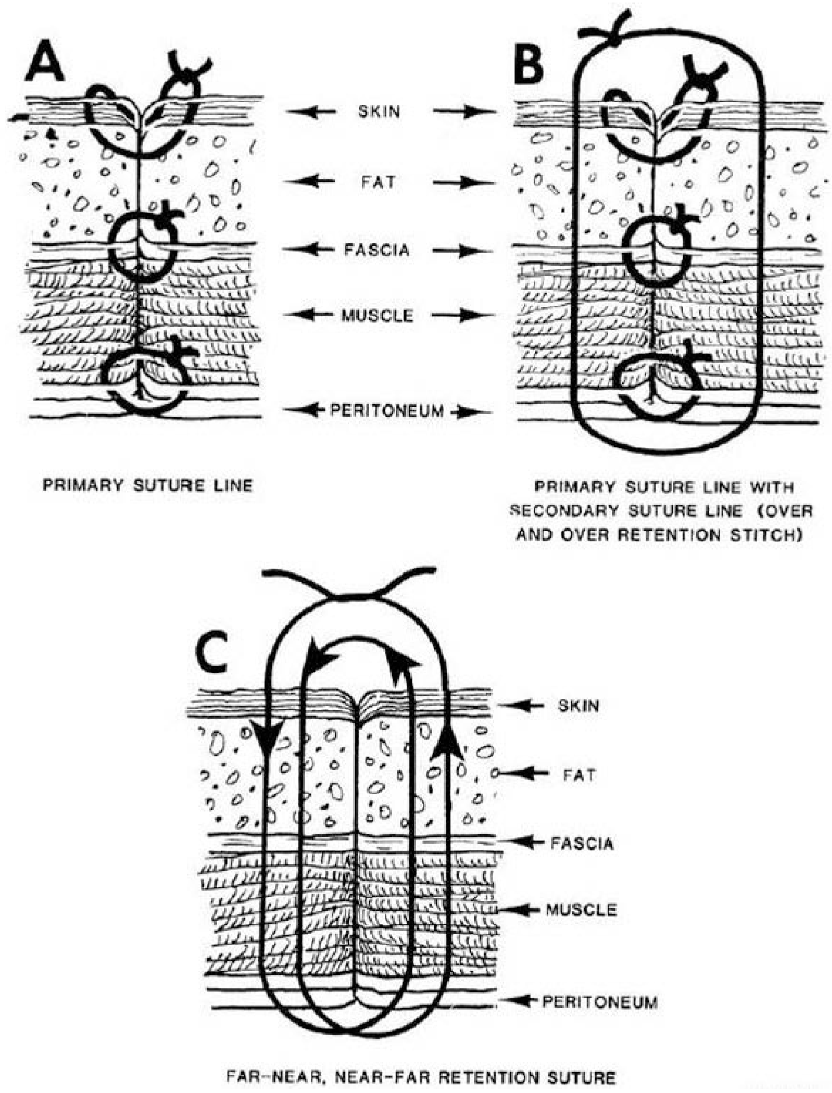


Figure 3–22. Primary and secondary wound closure.

Large diameter nonabsorbable materials (size 0 to #5) are usually used for retention sutures. Large sizes are used mainly to prevent the sutures from cutting through the tissues by distributing the tension over a wider surface area, not just because they are stronger than the sutures used in the primary suture line. To further reduce the risk of the sutures cutting into the skin, they are threaded through special bolsters or rubber "shods" made from cut pieces of tubing. The surgeon may also thread the suture over plastic suture bridges designed specifically for use with retention sutures and use buttons beneath the suture knots.

There are two commonly used techniques for placing retention sutures: the over-and-over technique and the far-near, near-far technique. The over-and-over retention suture is placed in the tissues in basically the same manner as a simple interrupted suture, except it encompasses considerably more tissue. The over-and-over retention suture passes through all the tissue layers in the abdominal wall, from the skin down through the peritoneum (fig. 3–22, B). The far-near, near-far technique produces better approximation of the tissue edges because of the double suture line that is created (fig. 3–22, C). This type of retention suture may be used by the surgeon in place of a layered primary closure as long as several of the retention sutures are placed at approximate 1/2-inch intervals along the incision. After wound dehiscence, it is sometimes difficult for the surgeon to distinguish between the different abdominal tissue layers, a circumstance that makes a layered primary closure impossible. In this instance, retention sutures are used as the sole method of re-approximating the disrupted wound edges.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

823. Care of the wound

1. Briefly describe the four basic types of wounds.

2. What is the ideal intention of wound healing?

3. Describe wound dehiscence.

824. Interrupted suturing techniques

1. What is the primary suture line?

2. What are two advantages of using interrupted sutures over a continuous suturing technique?

3. What is another name for simple sutures?

4. Why are the knots used to secure interrupted sutures tied on the side of the incision line?

5. Simple interrupted sutures often are used to approximate what type of tissues?

6. What interrupted suturing technique everts wound edges and causes greater scarring when used for skin closure?

7. What special interrupted suturing technique used mainly for hemostasis squeezes tissue edges tightly together and distributes pressure almost equally across the surface of approximated tissues?

825. Continuous suturing techniques

1. What is another name for continuous sutures?

2. Cite three advantages and two disadvantages associated with the use of continuous sutures.

3. What are continuous over-and-over sutures primarily used for?

4. What are continuous horizontal mattress sutures mainly used for?

5. What type of running stitch provides the best cosmetic results?

6. For what is a purse string stitch most often used?

7. Which special continuous suturing technique may be used for a GIA?

8. What continuous suturing technique allows the suturer to keep tension on the previously placed stitches without having to pull on the suture?

826. A typical layered abdominal wound closure

1. Why is it necessary to approximate tissues in the abdominal wall separately?

2. What is the first layer of tissue the surgeon usually closes during an abdominal wound closure?

3. What abdominal tissue heals very slowly and needs to be closed with a suture that retains its tensile strength for a long period of time?

4. Why does the surgeon not usually need to suture the muscle layers together?

5. If a surgeon decides to close the subcutaneous layer, what size and type suture would most likely be used?

6. When are most skin sutures removed?

7. What type suture needle do most surgeons prefer to use for skin closure?

8. What are the two main reasons for using retention sutures on an abdominal wound closure?

9. What can the surgeon use to prevent retention sutures from cutting through the skin?

10. Name the two common types of retention suture techniques.

Answers to Self-Test Questions

814

1. Absorbable.
2. The body usually encapsulates, or walls-off, nonabsorbable sutures until they are physically removed.
3. Multifilament.
4. 5–0.
5. The measured force in pounds (tension) that a suture, when knotted, withstands before it breaks.
6. 2–0.
7. Length of time it takes the body to break down and completely absorb the suture.

8. Any five of the following:
   (1) Could be used on any type of surgical procedure.
   (2) Would be sterile.
   (3) Would be noncapillary (nonwicking), nonallergenic, noncarcinogenic, nonmagnetic, and nonelectrolytic.
   (4) Would be easy to handle and tie.
   (5) Would cause minimal to no tissue reaction, and would not harbor or serve to aid microbial growth.
   (6) Won't cut into tissue or fray when knotted.
   (7) Would not shrink after implantation.
   (8) Would be absorbed after serving its purpose, and would cause minimal tissue reaction during absorption.
9. Any four of the following:
   (1) High uniform tensile strength, if used to approximate wound edges.
   (2) Consistently uniform strand size.
   (3) Pliable enough to allow ease of handling and good knot security.
   (4) Predictable absorption rate and loss of tensile strength after implantation in the body.
   (5) Free of impurities and irritating substances, and made of materials that cause minimal tissue reaction.
   (6) Sterile and packaged in ready-to-use form.
10. Any six of the following:
   (1) Biological properties of material in relation to wound healing process.
   (2) Healing properties of various tissues.
   (3) Presence of active infection, wound contamination, or drainage.
   (4) Patient's overall health and physical condition.
   (5) Physical characteristics of suture material.
   (6) Size and location of incision or wound.
   (7) Training and experience of surgeon.
   (8) Availability and cost of suture material.

815

1. To keep the sutures moist and pliable.
2. Processed ribbons of purified collagen taken from the submucosal layer of sheep intestine or the serosal layer of beef intestine.
3. About 70 days.
4. To suture epidermal (skin) tissues that require suture support for only 5 – 7 days.
5. Plain surgical gut that has been treated with a chromium salt solution to prolong the absorption rate.
6. They are made of a pure protein (collagen) that allows suture knots to flatten when tied. Eye surgeons like flatter knots because they cause less irritation of delicate eye tissues.
7. Hydrolysis.
8. Synthetic absorbable sutures.
9. Polyglycolic acid (Dexon).
10. Polyglactin 910 suture (Vicryl).
11. Polyglactin 370 and calcium stearate.
12. In situations where the use of an absorbable suture and extended wound support is desired.
13. Approximately 6 months.

816

1. Tissues that heal slowly and require additional support during the healing process.
2. Surgical silk.

3. They can cause stones to form.
4. Regular silk sutures are braided; usually dyed black; have natural waxes and gums removed from the fibers; and are used for ligating and suturing many different tissues throughout the body. Virgin silk sutures are made from twisted silk fibers that still contain the natural gum, which have white strands, and are primarily used in eye surgery.
5. Cotton.
6. 316L (low carbon stainless steel) that is compatible with stainless steel implants and prostheses.
7. Metal fatigue may develop and cause the sutures to weaken and perhaps break.
8. Infected wounds or wounds where approximated tissues are subjected to great postoperative stress.
9. To prevent kinking and bending thant can cause metal fatigue and weaken the suture.
10. The B&S scale.
11. They require more throws in a knot to ensure security and tend to return to their original coiled packaging configuration (a characteristic known as "memory").
12. To reduce suture drag through the tissues.
13. Due to hydrolysis, they gradually break down and lose tensile strength after implantation.
14. Dip them in warm saline.
15. For retention sutures on large abdominal wounds.
16. Polyester.
17. (1) Polybutilate.
    (2) Teflon.
    (3) Silicone.
18. Teflon.
19. Polypropylene (Prolene).

817

1. Any four of the following:
   (1) Be stable when clamped in a needle holder.
   (2) Carry suture through tissues with minimal trauma.
   (3) A smooth surface and designed to create the smallest diameter puncture wound possible.
   (4) Be sharp enough to penetrate tissues with minimal resistance.
   (5) Be rigid enough to resist breaking, but flexible enough to bend before breaking.
   (6) Be made of a corrosion-resistant material, and sterile to prevent introduction of contaminants and microorganisms into the wound.
2. High-quality, heat-treated stainless steel.
3. (1) Closed.
   (2) French eye.
4. (1) Having to pull a double strand of suture through the tissues.
   (2) Scrub must take more time to thread them.
   (3) Sutures may unthread from eye during passing and suturing.
5. By a sharp tug, straight back from the point of attachment.
6. A single-armed suture has a swaged-on needle at one end of the suture strand; a double-armed suture has a needle swaged to both ends.
7. The body or shaft.
8. To improve the grip of a needle holder and prevent the needle from twisting when it is passed through tissues.
9. Keith.
10. 3/8 circle.
11. 1/2 circle.

12. (1) Cutting.
    (2) Tapered.
    (3) Blunt.
13. Reverse; the third cutting edge is on the outside of the needle curvature, rather than the inside.
14. To increase the cross sectional width so that the needle can be gripped more firmly in a needle holder jaw to prevent twisting as the needle passes through tissue.
15. When suturing delicate, easily torn tissues such as those found in the spleen, liver, and kidneys; for passing heavy ligatures around the cervix during a Shirodkar procedure.
16. Any five of the following:
    (1) Scrub does not need to decide what needle to use with a certain suture.
    (2) They require minimal preparation and handling.
    (3) There is less chance of the sutures pulling free of the needle.
    (4) Easier to find and retrieve if dropped due to attached suture strand.
    (5) Eliminates need for resterilizing or sharpening needles because swaged-on needles are disposable.
    (6) Controlled release swaged-on needles facilitate rapid interrupted suture placement.
    (7) They reduce tissue trauma because there is no eye to make needle hole larger than suture; no double suture strand to drag through tissue; and no chance of a dull, burred, or corroded needle being used (new needle is used for each suture placement).

818

1. Rectangular.
2. Holds the skin edges together and minimizes the rotation of the staples. It also minimizes the tissue compression, postoperative edema, and “railroad tracks” (skin crosshatching) that often result when sutures are used.
3. For suture removal, lift the knot of the suture away from the skin with a pair of forceps. Clip beneath the knot with scissors to release the suture.
4. For staple removal, a staple removal device or a hemostat can be used for extraction.
5. It bends the top part of the staple down against the tissue, forming a kind of figure-eight pattern instead of the rectangular pattern formed by the skin staples; keeps the tissue edges from everting and adds strength to the staple line.
6. To reinforce or bridge defects in fascia and other body tissues.
7. To help the strips adhere to the skin better.
8. An empty suture pack.
9. (1) The tapes are made of cotton and become stronger when wet.
   (2) The dry cotton fibers may stick to the tissue and cause damage, as well as, leave lint in the wound.
   (3) Wetting prevents the tapes from adhering to surgical gloves.
10. Bone cement (methyl methacrylate).
11. (1) Always use a mixing hood or bowl to remove harmful vapors.
    (2) Wear double gloves for insulation from the heat of reaction and to prevent accidental chemical burns.
    (3) Wear protective eyewear.

819

1. Types and amounts of sutures used on a particular procedure; which sutures are used as free ties; which sutures should have swaged-on needles; types of eyed needles required if threaded sutures are used; how long to cut suture strands; and what tissues the various sutures will be used on.
2. Enough suture should be opened so the surgeon won’t have to wait during the procedure (usually one or two packages of each suture listed on the surgeon’s preference card).
3. The scrub and the circulator to pay attention to what the surgeon is doing.
4. (1) The patient’s size and age.
   (2) The patient’s physical condition.

(3) The urgency of the surgery.

(4) The length of the incision.

(5) Possible complications.

(6) How the sutures are packaged.

820

1. Where it is most accessible to the scrub after the operation is underway.
2. To prevent the sutures from cutting through the sterile cover as they are pulled out.
3. (1) Free ties; (2) Continuous ties; (3) Ties-on-a-passer; (4) Stick ties.
4. By looking for a series of holes that represent the size of the suture on the zero sizing scale.
5. When ligating structures in deep cavities and hard-to-reach areas where exposure and visibility are limited.
6. A long, smooth forceps or Debakey pickup; to grasp the end of the tie near the jaw of the right angle clamp after the tie is passed around the structure to be ligated.
7. A suture on a needle that the surgeon passes through the end of a large severed blood vessel before tying the ends of the suture around the vessel stump.

821

1. Any five of the following:
   (1) Store absorbable suture packages at room temperature—avoid areas of high heat and humidity.
   (2) Avoid prolonged soaking of gut sutures. If they must be rinsed, just dip them in sterile saline.
   (3) Keep synthetic absorbable sutures dry—use them directly from the package whenever possible.
   (4) Never re-sterilize absorbable sutures.
   (5) Limit contact between surgical gloves and gut suture strands. Handle gut sutures as little as possible to minimize fraying.
   (6) Straighten coiled strands with a steady gentle pull, do not jerk or tug on the strands.
   (7) Do not test the strength of a suture strand by pulling on it—never pull on a straightened strand to test its strength.
2. It reduces its tensile strength—dry silk is stronger than wet silk
3. A toxic substance called lignin will leach out of the wood and onto the wire. If the "contaminated" wire is then implanted, a severe tissue reaction may result.
4. Gently stroke the strands with gloved fingers a few times—avoid stretching.
5. To ensure you select and open the right type and size suture; to see if there are any needles attached; to determine how many individual sutures or strands are in the package; to determine if swaged-on needles are the controlled release-type; and to learn how to open the package without damaging the contents.
6. To prevent the "springy" strands from becoming contaminated and to give the surgeon "handles" with which to manipulate the wire (this prevents cuts and punctures in the surgeon's gloves). If the wire suture has a swaged-on needle, attach a clamp to the free end before passing it to the surgeon for the same reason.
7. You may accidentally cut the suture inside.
8. To validate counts or double-check after miscounts.
9. Because their cutting surfaces would be dulled and damaged if they were used on the wire.

822

1. (1) If using free needles, try to match the size of the needle to the size of the suture.
   (2) Consider the depth and size of the surgeon's working area to determine the proper needle length, diameter, and curvature.
   (3) Know what type of tissues the surgeon is working on. Choose a cutting needle for dense, tough, fibrous, tissue and a taper needle for delicate, easily penetrated tissues. When in doubt, choose a taper needle.
   (4) Verify the surgeon's suture requirements by asking the surgeon what sutures are needed.

2. The needle should be clamped about one-fourth to one-third of the distance along the shaft away from the eye or swaged end, at right angles to the jaw (unless the surgeon tells you otherwise). The needle holder should be clamped to the first or second ratchet.
3. Ensure 2 – 3 inches of the suture is threaded through the eye and lock the two parts of the suture strand in the gap in the tip of the needle holder jaws.
4. Push 2 – 3 inches of one end of the suture through the eye, pinch the short and long parts of the suture together, and twist them two or three times.
5. Hold onto the long end of the suture until the surgeon has control of the needle holder, and then release it so it falls across the back of the hand holding the needle holder.
6. Because it increases the likelihood the needle will bend or break when passed through the tissues.
7. On a one-for-one basis.
8. All pieces must be accounted for. If the pieces cannot be found, the surgeon is notified, a postoperative X-ray should be taken, and the incident is recorded on the operation report, perioperative nursing record, and hospital incident report form.

823

1. (1) Incised wounds are made by a clean cut with a sharp instrument (i.e., a surgeon's incision with a scalpel).
   (2) Contused wounds are made by blunt force, do not puncture the skin, and cause considerable soft tissue damage, hemorrhage, and swelling.
   (3) Lacerated wounds are made by an object (i.e., a piece of glass or barbed wire) that tears the tissue and produces jagged, irregular edges.
   (4) Puncture wounds are made by a pointed object (i.e., bullet, ice pick, or knife point) and cause a small opening in the skin.
2. First.
3. A forcible splitting open of the wound. A partial dehiscence involves one or more layers, and is usually in the superficial tissues. In a total dehiscence, the entire wound opens and the underlying structures protrude.

824

1. Sutures placed with the main intent of holding wound edges together until they are healed.
2. (1) They provide better wound security.
   (2) In infected or contaminated wounds, interrupted sutures help prevent the spread of infection along the primary suture line.
3. Over-and-over sutures.
4. To prevent the knots from being incorporated into the wound during healing.
5. Deep tissues where strength of closure is critical.
6. Horizontal mattress.
7. Figure-of-eight.

825

1. Running stitches.
2. Advantages:
   (1) They can be placed faster than interrupted sutures.
   (2) They provide a strong closure because tension is distributed evenly along the suture line.
   (3) Less foreign material is left in the wound so there is less risk of a severe foreign body reaction.
   Disadvantages:
   (1) If one area of the suture breaks, the whole suture line unravels and partial or complete dehiscence may occur.
   (2) If used in the presence of infection, microorganisms can travel down the length of the suture, transferring infection from one area to another.
3. Approximating skin edges.

4. For skin closure in areas of the body where cosmetic closure is not critical.
5. Subcuticular.
6. To invert the stump of an appendix within the bowel.
7. Cushing inverting continuous stitch.
8. Locking over-and-over stitch.

826

1. Dead spaces, which may collect body fluids and blood, may be created between the tissue edges. These fluid-filled spaces would then become ideal breeding grounds for microorganisms, and nasty infected abscesses would develop. Another reason is to ensure the wound heals strong enough to withstand the day-to-day stresses and strains the body is put through, without rupturing and causing an evisceration to occur
2. The peritoneum.
3. Fascia.
4. The surgeon usually tries to make an incision that splits the muscles along the length of their fibers rather than across them. This is done to allow the muscles to heal quickly after surgery.
5. 3–0 or 4–0 plain gut on a large taper needle.
6. Between 3 and 10 days postoperatively.
7. A 3/8 circle reverse cutting needle.
8. (1) To help support the primary suture line.
   (2) To eliminate dead spaces in the wound.
9. Bolsters, rubber shods, special plastic suture bridges, or buttons.
10. (1) Over-and-over.
    (2) Far-near, near-far.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

33. (814) What term describes a suture's tendency to wick and provide infected body fluids a pathway to travel between tissue layers?
    a. Tonicity.
    b. Capillarity.
    c. Hydrolysis.
    d. Electrolysis.

34. (814) Which suture is the largest in diameter?
    a. 50 Dexon.
    b. 20 Prolene.
    c. #2 Mersilene.
    d. #5 Nylon.

35. (815) Why do suture manufacturers treat plain gut sutures with chromium salt solution?
    a. Prolongs the suture's absorption rate.
    b. Reduces or blocks its wicking properties.
    c. Lowers the suture's drag through the tissues.
    d. Prevents the suture from fraying when handled.

36. (815) What is a disadvantage of synthetic absorbable sutures?
    a. Tend to flatten when tied in knots.
    b. Must be rinsed in saline before use.
    c. Their packages must contain liquid to keep them pliable.
    d. They may require special knot tying techniques to prevent slippage.

37. (815) Which synthetic absorbable suture is often violet colored, and why?
    a. Collagen. It is intentionally dyed to enhance visibility.
    b. Polyglactin 910. It is intentionally dyed to enhance visibility.
    c. Collagen. Because the chemicals used to make it turn violet when mixed.
    d. Polyglactin 910. The chemicals used in making it turn violet when mixed.

38. (815) Which monofilament suture is made from a synthetic absorbable material and provides wound support nearly twice as long as other synthetic absorbables?
    a. Polyester.
    b. Polyglactin.
    c. Polydioxanone.
    d. Polyglycolic acid.

39. (816) What type of suture must be moistened before use to increase its tensile strength?
    a. Silk.
    b. Nylon.
    c. Cotton.
    d. Collagen.

40. (816) Which suture is the *most* nonreactive and strongest suture available?
    a. Nylon.
    b. Polyester.
    c. Polybutilate.
    d. Stainless steel.

41. (816) Other than stainless steel, which suture is often used for tendon repairs because it causes very little tissue reaction and does *not* adhere to tissue?
    a. Polyester.
    b. Virgin silk.
    c. Polypropylene.
    d. Poliglecaprone 25.

42. (817) Which statement concerning swaged-on needles is false?
    a. Double-armed sutures have a needle swaged to each end of the suture strand.
    b. Most swaged needles have a hole in the side of the shaft to allow for suture insertion.
    c. Controlled-release swaged-on needles are designed to be removed from the suture by a sharp tug.
    d. Needles swaged onto sutures provide a continuous suture-needle unit which minimizes tissue trauma.

43. (817) The longitudinal ribs from point to end on many needles are *primarily* designed to
    a. reduce glare and reflection.
    b. help the needle cut dense tissue.
    c. increase the strength of the needle.
    d. improve the grip of the needle holder.

44. (817) The type of needle point used when suturing dense tissue, and designed to reduce the chances of cutting the tissue between the needle holes and the wound edges is a
    a. taper.
    b. side cutting
    c. reverse cutting.
    d. conventional cutting.

45. (817) What type of needle point is used on tissues such as peritoneum, intestines, and subcutaneous fat?
    a. Blunt.
    b. Taper.
    c. Trocar.
    d. Cutting.

46. (817) What type of needle point would a surgeon *most* likely use to suture friable tissue like that found in the liver and kidneys?
    a. Blunt.
    b. Taper.
    c. Trocar.
    d. Cutting.

47. (818) In surgery, benzoin is applied to the skin before application of skin closure strips to
    a. create an anti-bacterial film on the skin.
    b. form a transparent protective seal over the wound.
    c. make the skin tacky to help the strips adhere better.
    d. prevent an allergic reaction to the adhesive on the strips.

48. (818) What should you use as a container for collodion?
    a. A prep cup.
    b. A medicine glass.
    c. A specially vented bowl.
    d. An empty suture packet.

49. (818) When mixing bone cement on the sterile field, the scrub should employ all safety measures *except*
    a. wearing double gloves to prevent chemical burns on the hands.
    b. wearing protective eyewear to prevent chemical burns of the eyes.
    c. wearing a fine micron filter mask to prevent inhalation of noxious fumes.
    d. using a special hood or bowl that vents harmful fumes out of the operating room.

50. (819) During an operation, the scrub should anticipate what sutures the surgeon will need by doing all of these *except*
    a. looking into the wound to determine what type of tissue the surgeon is working on.
    b. loading needle holders with one of each type of suture and keeping them all on the Mayo tray.
    c. trying to estimate how deep the tissues are that the surgeon is working on and determine whether there are any bleeders.
    d. listening to the conversations between the surgeon and the assistants to determine what stage of the operation has been reached.

51. (819) At the latest, when should a surgical technician ask the surgeon if more of a particular kind of suture is required?
    a. After passing the last suture of that particular kind to the surgeon.
    b. At the beginning of an operation, before the surgeon gets too busy to answer.
    c. When there is still one unused suture of that particular kind on the sterile setup.
    d. As the surgeon is tying the knots in the last suture of that particular kind in the wound.

52. (819) A surgeon may substitute monofilament suture for multifilament suture in an infected wound primarily because
    a. monofilament suture generally has less capillary action than multifilament.
    b. multifilament suture generally has less capillary action than monofilament.
    c. monofilament suture is made from stronger material than multifilament.
    d. multifilament suture is made from stronger material than monofilament.

53. (820) When sutures are placed under the instruments on the Mayo tray, the scrub should pad the sterile Mayo stand cover with a towel. This is necessary to
    a. keep the sutures as dry as possible to preserve pliability.
    b. keep the sutures as dry as possible to preserve their strength.
    c. prevent the suture strands from fraying as they are pulled out.
    d. prevent the suture strands from cutting through the cover as they are pulled out.

54. (820) How should you determine what size suture is on a ligature reel?
    a. Count the number of holes in the reel.
    b. Ask the circulator to check the package.
    c. By the color of the reel; most are color coded by size.
    d. Compare the suture with other suture strands on the field.

55. (820) What is another name for a suture ligature or stick tie?
    a. Stay suture.
    b. Running stitch.
    c. Tie-on-a-passer.
    d. Transfixion suture.

56. (821) How should the circulator open long suture packages like the ones used for wire sutures?
    a. Open the end cap and slide the wires out until the scrub can grab them.
    b. Peel back the flaps of the external package fully, and project the inside package onto the sterile field.
    c. Open the end cap and let the scrub reach into the package and remove the wire with a clamp or forceps.
    d. Peel back the flaps of the external package about 6–8 inches, and present the inside package to the scrub.

57. (821) What is the *best* way to open a foil suture pack on the sterile field?
    a. Cut the sealed edge of the package with suture scissors.
    b. Squeeze the center of the package to pop the package end open.
    c. Hold the package by the sealed edge and tear open the notched end.
    d. Cut the notched end with a delicate scissors to avoid harming the suture inside.

58. (822) When positioning a needle in a needle holder, the needle holder should be clamped
    a. as close to the needle end as possible.
    b. on the last ratchet to hold the needle firmly.
    c. about 1/4 to 1/3 of the distance from the end.
    d. about 1/4 to 1/3 of the distance from the point.

59. (822) To straighten out a suture with a swaged-on needle, you should
    a. clamp the needle in a needle holder, then pull gently on the free end and the needle holder.
    b. hold the needle in one hand, the free end of the strand in the other and pull firmly in a straight line.
    c. hold the suture a couple inches from the needle in one hand, the free end in the other, then pull gently.
    d. clamp a hemostat to the free end of the strand and clamp a needle holder to the needle, then pull firmly.

60. (822) To effectively control needles during a surgical procedure, the scrub should do all of these *except*
    a. keep the empty suture packets on the field to help verify counts.
    b. secure each needle in the count pad or other sterile container after the surgeon has used it.
    c. keep needles well away from sponges and tapes so that they will not be pulled into the wound.
    d. always pass the surgeon a fresh suture and needle before the previously passed needle is returned.

61. (823) Which type of wound has jagged, irregular edges and is often made by glass or barbed wire?
    a. Incision.
    b. Puncture.
    c. Contusion.
    d. Laceration.

62. (823) What surgical procedure is often performed on infected wounds with necrotic tissue?
    a. Ablation.
    b. Dessication.
    c. Cryosurgery.
    d. Debridement.

63. (823) When one or more superficial layers of the wound split open, you refer to the condition as a
    a. total disruption.
    b. partial dehiscence.
    c. ruptured hematoma.
    d. complete evisceration.

64. (824) The knots of a skin suture are tied to one side of the incision to
    a. keep the suture from being incorporated into the wound.
    b. lock the stitches together in a chain-pattern to reinforce the closure.
    c. increase the tensile strength of the suture at one of its weakest points.
    d. allow antibiotic ointments and/or dressings to make maximum contact with the incision.

65. (824) What suture stitch is often used by obstetrics and gynecology (OB/GYN) surgeons to ligate the ligaments during a hysterectomy?
    a. Noncrushing B.
    b. Figure of eight.
    c. Continuous horizontal mattress.
    d. Interrupted horizontal mattress.

66. (825) Advantages of continuous suturing techniques include all *except*
    a. they can be placed much faster than interrupted stitches.
    b. they evenly distribute tension along the entire suture line.
    c. the wound is more secure because if one stitch breaks, the others still hold.
    d. less foreign material (suture) is left in the wound to cause potential reaction.

67. (825) The special suturing technique used solely for closing the outer layer of a gastro-intestinal anastomosis is the
    a. subcuticular.
    b. Cushing inverting.
    c. purse string suture.
    d. locking over-and-over.

68. (826) A surgeon will *most* likely use a 3–0 or 4–0 absorbable suture with a fine, taper point, gastrointestinal (GI) needle to close the layer of
    a. skin.
    b. fascia.
    c. muscles.
    d. peritoneum.

69. (826) Which layer is closed with a suture material that retains its tensile strength for a long period of time because, once cut, it takes over a year to heal enough to withstand the normal stresses placed on it?
    a. Skin.
    b. Fascia.
    c. Peritoneum.
    d. Subcutaneous.

70. (826) Why are bolsters and suture bridges ujsed on the sutures used to support the primary suture line and eliminate dead spaces?
    a. Make it easier to remove the sutures.
    b. Prevent the suture from cutting into the skin.
    c. Prevent uneven tension on the wound edges.
    d. Identify the order the sutures should be removed.

Student Notes

Glossary

Terms

Absorbable suture–A suture that will be dissolved or digested by body enzymes or other chemical processes, and absorbed into the tissues.

Absorption rate–The length of time required before an absorbable suture is completely broken down by enzymes and absorbed into the body, with no physical remnants of the suture remaining in the tissues.

Acidosis–A pathological condition caused by accumulation of acid or depletion of the alkaline reserve (bicarbonate content) in blood and body tissues, characterized by a decrease in pH.

Alkalosis–A pathological condition caused by an accumulation of base or loss of acid in body fluids, characterized by an increase in pH.

Anesthesia–Loss of sensation with or without the loss of consciousness.

Approximate–To bring together; join. In wound closure, bringing cut tissue layers together through the use of sutures or staples.

Arteriogram–Injection of an iodine based contrast media into to arterial system to determine areas of restricted or blocked blood flow, or possible aneurysms. These diagnostic studies are also called angiograms.

Capillarity–In wound closures, it is a property of multifilament sutures which causes them to soak up and transfer fluids along the length of a strand, much like the wick on a candle. This can lead to the spread of contaminants from one area in the body to another.

Cholangiogram–Injection of an iodine based contrast media into the biliary tract to determine the presence of stones or other obstructive conditions.

Continuous reel–A round plastic spool containing a long strand of suture from which a surgeon can strip or cut a length of material for use as a tie. Reels allow the surgeon to make several ties without having to wait for the scrub to pass individual suture strands.

Crenation–Shrinking of a cell (such as a red blood cell) when it is placed in a hypertonic solution.

Dehiscence–Separation of the layers of a surgical wound.

Diluent–An agent (solution) used to dilute an existing solution or reconstitute a powdered substance.

Encapsulated–Enclosed by a “capsule” or sheath of material not normally found in that part. Most nonabsorbable sutures will become encapsulated by fibrous connective tissue after implantation in the body.

Eversion–Turning outward. In wound closure, the turning out of wound edges that is caused by certain suturing techniques.

Evisceration–Protrusion of the internal organs through the abdominal wall.

Free-tie–A strand of suture without attached needles, used for tying off bleeders or other structures.

Glucose–A six carbon sugar found in certain foods, especially fruits, and in the normal blood of all animals. It is the end product of carbohydrate metabolism and is the main source of energy for living organisms. Utilization of glucose in the human body is controlled by the pancreatic hormone insulin.

Hemolysis–Lysis or bursting of red blood cells.

Hemostasis–Stopping the free-flow of blood or hemorrhage; by induced coagulation, which is the formation of a blood clot by thermal, chemical or mechanical methods.

Hydrolysis–A chemical process whereby water molecules split chemical bonds. In suture terms, it is the process where water molecules from tissue fluid penetrate and split the chemical bonds between the polymers in synthetic absorbable and some “nonabsorbable” suture materials, causing the suture to dissolve and be absorbed into the tissues.

Hypertonic–The term used to describe the tonicity of a solution which has a higher solute concentration than that of the body cells. When cells are placed in a hypertonic solution, water will move out of the cells across their semipermeable membranes into the hypertonic solution, causing the cells to shrink.

Hypotonic–A term used to describe the tonicity of a solution which has a lower solute concentration than that of the body cells. When cells are placed in a hypotonic solution, water will move into the cells across their semipermeable membranes, causing the cells to swell.

In vivo–Within the living body.

Induced hypothermia–An intentional cooling of a part of the body or the entire body for the purpose of relieving pain, decreasing metabolic processes, lowering body temperature, or lowering the body’s oxygen requirement.

Inert–In reference to suture materials, it is the property which makes the material nonreactive in tissues. In other words, the material will not cause a tissue reaction or inflammation.

Inversion–Turning inward. In wound closure, the turning in of the wound edges caused by certain suturing techniques.

Isotonic–A term used to describe the tonicity of a solution which has the same solute concentration as the body cells. When cells are placed in an isotonic solution (such as normal saline), there will be no movement of water either into or out of the cells.

Lower GI series–An x- ray diagnostic procedure of the large intestines and rectum usually accomplished after a patient has been given an enema containing barium sulfate in solution.

Lysis–Bursting of a cell (such as a red blood cell) when it is placed in a hypotonic solution.

Monofilament suture–A suture made from a single strand of material.

Multifilament suture–A suture made from several filaments twisted or braided together into a single strand.

Myelogram–Injection of an iodine based contrast media into the spinal subarachnoid space to determine the presence of spinal cord tumors, congenital defects, and herniated intervertebral disks.

Necrosis–Physical and physiological changes in cells, tissues, and organs indicating death of these structures.

Nonabsorbable suture–A suture that will not be dissolved, digested, or absorbed when implanted in the body. Nonabsorbable sutures placed in deep tissues will become walled off or encapsulated. Those placed in skin must be removed after wound healing in the tissues.

Osmosis–Movement of a pure solvent (such as water) across a semipermeable membrane, from an area of lesser solute concentration to an area of greater solute concentration.

Parenteral administration–Is injecting a drug or solution through a needle or infusing it through a catheter.

Ph–Acidity measurement. It refers to the degree of acidity or alkalinity of a substance.

PO–Oral medications are solids (tablets, powders, or capsules) or liquids given to the patient to take by mouth.

Platelet–A **disk** shaped structure found in the blood of all mammals which plays a key role in blood clot formation.

Polymer–A chemical compound formed by the linear combination of repeating molecules (a chain of molecules).

Primary suture line–Sutures placed with the main intent of holding wound edges together until they are healed.

Reconstitution–Restoring a substance previously altered for preservation or storage to its original form. For example, adding a diluent to a powdered drug to make a solution.

Retention suture–Heavy nonabsorbable sutures placed behind and around the primary suture line to add support to the wound and help eliminate dead spaces in the tissues. They can also be used to close ruptured abdominal wounds where it is impossible for the surgeon to distinguish between the various tissue layers and perform a layered primary closure.

Running stitch–A continuous suturing technique where one strand of suture is stitched along the entire length of an incision to approximate the tissues.

Secondary suture line–A line of sutures placed behind and around a primary suture line in order to help support the wound closure and eliminate dead spaces in the tissue. Another term for retention sutures.

Solute–A substance dissolved in a solvent (liquid).

Specific gravity–The ratio of the density of a substance to the density of another substance taken as a standard. Water is the standard for liquids and solids, and hydrogen is the standard for gases. In body fluids such as urine, specific gravity is the mass (weight) per unit volume of the fluid, expressed in grams per milliliter (gm/ml).

Stick tie–Any suture material attached to a needle (threaded or swaged on), which is stitched through the end of a severed blood vessel before the suture is tied around the vessel. This is done to prevent the knotted tie from slipping off the vessel. (Also called a suture ligature or transfixion suture.)

Suture–Any material used to bring tissues together by sewing; also can refer to a suture needle combination or the act of sewing tissues together.

Suture ligature–Another term for a stick tie.

Swaged–Term used to describe the attachment of a suture strand inside the head of an eyeless needle.

Tensile strength–The amount of force a suture will withstand before breaking, after being tied in a knot. Sometimes called “knot pull strength.”

Tie-on-a-passer–A strand of suture attached to the end (jaw) of a long ring- handled forceps (clamp) for the purpose of tying off blood vessels and other tubular structures in deep cavities where exposure is limited.

Upper GI series–An x-ray diagnostic procedure of the oropharynx, esophagus, stomach, and small intestine, usually accomplished after a patient swallows a thick, chalky solution containing barium sulfate contrast media.

Abbreviations and Acronyms

B&S	Browne and Sharpe (scale used to size wire sutures)
cc	cubic centimeter
CDC	career development course
CHG	chlorhexidine gluconate
CO_2	carbon dioxide
D5W	dextrose 5 percent in water (IV solution)
D5RL	dextrose 5 percent in Ringer's lactate (IV solution)
D10W	dextrose in water 10 percent in water (IV solution)
D20W	dextrose in water 20 percent in water (IV solution)
EEA	end-to-end anastomosis
EID	electronic infusion device
ENT	ear, nose, and throat
ESU	electrosurgical unit
FIFO	first in, first out
GI	gastrointestinal
GIA	gastrointestinal anastomosis
gtt/min	drops per minute
HF	high-frequency
ILS	intraluminal stapler
IM	intramuscular
IV	Intravenous
KTP	potassium titanyl phosphate
LDS	ligator-divider staplers
LR	lactated Ringer's solution (also abbreviated RL)
MCH	microfibrillar collagen hemostat
m	Minimum
ml	Milliliter
ml/hr	milliliters per hour
mm	Millimeter
NCOIC	noncommissioned officer in charge
Nd YAG	neodymium-yttrium aluminum garnet
NPO	nothing by mouth
NS	normal saline
OB-GYN	obstetrics and gynecology

OR	operating room
PACU	postanesthesia care unit
PDS	polydioxanone suture
pH	measure of the acidity or alkalinity of a substance
RBC	red blood cells (erythrocytes)
Rh	Rhesus factor
SF	standard form
SQ	subcutaneous
TURP	transurethral resection of the prostate gland
USP	United States Pharmacopeia
YAG	yttrium aluminum garnet

Student Notes

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