The aim of suturing is to hold tissues together with the least interference with their blood supply. Apply the technique most suitable for the tissue, but use the smallest size and, for economy, the fewest types of sutures.

Properties of Absorbable Sutures

Sutures are monofilament and come in a variety of absorbable and nonabsorbable materials, and come in a variety of needles for specific uses. Once the suture is passed through tissue, the barbs provide anchoring and prevent backward slipping of the previously thrown sutures. With each individual barb to tissue connection contributing to the overall strength of the closure, less tension is placed on the knot(s) holding together a traditional closure. Their ease of use also includes a decreased need for slack management as an assistant instrument is not needed to follow and maintain tension on the closure. These sutures have gained popularity among surgeons, especially within the fields of laparoscopy and robotics where knot-tying has increasing difficulty and surgical exposure is more limited. Two common uses include the renorrhaphy closure in partial nephrectomy and the vesicourethral anastomosis in radical prostatectomy.

Table 2.1 summarizes the characteristics of several sutures. In general, polyglycolic acid sutures are preferable to PCG or CCG for urologic surgery, except in cases of infected urine and for the skin. Because of expense, use as few different sizes and kinds of sutures as possible for urologic surgery, except in cases of infected urine and for the skin. Because of expense, use as few different sizes and kinds of sutures as possible:

<table>
<thead>
<tr>
<th>Most Reactive</th>
<th>Catgut</th>
<th>Synthetic absorbable</th>
<th>Nylon</th>
<th>Least Reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactive</td>
<td>Cotton</td>
<td>Multifilament</td>
<td>Steel</td>
<td>Nonabsorbable</td>
</tr>
<tr>
<td></td>
<td>Silk</td>
<td>nonabsorbable</td>
<td>Polyethylene</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Polypropylene</td>
<td></td>
</tr>
</tbody>
</table>

Reactivity of the tissue to the foreign body depends on the size and type of suture material and the type of reaction it invokes. The larger the size, the greater the reaction.

Suture Techniques

KNOT-tyING TECHNIQUES

There are three basic knots: square, surgeon’s, and double throw (Fig. 2.1).

- **Square knot** (see Fig. 2.1A). The simple square knot holds in polyglactin and polyglycolic acid sutures if they are uncoated (Dexon). If coated sutures (Vicryl and Dexon S) are used, an additional throw is needed (see Fig. 2.1B). Care must be taken to lay each throw square to the last.

- **The surgeon’s knot** (see Fig. 2.1C) allows the suture to hold the tissue without slipping after placement of the first throw but is no more secure than the square knot, requiring, except with Dexon, additional throws.

- **The double-throw knot** (see Fig. 2.1D), essentially a double surgeon’s knot, has the greatest knot-holding ability for all suture materials. Only polydioxanone (PDS) and nylon (Ethilon, Dermalon) require an extra throw. Polyglyconate (Maxon) was found to be the best for knot-holding capacity and breaking force. To be absolutely safe, tie synthetic absorbable sutures (SASs) with three knots. Monofilament nonabsorbable sutures (NASs) may require six or even seven extra throws, all placed flat.

Tie a suture while holding it near its free end; the suture may thus be used twice, saving suture material and time. Instrument ties are somewhat slower to make but use appreciably less suture material.

SUTURES

Selection

Individual surgeons have their own preferences for sutures, but two important variables must be considered: the persistence of strength and the degree of tissue reactivity. The initial strength is proportional to size, but the rate of loss of strength is a function of the suture material. The rate of absorption also depends on the suture material, but it is not directly related to the rate of loss of strength. In general, the strength of the suture is lost much more rapidly before it has been absorbed. A suture must maintain sufficient strength to ensure adequate apposition of tissue until the wound can withstand stress without mechanical support. Decrease in the strength of a suture during healing should be no more than proportional to the gain in wound strength. Relative absorption of suture material in the subcutaneous tissues: catgut—1 month; polyglactin (Vicryl)—2–3 months; polyglycolic acid (Dexon plus)—4 months; PDS—6 months; polyglyconate (Maxon)—7 months. Bladder regains 70% of tensile strength in 2 weeks, fascia 50% in 2 months, and skin 30% in 3 weeks.
TABLE 2.1  SUTURE TYPES

<table>
<thead>
<tr>
<th>TRADE NAME</th>
<th>Absorbable</th>
<th>Synthetic Braided</th>
<th>Synthetic Monofilament</th>
<th>Nonabsorbable</th>
<th>Synthetic Braided</th>
<th>Synthetic Monofilament</th>
<th>Barbed Locking Sutures</th>
<th>Absorbable and Non-Absorbable Monofilament Polymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethicon</td>
<td>Polyglactin Coated</td>
<td>Vicryl Uncoated</td>
<td>Polysorb Dexam S</td>
<td>Polyglyconate</td>
<td>Maxon</td>
<td>PDS</td>
<td>Proline Surgilene</td>
<td>Stratafix V-Loc</td>
</tr>
<tr>
<td>Covidien</td>
<td>Polyglycolic acid Coated</td>
<td>Dexam plus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polyglycolic acid Coated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polyglycolic acid Coated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polyglycolic acid Coated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


TABLE 2.1  SUTURE TYPES

Regardless of what suture is used, the immediate strength of the wound is only 40%–70% of the intact structure. With NASs, reduced strength persists at least for the 2 months or so that it takes for the wound to heal completely. For an absorbable suture, the initial strength is the same as that of a nonabsorbable one if an equivalent size is used, but in 1 or 2 weeks the strength declines appreciably. However, by that time, the wound itself has gained enough strength that it balances the diminished strength of the sutures. Thus the wound is most vulnerable to separation during the second week. For this reason, NASs are often used for closure of wounds subjected to stress, such as those of abdominal and flank incisions.

Fascia

For contaminated wounds, the process of absorbing the sutures stimulates macrophage activity with resultant low tissue oxygen tension. This activity also reduces endothelial migration and capillary formation, thus providing a suitable environment for anaerobic bacterial growth. Polyglycolic acid sutures foster the least inflammatory response of absorbable sutures, and the degradation products themselves may be antibacterial. Conversely, NASs, especially monofilaments, produce the least reaction, but once infected they may stay infected because they remain in the wound. Polypropylene is the best choice in contaminated wounds, much better than silk or cotton. For a debilitated patient, in whom poor healing is expected, use either an NAS or an absorbable suture that retains its strength the longest (i.e., PDS). Retention sutures of heavy nonabsorbable material (polypropylene or wire) may be needed in a debilitated patient, especially if the wound is
contaminated. Bolsters cut from a red rubber catheter reduce damage to the skin.

**Subcutaneous Tissue**

The subcutaneous tissue layer is the site of most wound infections because of the weak defense mechanisms in the fatty areolar tissue. Do not use sutures here unless necessary, and then use the finest minimally reactive absorbable suture of polyglycolic acid. Avoid PCG or CCG.

**Skin**

Waterproof tape is best if it is not subjected to too much tension. Staples, if not too tight, are the next best choice because they do not penetrate the wound, but they cost more and require subsequent removal. A subcuticular stitch of monofilament nonabsorbable material leaves a better wound but must be removed. Polyglycolic acid sutures subcuticularly can remain until resorbed, at the same time producing little reaction. This material is not suitable when placed through the skin as interrupted sutures because absorption depends on hydrolysis, and so it persists on the dry surface.

**Urinary Tract**

Urothelium covers the suture line within 5 days. Ureteral and vesical wounds gain strength more rapidly than those in the body wall; normal strength is reached in 21 days. The type of suture material is not as critical here, but absorbable sutures cause less reaction than nonabsorbable ones in the long term. Although more subject to encrustation, absorbable sutures are usually gone before stones can form. Polyglycolic acid sutures are less reactive than CCG sutures, and they have a more predictable rate of absorption. Although polyglycolic acid sutures are not completely absorbed before 28 days, they are usually the better choice, with one exception. In the presence of *Proteus* infection, resorption is much too rapid and catgut should be used.

**Intestine**

Use interrupted NAS, reaching through the muscularis well into the submucosa. If a hemostatic layer is desired, place a running absorbable suture in the mucosa-submucosa. CCG is suitable for sutures penetrating the lumen; otherwise, use SAS. Controlled-release needles speed the process of suturing. In general, place continuous sutures if the tissue is of good quality and interrupted sutures if tissue quality is poor.

**Vascular**

Monofilament synthetic NASs are strongest and least reactive.

### Size and Type

The size and type of suture and the appropriate needle for various structures are listed in Table 2.2.

**SKIN SUTURE TECHNIQUES**

Alternative skin suture techniques include a subcuticular suture, interrupted sutures, staples, and tapes.

**Subcuticular closure** (Fig. 2.2): Use a 4-0 SAS or a monofilament pull-out NAS.

Start the stitch from a buried knot at one end (see Fig. 2.2A). Pull the subcutaneous tissue forward with a fine skin hook, and drive the needle point well into the dermis in a plane parallel to the surface, entering exactly opposite the exit site of the last bite.

To bury the last knot, place a deep stitch and, after tying it, bring the end out through the skin 1 cm from the wound (see Fig. 2.2B). Cut the excess suture, and let the end retract. Alternatively, lock the suture at the start by passing back and forth at one end of the wound, having the needle enter exactly at the site of

### Table 2.2  SUGGESTED TYPE AND SIZE OF SUTURE FOR VARIOUS TISSUES

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Adult</th>
<th>Pediatric</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>Size</strong></td>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>Skin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cosmetic closure</td>
<td>Absorbable</td>
<td>4-0</td>
</tr>
<tr>
<td>Noncosmetic closure</td>
<td>Staples</td>
<td>4-0</td>
</tr>
<tr>
<td></td>
<td>Nonabsorbable</td>
<td>3-0</td>
</tr>
<tr>
<td>Fascia</td>
<td>PDS</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td>Maxon silk</td>
<td>1-0</td>
</tr>
<tr>
<td>Muscle</td>
<td>Absorbable</td>
<td>1-0</td>
</tr>
<tr>
<td></td>
<td>2-0</td>
<td>3-0</td>
</tr>
<tr>
<td>Bladder</td>
<td>Absorbable</td>
<td>3-0</td>
</tr>
<tr>
<td></td>
<td>2-0</td>
<td>3-0</td>
</tr>
<tr>
<td>Ureter-pelvis</td>
<td>Absorbable</td>
<td>5-0</td>
</tr>
<tr>
<td></td>
<td>4-0</td>
<td>6-0</td>
</tr>
<tr>
<td>Urethra (vascular)</td>
<td>Absorbable</td>
<td>4-0</td>
</tr>
<tr>
<td></td>
<td>(Maxon, PDS)</td>
<td>5-0</td>
</tr>
<tr>
<td>Bowel</td>
<td>Staples</td>
<td>3-0</td>
</tr>
<tr>
<td></td>
<td>Absorbable (inner layer)</td>
<td>4-0</td>
</tr>
<tr>
<td></td>
<td>Nonabsorbable (outer layer)</td>
<td>3-0</td>
</tr>
<tr>
<td>Vascular</td>
<td>Nonabsorbable</td>
<td>4-0</td>
</tr>
</tbody>
</table>

FASCIAL SUTURES

Interrupted Sutures

Place 2-0 synthetic absorbable or monofilament sutures 1 cm deep and 1 cm apart (the “one-by-one” rule) (Fig. 2.5A).

Tie suture only tight enough to bring the edges in contact. Throw at least three square knots (see Fig. 2.5B). Monofilament sutures consist of only one strand, so they “can be inadvertently and easily damaged by any instrument, needle or sharp-edged material that cuts or scratches its surface” (The Wound Closure Manual, Ethicon, Inc.). This risk is greater with running sutures that depend on a single knot at either end. If the terminal knot is tied with the so-called loop-to-strand knot, it may pull out. In thin patients and in children, bury the knots to prevent wound discomfort.

Far-and-Near Sutures

Place 2-0 SAS at 1-cm intervals, first deep on one side and shallow on the other, then shallow on one side and deep on the other (Fig. 2.6).

Skin Clips

Skin clips in an automatic dispenser are a rapid but relatively expensive way of closing the skin. Partially squeeze the handle to advance the staple into position. Hold the end of the stapler loosely against the skin with the arrow in line with the incision. Fire the staple. Clips require subsequent removal.

Other Types of Fascial Sutures

Near-and-far suture for mass closure of the abdomen (Fig. 2.7A):

Use 2-0 NAS. Place the deep sutures first, then catch the edges with the shallower bites.

Smead-Jones fascial closure technique (see Fig. 2.7B): Place 2-0 NAS 2 cm apart as figure-eight stitches, taking bites near and far.

Vertical mattress suture (sometimes called a Gambee stitch) incorporates both fascial layers (see Fig. 2.7C): On the first side, pass the suture through the superficial and deep fascia and the...
peritoneum, then back through the peritoneum to exit from
the muscle. Cross to the other side of the wound, enter
the muscle layer, pass out through the peritoneum and deep fascia
and then back through the peritoneum and both layers of
fascia; tie the knot subcutaneously.

The stitch was originally designed as a bowel stitch to prevent
herniation of the mucosa (see Fig. 2.12). For application as a
bowel suture, pass it through all layers on one side, then through
the mucosa and submucosa on the opposite side, next through
the submucosa to exit from the mucosa on the first side, and
finally through all layers on the opposite side.

**BOWEL SUTURES**

**Connell Suture**
The Connell suture is a continuous suture that inverts the inner
wall of the intestine.

Insert the stitch so that it enters and exits the bowel on each
side successively (Fig. 2.8A). It may include only the mucosa and
submucosa. Use 3-0 SAS.

When passed from the inside to the outside, it is an especially
useful technique for closing the angles of a bowel anastomosis (see
Fig. 2.8B).

**Lembert Suture**
An inverting suture that produces serosal apposition, the Lembert
suture includes the muscular layer and some of the submucosal
layer. (No satisfactory form of intestinal anastomosis was available
before the introduction of the Lembert suture.)

Place the suture as an interrupted suture. Insert each bite
to reach into but not through the tough submucosal layer
(Fig. 2.9A).
Purse-String Suture
Place a continuous suture around a defect for inversion (appendix) or closure (hernia sac) (Fig. 2.10).

Lock-Stitch
The lock-stitch is a continuous suture used for mucosal edges (Fig. 2.11). Pass every third or fourth stitch under the previous one. Select this stitch when puckering is to be avoided.

Figure-Eight Bowel Suture
Figure-eight bowel suture is an interrupted suture that approximates the mucosa independently from the muscularis and serosa (Fig. 2.12). Pass the suture through all layers on one side, then through the mucosa and submucosa on both sides. Finally, bring it through all layers on the other side.

Laparoscopic Suturing
In laparoscopic suturing, two needle holders are used. Once the needle is in the abdomen, it should be loaded forehand into the dominant hand driver. It should then be passed through the tissue in a smooth motion, following the curve of the needle. Once the needle is through the tissue, the nondominant hand driver should grasp the needle while releasing the needle from the dominant needle driver.

The method of knot tying is by the “instrument tying” technique that is used in open surgery. The suture should be pulled though the tissue, leaving only a short tail. A C-loop should be formed with the nondominant needle grasper by grasping the needle end of the suture (not the free end) approximately 5 cm from the tissue and holding the suture with some laxity. The dominant needle driver should then be advanced into the concavity of the C-loop. The suture is then wrapped around the dominant needle grasper. The dominant needle grasper should then be used to grasp the short tail of the suture. The short tail is then pulled through the loop and the needle graspers are drawn apart to lay down the knot. This accomplishes the first half of the square knot (an overhand flat knot). The sequence is then repeated with the opposite hands in order to throw the second opposing flat knot, thus completing the square knot.

Knot tying when using barbed sutures remains a topic of debate. With the tension being evenly distributed and the suture secured along its length with each individual barb, the need for a terminating knot may be unnecessary. Comfort with this no-knot technique contradicts decades of surgical experience with nonbarbed sutures, and knots are frequently used to secure barbed suture closures. Although tapered in the direction of the suture, the added barbs cause more friction than standard sutures when passing through tissue. The suture should be pulled through the tissue with as little tension as possible and be done perpendicularly to the tissue to reduce the risk of tearing. When using a unidirectional barbed suture such as the V-Loc, once the needle is passed through the tissue it is then passed through the manufactured loop at the tail of the suture. An anchor in the tissue is created once the suture is pulled through and the loop cinched down on the tissue. After the closure is completed, the end opposite the anchor can be secured by tying the suture to itself similar to with nonbarbed sutures. Alternatively, a locking clip may be placed at the end of the suture. The bidirectional barbed suture such as the Quill, comes double armed; thus the closure starts in the middle rather than at the edges. The terminal ends of the suture can similarly be anchored with a knot or locking clip.

The suture may be placed as a continuous stitch (see Fig. 2.9B). This stitch is useful for closing the end of the bowel or for anastomosis of two ends. Use 4-0 braided NAS. Be sure to catch the submucosa.

To close the end of the bowel, use interrupted Lembert sutures over a clamp (see Fig. 2.9C). Start by placing a traction suture at each end. Lay all the sutures. Hold the sutures on each side, and remove the clamp carefully. Tie each suture successively as the mucosa is inverted.

For a one-layer bowel anastomosis, place interrupted Lembert sutures on both sides, then have an assistant gently withdraw the clamps (see Fig. 2.9D). Tie each suture successively, taking care that the ends are inverted.
FIGURE 2.8 (A, B) Connell suture.

FIGURE 2.9 (A–D) Lembert suture.
For fascial sutures, interrupted sutures in the young healthy male who is muscular or the patient who may be cachectic from cancer or malnutrition are preferable. In other patients, a running absorbable monofilament (size 0) suture is acceptable. It must be emphasized that the fascia should be approximated, not strangulated. Fascial sutures that use near-far figure-eight-type stitches tend to strangulate one of the loops. The Connell suture is a particularly nice technique to use on each end of the inner layer of a bowel anastomosis. This stitch tends to avoid purse-stringing the lumen. Its disadvantage is that it is not a hemostatic stitch.

**SUGGESTED READINGS**

