Disruption of the abdominal incision in the early postoperative period is a persistent problem. The incidence in large series over the past 100 years has not changed appreciably and is in the range of 1% to 2%. Both the ideal wound closure technique and the management of acute wound failure are somewhat controversial because they are predicated on uncontrolled data.

**PATHOGENESIS**

The most common immediate cause of an abdominal wound dehiscence can be placed in one of the following four categories: (1) suture tearing through the fascia, (2) knot slippage, (3) suture failure, or (4) an excessively loose closure and/or excessive stitch interval. Suture breakage is rare with modern materials. Knot slippage and an excessively loose closure would be the fault of the surgeon, but these causes of wound failure also are uncommon. The most common immediate cause (70% to 90% of cases examined) of acute wound failure is suture tearing through fascia, or "fascial failure."

Factors that contribute to fascial failure are debatable. A long list of patient-related conditions (Table 1) have been labeled as risk factors for a burst abdomen. An occasional patient has fascial failure secondary to a true necrotizing infection of the abdominal wall. The putative risk factors in Table 1 are not reviewed in detail here, except to say that a patient with multiple risk factors (the number and combination being unknown) probably is at greater risk (the degree being unknown) for acute wound failure than a patient who has no risk factors. In my opinion, patient-related risk factors, although discussed much in the literature, do not contribute greatly to a patient's risk of fascial failure. The predominant risk factor for fascial failure is the surgeon or, more precisely, inadequate wound closure technique.

<table>
<thead>
<tr>
<th>Table 1 Patient-Related Risk Factors for Acute Wound Failure</th>
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<tr>
<td>Obesity</td>
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<td>Steroids</td>
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<td>Male sex</td>
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<td>Pulmonary disease</td>
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<td>Anemia (especially acute)</td>
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<td>Jaundice</td>
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<td>Cancer</td>
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<td>Wound infection</td>
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<td>Emergency operation</td>
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Note: Factors listed in no particular order.

Throughout the twentieth century, and especially in the last decade, a number of uncontrolled studies have indicated that an adequate bite of tissue during abdominal incision closure can prevent wound disruption in the postoperative period and that an inadequate fascial bite probably is the immediate cause of fascial failure in most wound dehiscences. Animal studies of wound bursting using pneumoperitoneum have demonstrated that, with a relatively small fascial bite, the mechanism of induced rupture in nearly 100% of the wounds is suture tear-through. If a relatively wide fascial bite is maintained, rupture of the abdominal wall occurs remote to the incision. There are clinical series of literally thousands of incisions, most of them vertical midline, in which a wide fascial bite technique was used and in which the incidence of dehiscence is virtually nil. One may conclude that the wound closure technique is the predominant risk factor for wound dehiscence. In other words, the surgeon should be able to prevent most cases of acute wound failure.

**PREVENTION**

Definitions of optimal wound closure technique are based mostly on uncontrolled data and therefore are controversial and evolving. The following guidelines are a perspective on a reasonable closure technique and what appears to be important with respect to prevention of acute wound failure in a vertical midline abdominal incision. This has been the most commonly studied incision; it is not clear if these guidelines pertain to other types of incision.

Running closure of a vertical midline incision should be performed with a relatively wide fascial bite, a relatively short stitch interval, and nonstrangulating tension on the suture (i.e., a loose closure). The fascial bite and stitch interval may be quantified by measuring the suture length/wound length (SL:WL) ratio. An SL:WL ratio of 4 or greater seems to be optimal for the prevention of wound dehiscence; if the SL:WL ratio is less than 4, the risk of wound failure is increased. The degree of risk elevation has yet to be quantitated. A ratio of 4, however, appears to be the break point. It is unclear whether higher ratios (e.g., 6, or 8) offer the same protection without producing other wound complications.

The SL:WL ratio may be calculated by measuring the suture remnants (running closure) after the wound is closed, subtracting them from the starting suture length, and dividing this sum by the wound length (generally taken as the length of the skin incision). Maintaining a fascial bite of 1 cm or more from the wound edge and a stitch interval of 1 cm or less between loops should produce an SL:WL ratio of 4 or greater, but it is recommended that an individual surgeon measure his or her SL:WL ratio to confirm the clinical impression. Taking a wide bite as such usually necessitates going beyond the linea alba into the rectus sheath. Some believe that it is inappropriate to do this because the rectus muscle is included within the suture loop and might undergo necrosis or result in long-term wound pain. I maintain that if a loose closure with an absorbable suture is performed, then including the rectus sheath in the closure will mini-
mize, not increase, the risk for any adverse short- or long-term outcome with respect to the incision.

The assistant who follows during a running closure should apply suture tension so as to just approximate, not strangulate, the tissue. Appropriate suture tension is difficult to assess clinically; theoretically speaking, if the interstitial pressure of the tissue caught within the loops of the suture is elevated above capillary pressure, this tissue will undergo ischemic necrosis, possibly with infection, and the wound will fail. Postoperative abdominal distension can exacerbate or accelerate this potential scenario. Therefore a clinical axiom to follow is to keep the suture of a fascial closure loose. The counterargument to a loose closure is that a loop of bowel will insinuate between slack suture loops; however, maintenance of a short stitch interval (1 cm or less) should prevent this event.

Other issues surrounding abdominal wound dehiscence seem less important. Historically, transverse incisions have been thought to be less prone to failure than vertical midline incisions, but this has not been demonstrated in controlled studies. I prefer the scalpel to open the abdomen because, in animal models, tissue damage from scalpel use is less compared with that from use of cautery. Suture choice (absorbable versus nonabsorbable) has never been shown to be a factor in acute wound failure, as long as the ex vivo tensile half-life of the suture is 2 weeks or greater (for reference, the half-life of polyglactin 910, or Vicryl, is approximately 2 weeks). I usually use a suture with slow absorption (e.g., polydioxanone [PDS]; half-life of 6 weeks). All other variables being equal, mass closure (all coats except skin) may have a slight advantage over layered closure in the prevention of burst abdomen. Running closure is quicker than interrupted closure; other than this difference, neither mass or running closure has been shown to be superior in controlled studies. In addition, whether the peritoneum is closed or not does not affect the incidence of wound dehiscence.

One might argue that if wide fascial bites are vital in the prevention of acute wound failure, placement of prophylactic retention sutures (which take an all-coats bite of 3 cm or more) in all patients should be beneficial. There is support for this approach in the literature of the early twentieth century; of course, many incisions during this period were closed with tanned catgut (catgut closure by itself has a dehiscence rate of 10%), so reinforcement was helpful. There was no positive effect of prophylactic retention sutures in the one controlled study that has been done. Currently, there is no good evidence for the routine use of prophylactic retention sutures. This is not to say, however, that prophylactic retentions should never be used; it may be appropriate to use them in select high-risk patients. Guidelines for the selective use of prophylactic retention sutures are imprecise.

# DIAGNOSIS

The diagnosis of dehiscence with evisceration is obvious, yet many burst abdomens do not present so overtly. Often, there is subclinical dehiscence in which a portion of the fascial closure fails but the skin closure remains intact. This situation usually presents with persistent serosanguinous drainage from the incision. It is important to recognize, however, that most incisions (especially in obese patients) will leak some fluid postoperatively but will not have wound failure. Persistent wound drainage should raise the suspicion for wound dehiscence. A patient with an ongoing leak of serosanguinous fluid from the wound should be monitored closely; early wound exploration in the operating room should be considered. Removing skin staples and probing the incision at the bedside to determine the source of the fluid leak is not advisable. Diagnosis of abdominal wound dehiscence remains a clinical diagnosis. Radiographic studies such as computed tomography delay treatment and are not as informative about the state of the incision as an operative wound exploration. If wound dehiscence is suspected, the best place for the patient is in the operating room.

# MANAGEMENT

## Conventional Closure

Immediate reoperation is the treatment of choice for abdominal wound dehiscence. There are descriptions of nonoperative management ("tamponade") in the earlier literature, but advances in wound closure techniques and critical care have made operative management appropriate for virtually all patients with acute wound failure. The mortality associated with burst abdomen has remained high—up to 25% in large reviews—so attention to the overall condition of the patient is paramount. One should keep in mind that sepsis or cardiopulmonary disease is the cause of death in most patients who die after wound dehiscence.

The patient is given general endotracheal anesthesia with muscular relaxation. The full length of the skin incision is reopened. The fascial closure is inspected, and if deficient, the full length of the fascial incision is reopened. All old suture material is removed. Any devitalized fascia is debrided back to bleeding tissue. An abdominal exploration is performed if there is a suspicion that a leaking anastomosis contributed to the wound failure. The wound is irrigated before resuture.

Virtually all treatises on the treatment of abdominal wound dehiscence recommend close support with retention sutures. There will be no deviation from that tradition here, but it should be pointed out that the efficacy of retention sutures in closure of a burst abdomen has never been demonstrated in a controlled fashion. A variety of techniques for retention suture placement have been described; my fundamentals for retention placement include (Figure 1) the following: (1) use of a large-gauge monofilament nonabsorbable suture on a large cutting needle (e.g., no. 2 nylon swaged to a 2.5-inch needle), (2) an all-coats (peritoneum to skin) course of the needle, (3) a 3- to 5-cm (distance from skin edge) bite of abdominal wall, (4) interrupted suture placement, (5) a stitch interval of 2 to 3 cm, (6) skin protection with suture bolsters, (7) minimal tension when the knot is tied, and (8) removal after a minimum of 3 weeks.

The debrided wound is manually brought together to see if closure can be performed without undue tension. A
A precise definition of undue tension is difficult; it depends in part on the length of the incision and the number of suture loops placed. The force required to tear a single suture from the linea alba (1.5-cm bite) is about 13.5 pounds (60 Newtons). An empiric estimate of undue wound tension would be a force greater than about 5 pounds (about 22 Newtons) pulling on each wound. One of the problems with a wound closed under tension is that, in the extreme, tension may break down the best closure. A more relevant problem, however, is the effect of elevated intraabdominal pressure on respiration. Raised ventilatory pressures may make successful extubation difficult, especially in patients with underlying pulmonary disease. In addition, if visceral edema develops or increases after a tight abdominal closure, there is the risk for abdominal compartment syndrome with subsequent adverse effects on renal function and venous return, as well as respiration. If, in the judgment of the operating surgeon, the wound cannot be closed without undue tension, temporary abdominal closure should be done.

If the wound can be closed without undue tension, retention sutures are placed, going from outside to inside (skin to peritoneum) to inside to outside (see Figure 1). Retentions are left untied until the fascia and skin are closed. The fascia is then approximated using the technique described for primary closure (i.e., with an SL:WL ratio of 4:1). The skin is closed with staples. A skin-protecting bolster (e.g., a sleeve of red rubber catheter or a commercial device) is used as the retentions are tied to complete the closure (see Figure 1).

**Temporary Abdominal Closure**

Temporary abdominal closure (TAC) is an important treatment alternative in patients in whom primary closure of a midline incision is difficult or not desired. If, for example, a patient experiences necrosis of the abdominal wall (e.g., secondary to infection, ischemia) in conjunction with wound dehiscence, approximation of the wound edges may not be advisable because of resultant tension. Temporary closure of the abdomen in such a situation can provide time for conditions to improve so that an elective, permanent closure may be undertaken days to weeks later.

One method of TAC is simply to bridge the fascial defect with a sheet of polypropylene mesh (Prolene) placed in an intraperitoneal position with a generous underlap of the fascial edges. The mesh is secured with circumferential all-coats bolstered sutures (Figure 2). An issue with this technique is how the wound will be handled in the long term (i.e., whether the polypropylene should be removed). It is possible that closure by secondary intention (with or without skin grafting) can occur by leaving the polypropylene in the open (and often contaminated) wound. However, there is a 40% rate of mesh-related wound complications (mesh extrusion or intestinal fistula) in doing this; it actually is remarkable that this complication rate is not higher. If the polypropylene is covered with tissue flaps (full-thickness

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**Figure 1**

Transverse section of retention suture placement. a, Skin; b, rectus muscle; c, peritoneum; d, retention suture; e, bolster; f, fascial closure stitch; g, linea alba.

**Figure 2**

TAC with a sheet of polypropylene mesh placed under the fascia and secured with through-and-through bolstered monofilament sutures. (From Schwartz A, et al: Int Surg 82:42, 1997.)
coverage) at some point after placement, the risk of mesh-related wound complications may be reduced. Alternatively, the mesh may be removed 1 to 2 weeks after placement, at which time a closure may be attempted. Unfortunately, peeling polypropylene mesh from the surface of inflamed bowel after 14 days of contact can be difficult; placing omentum or a sheet of Vicryl mesh between the polypropylene and exposed bowel can reduce this problem somewhat. Vicryl mesh (woven or knitted) may be used by itself for the technique of TAC shown in Figure 2; if Vicryl is used, however, the surgeon should layer two or three sheets together because the bursting strength of a single layer of Vicryl mesh is marginal for abdominal wall integrity. In addition, if the Vicryl is left in situ for the long term without fascial closure, the surgeon should be prepared to deal with the ventral hernia that almost inevitably will ensue.

TAC with progressive abdominal closure may be obtained with the method illustrated in Figure 3. Nylon sutures (no. 2) are placed through all layers of the abdominal wall at least 4 cm from the wound edge and at 2-cm intervals. Rayon cloth is placed below the suture rows onto the bowel surface; this is followed by fluff gauze between the Rayon and the sutures. The sutures are tied so that this mass of dressings lays below the peritoneal level. The patient can be returned to the operating room at 3- to 4-day intervals so that the dressings may be changed and the retention sutures can be progressively tightened; thus delayed primary closure may be obtained.

TAC with progressive closure also may be obtained with a new product called the Wittman Patch, or artificial bur, a Velcro-like material approved for use in the United States in 1999. Insertion of the Patch is part of the operative strategy of serial planned relaparotomy, or staged abdominal repair (STAR), which is intended to treat poorly controlled in-
traabdominal sepsis, severe abdominal trauma, abdominal compartment syndrome, and difficult abdominal closure. The Patch consists of two 20-by-40-cm sheets (trimmable): one constructed of polypropylene with microscopic "mushroom" hooks (the bur), and the other made of polyamide with a loop mesh work. The two sheets are tailored to the wound and then sewn in with running Nylon suture (Figure 4). Wound closure is effected by pressing the sheets together for a Velcro-like adhesion. A self-adhesive plastic drape may then be placed over the entire abdomen (with a closed-suction drain between the bur and the drape) to function as a wound barrier and also to simplify nursing care. The patient is brought back to the operating room at least every other day, and the abdomen is progressively closed by incrementally pulling the Patch leaves together and trimming the excess prosthetic. An advantage of this technique over other TACs is that the Patch permits easy access to the peritoneal cavity for repeated observation/intervention. The Wittman Patch appears to be a promising development in the treatment of difficult abdominal closure.
Figure 4, cont'd
B, Transverse section of delayed primary closure in a wound treated with the Patch.

Suggested Reading