8.1 Incidence

The incidence of acute wound failure (also known as wound dehiscence, wound disruption, burst abdomen, evisceration, or eventration) has remained relatively constant during this century. If data from retrospective studies of large numbers of surgical patients are combined, rates of 0.4% (representing 71,000 incisions), 0.59% (320,000 incisions), and 1.2% (18,000 incisions) are obtained for the time periods 1900–1940, 1950–1984, and 1985 to the present, respectively [7, 13, 54]. The incidence of dehiscence is higher in prospective studies (failure rates ranging from 1% to 3%) compared to retrospective studies [54].

8.2 Pertinent Aspects of Fascial Healing

Fascial incisions have no inherent strength during the first week of healing, so the early integrity of a fascial wound depends entirely on the suture. In the second week of healing, there is a rapid increase in tensile strength; animal data has been variable, but in general a fascial incision regains 50% of the tensile strength of unwounded fascia after 4–6 weeks and plateaus at about 60%–80% after 1 year [2, 19, 24, 47, 51]. Rarely has it been documented that a healed fascial wound reaches 100% or more of the strength of unwounded fascia. The general belief is that wounded fascia never regains its full tensile strength.

The healing zone of a noninfected fascial wound is defined as the area within about 5 mm of each wound edge in which collagen deposition, degradation, and reorganization occurs [1]. An incision closed with sutures placed within this zone is more prone to dehiscence, as the suture can easily tear through the tissue of this biochemically active region. The healing zone may be avoided by placing fascial sutures 10 mm or more from the wound edge.

The presence of a mild degree of inflammation is important for timely gain of fascial strength after wounding. Wounds that have been sutured, allowed to heal for several days, forcefully disrupted, and then resutured regain strength faster than a primarily sutured wound [33, 56, 59, 62]. The explanation for this is that the inflammatory process healing is further along in the disrupted/resutured wounds, shortening the lag time to wound strength development. The injury from the scalpel blade usually
results in adequate inflammation to ensure timely healing of a typical wound [50]. Use of coagulation current from a cautery device, however, may be too destructive, as there is evidence in animals that making an incision with this technique results in slower gain of wound strength compared to use of the scalpel [55]. Inflammation from a mild wound infection may speed gain of tensile strength, as has been shown in animals [6, 65]. There is no data, however, to support the administration of a routine bacterial inoculum to the human wound as a healing aid.

8.3 Choice of Incision

There is considerable retrospective data which supports the superiority of the transverse incision over the vertical midline with respect to dehiscence prevention [16, 29, 30, 41, 43, 61]. A partial explanation for the lower rate of wound failure with the transverse incision is that it cuts the abdominal wall parallel to the aponeurotic fibers, so that contraction of the abdominal wall musculature will tend to pull the incision together. This is opposite to the situation with the vertical midline incision, which has been called "nonanatomic." Study of wound-bursting strength in cadavers has demonstrated that transverse wounds are slightly stronger than midline wounds when 0.5- to 1-cm bites of fascia are taken with the suture needle [27, 68]. However, if a midline incision is closed with wide fascial bites (such that the needle goes through and through the rectus sheath), the bursting strength is 1.5 times greater than the above transverse incision [68]. The available randomized prospective patient data comparing transverse and midline incisions do not show a difference in the dehiscence rates [21, 27]. Two English groups have enjoyed vanishingly low dehiscence and hernia rates with the lateral paramedian incision [15, 18], but confirmatory trials have not appeared yet. A strong declaration regarding the choice of incision to prevent acute wound failure cannot be made.

8.4 Mechanisms

There are four main causes of acute wound failure: a suture break, a slipped suture knot, a loose or excessive stitch interval which allows protrusion of viscer, and suture tearing through the fascia. A wound may fail secondary to a necrotizing infection, but this is rare. Suture tearing through the fascia is by far the most common cause (70%–95%) of acute wound failure, as noted in numerous prospective and retrospective reports and in animal and cadaver wound-bursting experiments [3, 26, 28, 48, 52, 53, 58, 60]. There may be a select few patients in which poor fascia may be blamed for tearing, but the predominance of evidence indicates that an inadequate bite of fascia with the suture needle is responsible for suture tearing through the fascia.
8.5 Choice of Closure

The technique of suturing the incision is the area where an individual surgeon can make the biggest impact in reducing acute wound failure. Taking a large (>1 cm) bite of fascia with each turn of the needle while maintaining a short (about 1 cm) stitch interval seems to produce the strongest closure [42]. This has been quantified as the suture to length ratio [25, 36, 37, 40, 44, 49]. The minimum ratio which has been advocated to optimize wound strength is 4:1, i.e., the length of the suture used to close the wound should be at least four times longer than the length of the wound. Groups which have followed this precept obtain wound failure rates approaching zero. Recently, however, there has been some concern that employment of a ratio greater than 5 will result in an increased chance of wound infection in the obese individual [38, 39].

Much has been written regarding the choice of suture material for abdominal incision closure. The two basic choices are absorbable versus nonabsorbable; another less important characteristic is monofilament versus multifilament. No clear favorite (in terms of dehiscence prevention) for fascial suture has emerged from randomized trials [8, 10–12, 44, 46, 70]. Suture choice, therefore, seems relatively unimportant as long as a rapidly absorbing material (e.g., chromic catgut) is not used for fascial closure [26, 28].

Excessive tension on the suture during wound closure can result in ischemic necrosis of the entrapped fascia, and tightly tied sutures will cut through fascia earlier than loose sutures during wound-bursting experiments [31, 45, 57]. Ideal suture tension should approximate the fascia, yet allow perfusion of the healing wound edges. This translates into a relatively loose closure; the risk of a knuckle of bowel protruding through such a closure can be eliminated by using a short (about 1 cm) stitch interval [40].

There are other aspects of wound closure which, though less important, deserve mention. There is no benefit to closing the peritoneum as a separate layer [22, 35]. There is no benefit to layered closure over mass closure [4]; the latter may be preferable simply because it is quicker. There is no advantage of interrupted closure over running closure [8, 14, 23]; the latter may also be preferable because it is quicker. Knot security is improved by using more throws overall, more double throws in particular, and using all square knots [17, 66, 67, 69]. Routine placement of prophylactic retention sutures is controversial and has not been of benefit in the one prospective trial that has been done [34].

8.6 Risk Factors

The implication from the preceding paragraphs is that an inadequate surgical technique is responsible for the vast majority of burst abdomens, and this is generally true. There are some conditions, however, which have been associated with dehiscence, including male sex, advanced age, emergency operation, operator inexperience, obesity, diabetes, renal failure, jaundice, hemorrhagic shock, protein malnutrition, vitamin C deficiency, zinc deficiency, steroids, and chemoradiation [13]. The signifi-
cance of the association between these factors and acute wound failure has been given
mostly in small retrospective studies, so the amount that any one of these factors adds
to the dehiscence risk of a given patient is difficult to quantify. Intuitively, it would
seem that the presence of multiple risk factors forebodes worse for the patient than
the presence of zero or one factor, but this has not been shown conclusively.

8.7
Role of Infection

Wound infection is a frequently cited risk factor for dehiscence, but again data are
lacking to support a causative role. The cause of fascial disruption is obvious in the
rare patient whose fascia has disintegrated from a necrotizing infection, but dehiscen-
ce usually occurs before most wound infections have an opportunity to become esta-
blished. The animal data on the role of wound infection is conflicting; both salutary
and detrimental effects of a bacterial inoculum on healing have been observed [5, 6, 9, 63, 65].

8.8
Postoperative Increases in Intra-abdominal Pressure

A common observation is that dehiscence is precipitated by a patient coughing or
straining; elevated intra-abdominal pressure is often cited as a cause of burst abdomen.
It has been demonstrated that a healthy awake man (during inguinal herniorrhaphy)
can raise his intra-abdominal pressure to 60–80 mmHg with a Valsalva maneuver [32].
Continuous monitoring of intra-abominal pressure with an intraperitoneal balloon has
shown that resting pressure is 8 cm H₂O (1 mmHg=1.36 cm H₂O), pressure during defe-
cation may rise to 35 cm, and it may go up to 60–80 cm with vomiting or coughing [20].
Wound-bursting experiments on cadavers required intra-abdominal pressure in the
200-mmHg range to rupture a midline or transverse incision [31]. One might conclude
that, based on the cadaver wound-burst data, a properly sutured incision should with-
stand the stress of intra-abdominal pressure generated by the average individual.

8.9
Summary

The incidence of acute wound failure in abdominal incisions has remained around
0.5%–1% during this century. There is little inherent strength in a fascial wound
during the first postoperative week, but during the next month or so there is a rapid
climb to 50% of baseline strength, and this increases to 60%–80% by 1 year. The pre-
dominant mechanism of acute wound failure is suture tearing through the fascia. The
technique of wide fascial bites with a short stitch interval is the most important step
an individual surgeon can take to prevent dehiscence. The rational behind this techni-
ique lies within what we know about fascial strength and healing. The soundness of
this technique has been demonstrated both retrospectively and prospectively.
8.10 Discussion

Filipi: Are there any studies to suggest that retention sutures impair wound healing?

Carlson: Strictly speaking, no. Two studies were published back in the 1930s. One was by Dr. Kennedy, who claimed that, in 56 years of abdominal surgery by himself and his mentor Josef Price in Detroit, they did not have one dehiscence with evisceration. He attributed this to his closure technique, which was a fascial closure with catgut reinforced with retention sutures. His technique of retention sutures was three to an inch, and an inch away from the incision.

Kingsnorth: You said less significant factors were interrupted versus running for closure of an abdominal wound. My concept of this is that, if you put interrupted stitches in, some are going to be tight and some are going to be loose. If there is any problem with the wound, the tightest one is going to give first, and then there will be a domino effect. If you have a running stitch of a monofilament suture, the tension will be spread equally across the whole wound. I wonder where you got this information from concerning interrupted versus continuous sutures for closing wounds.

Carlson: There has been one very good study from France in which 3000 patients were enrolled – a number large enough to prove the point – comparing interrupted versus running closure.

Kingsnorth: I think you have to define what you mean by absorbable. We have all decided that absorbable in terms of catgut is out. Gynecologists prove that to us time and time again. Many of us here in this room have had to reoperate gynecological wounds that were closed with catgut. Could you be a little more accurate in defining what you mean by absorbable?

Carlson: I did not mention catgut, but I should have. Generally, if you close a wound with chromic catgut, you can expect a dehiscence rate of 10% or more. That was shown by a number of investigators in the United Kingdom 30 years ago. Catgut is bad. On a scale of absorbability, Vicryl and Dexon would be intermediate. They have a half-life of 2–3 weeks of tensile strength. In prospective randomized trials, no one has been able to show that using those two sutures – Dexon, Vicryl – has resulted in greater dehiscence rates compared to nonabsorbable sutures.

Kingsnorth: Have they shown any difference in the late wound failure rate?

Carlson: The hernia rate is going to be affected by that type of choice.

Treatner: You told us that a certain degree of wound infection may enhance the tensile strength of the wound in the later course. From my recollection, patients who experience wound infection after hernia surgery are more prone to recurrence than those have had an uneventful course. How could you explain this fact?

Carlson: That would relate more to late wound failure. The effect of wound infection on late wound failure is probably more an issue than it is in acute wound failure.

Bendavid: To answer your question, I am not so sure any more either that wound infection is necessarily a prognostic factor in recurrence. You also have to distinguish
in wound infection between a superficial and a deep wound infection. I find that most of the infections we see are superficial. What you often have to do is open the wound and drain it. I have never seen a deep wound infection that went right through to the peritoneal cavity. Such infections might be associated with increased incidence of recurrence. It is very important to distinguish the two.

Klaiber: Is there any data comparing fascial incisions with the scalpel and electrocautery? It is becoming increasingly fashionable to work with electrocautery.

Carlson: There are some animal data suggesting that using a coagulation current produces a slower course of healing than using a cutting current or scalpel. If you use a coagulating current, it causes more tissue destruction. I use the scalpel.

Israelsson: At our clinic, we have a dehiscence rate of 0.4%. We have collected eight patients with wound dehiscence during the last 7 years. We measure the suture length to wound length ratio in all patients. Of these eight patients, one was sutured with a suture to wound length ratio greater than 4. In this patient, dehiscence occurred 10 days after the laparotomy. He suffered from a deep wound infection and showed necrotizing infection with complete disintegration of the entire abdominal wall. No suture in the world could have saved this patient from wound dehiscence. In one patient, the suture broke at the middle. That was clearly a surgical mistake, because modern suture material does not break unless you do not handle it properly. It was probably the grasp with a needleholder. In the other six patients, the suture length to wound length ratio was less than 4, and in three patients less than 2. In our experience, wound dehiscence is almost invariably due to a bad surgical technique. I would also like to mention a rather nasty way of establishing this. When you reoperate on a person with wound dehiscence, you can measure the length of the skin incision, and the suture is still in the wound. Just take the suture out, measure it, calculate the suture to wound length ratio, and you will find that it is very low. It is probably below 3.

Gislason: I carried out a study of the English literature and looked at all the prospective studies. I found that the continuous method is safer than the interrupted method. There are significantly fewer cases of burst abdomen using the continuous suture method. Regarding the effect of wound infection on burst abdomen, I found that late burst abdomen is associated with high wound infection rates. If you get a burst abdomen after the eighth or tenth day, you have a high incidence of wound infection. The early burst abdomen is probably due to a failure in surgical technique.

Carlson: I would suggest that one of the reasons why wound infection is greater with late dehiscence is probably that the tissue is being strangulated. That is just a hypothesis.

Schumpelick: If the surgeon and the tension of the knotting are really the risk factors, is there any device in the world available to measure it?

Carlson: That was actually done in one prospective study and it contradicts what I have been saying. There was a group in England that took a spring, put 5 kg of tension on each loop as they closed the wound, and found that their burst abdomen rate was lower in the wounds that had the tight closure than the loose closure. Unfortunately, they had a large number of wound infections in the patients that had a tight closure.
Schumpelick: A lot of surgeons are trained without this device. We do not know how to knot. We do it as best we can, but perhaps a lot of our incisional hernias, which are a late result of wound rupture, are caused by knotting in the wrong way. We do not have easily available devices to control our knotting strength. What about bed rest, coughing, weight-lifting, and all these things that are predominantly discussed by practitioners that the patient should avoid.

Carlson: You have to figure out when it is safe for patients to exert themselves, and therefore you have to know how quickly incisions are going to heal. There is a very wide variety from patient to patient. It may not even reflect what is the case in the animals, which is what a lot of these estimates are based on. But in the animals you reach a 50% point at about 4–6 weeks. That might be a safe point, but what exactly is a safe point, I really do not know. And I do not know how you really can determine it. To be safe, I would generally keep patients from exerting themselves for at least 2 months, and if they had a lot of risk factors it should be longer than that.

Kingsnorth: We are talking about acute wound failure. We have a clear distinction between later wound failure and acute wound failure, and I would completely agree with your conclusion about the incidence of acute wound failure being a surgeon-dependent variable. One additional point is the work of T.P.M. Jenkins. In his experimental studies, he found the figure 4. But he also looked at the figure 5. If you have too much suture material, you then begin to have failing wounds. You actually have to get it right. This highlights your point about pulling up the suture tight.

You did mention the spring balance man, who was actually a Pole. He did another very interesting study, in which he put clips along the wound edge in midline wounds. He then X-rayed the patients that day and at intervals up to 1 year. He found that his incidence of acute wound failure was also quite low. The late wound failures were the patients in which the clips separated on day 1. In other words, the surgeon is still an important factor.

Skandalakis: Do you use any gastrointestinal intubation postoperatively?

Carlson: Generally not. Not unless patients have a gastric distension or any reason to have gastrointestinal contents far back enough in the stomach.

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