

Management of Acute Full-thickness Losses of the Abdominal Wall

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Over a 20-year interval, 167 patients sustained acute full-thickness abdominal wall loss due to necrotizing infection (124 patients), destructive trauma (32 patients), or en bloc tumor excision (11 patients). Polymicrobial infection or contamination was present in all but five of the patients. Of 13 patients managed by debridement and primary closure under tension, abdominal wall dehiscence occurred in each. Only two patients survived, the 11 deaths being caused by wound sepsis, evisceration, and/or bowel fistula. Debridement and gauze packing of a small defect was used in 15 patients; the single death resulted from recurrence of infectious gangrene. Pedicled flap closure, with or without a fascial prosthesis beneath, led to survival in nine of the 12 patients so-treated; yet flap necrosis from infection was a significant complication in seven patients who survived. The majority of patients (124) were managed by debridements, insertions of a fascial prostheses (prolene in 101 patients, marlex in 23 patients), and alternate day dressing changes, until the wound could be closed by skin grafts placed directly on granulations over the mesh or the bowel itself after the mesh had been removed. Sepsis and/or intestinal fistulas accounted for 25 of the 27 deaths. Major principles to evolve from this experience were: 1) insertion of a synthetic prosthesis to bridge any sizable defect in abdominal wall rather than closure under tension or via a primarily mobilized flap; 2) use of end bowel stomas rather than exteriorized loops or primary anastomoses in the face of active infection, significant contamination, and/or massive contusion; and 3) delay in final reconstruction until all intestinal vents and fistulas have been closed by prior operation.

ONE OF THE MOST PERPLEXING situations ever to confront the general surgeon is an open abdomen in the absence of adequate somatic substance to effect secure closure of the peritoneal cavity.^{4,9,16} An obsession with the necessity to obtain fascia to fascia approximation, regardless of the tension, has appeared to be the overriding determinant of what action is taken to gain such an end. If, on the other hand, the surgeon attempts to obviate undue tension on the suture line, his debridement of contused and inflamed tissues becomes all too conservative for the massiveness of as-

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sociated bacterial contamination. In either event, the outcome is uniformly predictable. There is the rapid onset of a necrotizing wound infection, which in turn serves as the initiating focus of a progressive, fulminating, and often lethal, more generalized, sepsis.

A modest experience in the management of patients with acute full-thickness defects of the abdominal wall has led to the identification of certain surgical tenets. Unfortunately, failure, especially if repetitive after a specific method of repair, has been much more instructive than has any success. In addition, correction or control of associated injuries and disease states may, in final analysis, hold the balance between eventual life and death.

The following is a retrospective review of these patients, as cared for on the Surgical Service of Grady Memorial Hospital.

Patient Review

During the 20 year interval from 1960 through 1979, 167 patients had major abdominal wall defects created by external violence, necrotizing soft tissue sepsis, or en bloc excision of primary or secondary neoplasia. The average age of the patients was 44.6 years, with a range of 3 to 84 years. There were 118 males and 49 females, 106 black patients and 61 white patients.

These large somatic defects were the result of radical debridement in 124 patients with necrotizing soft tissue sepsis, destructive abdominal wall trauma in 32 patients, or a sizable full-thickness gap consequent to wide en bloc tumor excision in 11 patients (Table 1). Associated disease states reflected an impairment in host defense function, such as diabetes mellitus and renal disease, or extremes in nutrition (Table 2). Prior laparotomies had been performed either for repair of transperitoneal hollow viscus injuries in 58 patients or

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TABLE 1. Cause for Abdominal Wall Loss

	Number of Patients	Died	Mortality Rate (Per Cent)
Necrotizing infection	124	31	25
Traumatic wound	32	12	38
En Bloc tumor excision	11	2	18
Total cases	167	45	27

for corrections of intra-abdominal alimentary tract inflammatory processes in 46 patients.

Necrotizing Infection

Necrotizing infection of the abdominal wall was caused by a polymicrobial synergism between aerobic gram-negative rods and various anaerobic species in 111 patients (Table 3). Meleney's cellulitis and noma accounted for one symbiotic infection each. Classic gas gangrene occurred in seven patients, while pure aerobic streptococcal erysipelas led to extensive tissue necrosis in the remaining four patients.

The severity of the sepsis was reflected by the fact that 83, or 67%, of the 124 patients had an associated bacteremia (Table 4). Aerobic gram-negative rods, various anaerobes, and *Enterococcus* were the pathogens almost exclusively isolated from the blood. Clostridial bacteremia was attended by the highest mortality rate of any, *i.e.*, 54%.

Closure of the abdominal defect by approximation of debrided wound edges in two patients fostered a recurrence of sepsis, which then progressed on to fatal septicemia (Table 5). In two other patients, septic death resulted similarly from use of a pedicled abdominal flap. However, when the defect was relatively small, as in eight patients, and could be bridged by a gauze pack, persisting sepsis and eventual death followed in only one so managed. In 112 patients, larger defects not lending themselves to closure by a gauze plug were handled

TABLE 2. Associated Disease States in 124 Patients

Associated Disease	Number of Patients
Diabetes mellitus	61
Cardiovascular disease	43
Renal insufficiency	33
Advanced liver disease	21
Obesity	46
Malnutrition	17
Prior operation for trauma	58
Prior operation for gastrointestinal disease	46
Miscellaneous disease states	81

TABLE 3. Bacteriology of Necrotizing Infections

	Number of Patients	Died	Mortality Rate (Per Cent)
Streptococcal	4	1	25
Gas gangrene	7	4	57
Meleney's synergy	1	—	—
Noma	1	—	—
Polymicrobial synergy	111	26	23
Total patients	124	31	25

by insertion of a piece of synthetic mesh. Wound sepsis recurred and required at least one additional major debridement in 34 patients, (30%). Death followed in 24 patients (21%) as a result of such persisting sepsis with or without an associated small bowel fistula.

Overall, there were 29 deaths due to progressive wound sepsis, fulminating peritonitis, and/or bowel fistula, thereby producing a mortality rate of 23% on the basis of wound complications alone (Table 5). Two patients died of unrelated causes.

Destructive Trauma

Close-range shotgun blasts were responsible for 21 of the 32 abdominal wall losses caused by trauma (Table 6). An impalement accounted for five abdominal wall losses, while high velocity missiles and guillotine-like injuries, inflicted by railroad boxcar wheels, created three each. The majority of these patients (29 or 91%) presented with a penetrating wound of the abdomen. Other clinical findings included obvious evisceration, hemorrhagic shock in 22 patients, impalement in five patients, and traumatic hemipelvectomy in three patients.

An average of 3.3 associated organ injuries were noted in 31 of the 32 patients (Table 7). Gastrointestinal wounds were present in 30 of these 31 patients, and accounted for many of the postoperative septic complications. However, the greater amount of initial operative effort was directed toward control of the 13 associated major vascular injuries.

TABLE 4. Bacteremia/Septicemia in 83 of 124 Patients

	Number of Patients	Died	Mortality Rate (Per Cent)
Gram-negative rods	69	24	35
Clostridia	13	7	54
Other anaerobes	63	17	27
Enterococcus	32	7	22
Other streptococci	9	2	22
Staphylococcus aureus	5	1	20
Total patients	83	29	35

TABLE 5. Management of Defects Due to Necrotizing Infection

	Number of Patients	Wound Sepsis/Necrosis	Peritoneal Sepsis	Bowel Fistula	Died of Complications	Died of Other Causes
Primary closure	2	2	2	—	2	—
Gauze pack	8	3	2	1	1	—
Pedicled flap	2	2	2	1	2	—
Mesh prosthesis	112	34	17	7	24	2
Total patients	124	41	23	9	29	2

Primary closure of the abdominal defect, under tension in nine patients was followed by wound sepsis in all nine, peritonitis in four, bowel fistula in three, and death due to one or some combination of these complications in eight patients (89%) (Table 8). Six small wounds were successfully managed without complication by insertion of a gauze pack. Another three patients survived despite local wound necrosis when pedicled flaps were mobilized for closure. When a mesh prosthesis was used to bridge the gap in 11 patients, wound sepsis developed in three and there was one death due to this complication. Exclusive of the three patients who died in the immediate postoperative period as a result of hemorrhagic shock, the nine deaths caused by wound sepsis and/or intestinal fistula gave an overall mortality rate of 28% as a direct consequence of complications arising from wound management.

Fulminating wound sepsis and severe peritonitis were major factors in the disruption of gastrointestinal suture lines. Dehiscence of a small bowel repair or anastomosis occurred in four (15%) of the 27 patients requiring such. By contrast, only two of seven primarily established large bowel suture lines failed. All seven of the gastric and/or duodenal repairs remained intact.

En Bloc Resection

Eleven patients had major abdominal wall defects created by wide en bloc excision. Carcinoma of the colon was the responsible lesion in five patients, abdominal wall sarcomas in four patients, and a teratoma and recurrent nephroblastoma in one patient each.

Both of the patients managed by primary closure of the abdominal wound under excessive tension de-

veloped wound necrosis and infections (Table 9). In one, this progressed to peritonitis, bowel fistulization, septicemia, and death. There were no fatalities as the result of wound complications in the remaining nine patients, although five of the seven treated by primary closure with a pedicled flap had significant wound sepsis and/or necrosis.

Wound Management

Without exception, primary closure of the abdominal wall under tension preceded serious problems with wound necrosis and infection in each of the 13 patients thus treated (Table 10). The mortality rate was 85% on this basis alone. However, for small defects, that is, those with a diameter of less than 8 cm, gauze packing prevented evisceration and gave an acceptably low incidence of major wound complications in 15 patients. Pedicled flaps, on the other hand, did allow the wound to be closed initially without excessive tension, yet significant infection and/or necrosis of the wound occurred in ten of the 12 patients treated in this manner. Insertion of a fascial prosthesis of synthetic mesh was reserved for the larger and more massively contaminated defects as well as for patients with established sepsis that had reached an advanced stage. Still, wound infection recurred or developed in only 37, (30%) of the 124 patients, while a specific wound complication, such as more generalized sepsis or intestinal fistula led to death in 25 (20%) of the patients.

TABLE 7. One Hundred and One Associated Injuries in 32 Patients

Type of Injury	Number of Patients
Gastrointestinal	30
Urinary	14
Major vascular	13
Hepatobiliary	11
Spleen	3
Pancreas	2
Skeleton	11
Lung	5
Miscellaneous	12
None	1

TABLE 6. Mode of Injury

	Number of Patients	Died	Mortality Rate (Per Cent)
Shotgun blast	21	9	43
Impalement	5	1	20
High velocity missile	3	1	33
Boxcar wheel	3	1	33
Total cases	32	12	38

TABLE 8. Management of Defects Due to Trauma

	Number of Patients	Wound Sepsis/Necrosis	Peritoneal Sepsis	Bowel Fistula	Died of Complications	Died of Other Causes
Primary closure	9	9	4	3	8	—
Gauze pack	6	—	—	—	—	—
Pedicled flap	3	3	—	—	—	—
Mesh prosthesis	11	3	2	—	1	—
Operative death	3	—	—	—	—	3
Total patients	32	15	6	3	9	3

Complications of the abdominal wound did play a significant role in determining eventual survival, in that the mortality rate was 60% if wound sepsis and/or necrosis, peritonitis, or bowel fistula developed, but the mortality rate in the absence of such was only 3%, *i.e.*, three deaths of 99 patients (Table 11). Peritonitis carried the least risk to life of these three patients, *i.e.*, 23% as compared with 49% and 46% for wound infection and bowel fistula, respectively.

Of the various synthetic meshes used, the author's experience was limited to Marlex® in 23 and prolene in 101 (Table 12). Marlex had twice the incidence of postoperative wound sepsis, almost six times as many associated bowel fistulas, and less than one-third as many successful skin graft takes for cover. Even more striking was the fact that Prolene® mesh could be retained permanently once skin closure had been obtained in 21 patients, or one-third of the 63 patients where such had been planned. By contrast, Marlex mesh required removal in all but two patients in whom it had been inserted. Finally, ease of removal was dramatically different between the pliable, smooth Prolene fabric and the stiff, textured Marlex mesh.

Deaths

Three of the 45 deaths occurred in the immediate postoperative phase as a result of profound hemorrhagic shock (Table 13). Three other deaths were unrelated to mode of wound care. However, 39 deaths were directly due to some complication of abdominal wound management. Sepsis accounted for 33 deaths, while intestinal fistula was primarily responsible for death in the remaining six patients.

Discussion

Major defects in abdominal wall substance pose three basic problems.^{4,9,16} First, there has been varying depth and extent of abdominal wall infection,^{2,9,10,14} injury,^{3,5-7,9,11,12} or tumor infiltration^{4,5,15-17} which now requires radical excision. At this stage, no thought of subsequent closure should ever influence the surgeon to be less thorough in his debridement or to accept less than adequate tumor resection. Patient survival must always be the paramount consideration.

Secondly, the intra-abdominal visceral disease or injury must also be appropriately managed. If inflammation is intense, contamination by bowel contents has been significant, or polymicrobial peritonitis has become well established, primary intestinal repair or anastomosis takes on an added risk. No longer does the presence of a proximal intestinal vent bode the catastrophe it once was held to represent, as intravenous total parenteral nutrition can now provide all of the necessary foodstuffs both for sustaining life and for healing wounds. Even the most tenuous electrolyte balance can now be maintained.

Because of difficulty in the control of intestinal efflux from loop constructed enterostomies and colostomies, a primarily matured end-stoma is preferred. Sterile enterostomy bags can then be fitted immediately to the abdominal wall before the patient leaves the operating room. In this way, such proximal vents are easily isolated and thereby will avoid the disastrous consequences of a bowel fistula located in the depths of an infected wound.

Finally, when necrotizing infection or multiple organ system trauma is responsible for the abdominal wall

TABLE 9. Management of Defects Due to En Bloc Resections

	Number of Patients	Wound Sepsis/Necrosis	Peritoneal Sepsis	Bowel Fistula	Died of Complications	Died of Other Causes
Primary closure	2	2	1	1	1	—
Gauze pack	1	—	—	—	—	—
Pedicled flap	7	5	—	—	—	1
Mesh prosthesis	1	—	—	—	—	—
Total patients	11	7	1	1	1	1

TABLE 10. Complications of Wound Management/Death Due to Complications

	Number of Patients	Wound Sepsis/Necrosis	Peritoneal Sepsis	Bowel Fistula	Died of Complications	Mortality Rate (Per Cent)
Primary closure	13	13	7	4	11	85
Gauze pack	15	3	2	1	1	7
Pedicled flap	12	10	2	1	2	17
Fascial prosthesis	124	37	19	7	25	20
Operative death	3	—	—	—	—	—
Total patients	167	63	30	13	39	23

defect, intensive supportive care of associated disease states, such as diabetic ketoacidosis and end-stage renal failure, demand at least an equal therapeutic effort. Often, a team of specialists from many disciplines of medicine may be required. Nevertheless, the surgeon must remain the primary physician in charge, for it is wound management and wound complications which exert the greatest influence on patient outcome.

Closure of the abdominal wall under excessive tension has regularly failed because of subsequent tissue disruption and serious wound infection.^{5,9} In fact, fatalities are more often the result of choosing this method to gain closure than any other factor.⁹ The pedicled flap does eliminate tension,^{5,16,17} yet a less than ideal blood supply as well as greater exposure of subcutaneous surface to significant polymicrobial contamination will lead to an unacceptably high rate of wound complications and even to an occasional septic death.

Use of a gauze pack for such closure has appeared to provide a reliable alternative.⁹ If the wound is small, the pack itself can prevent abdominal evisceration. However, in cases where there is too great a gap between the abdominal side walls, insertion of a sheet of synthetic mesh to bridge the defect will maintain visceral position within the abdomen proper.^{2,6,7,9,11-15} The same technique of gauze dressing is still used, but now it is placed directly on top of the synthetic mesh. Accordingly, daily dressing changes are required, just as before, until the wound has developed granulations on bowel surface, as well as on incision side walls, thus indicating adhesions will avert evisceration and a

wound bed acceptable for skin grafting has been achieved.

In selection of a fascial substitute, certain fabric characteristics appear to be crucial.^{1,9,13,15} The substance should be: 1) pliable so as to preclude erosion into major structures, 2) inert, thereby avoiding a greater inflammatory response, 3) porous so as to allow free drainage of exudate, and 4) fiber resilience sufficient to maintain mesh integrity and thus to offer some potential for permanence. Marlex is stiff and exhibits fiber fatigue, while sheets of Silastic are not porous.^{1,15} To date, Prolene mesh has appeared to be the only fabric that meets all of these criteria.^{9,15}

Final restoration of abdominal wall structure should never be attempted until all intestinal vents have been closed.⁹ At a subsequent operation, the skin-covered scar which bridges the fascial defect is excised, another fascial prosthesis is inserted (preferably Prolene mesh), and skin with soft tissue is brought in as

TABLE 12. Comparison of Synthetic Meshes

	MARLEX	PROLENE
Patients	23	101
Wound sepsis	12	25
Intestinal fistula	4	3
Skin grafted	15	29
Acceptable take (>80%)	3	21
Planned mesh retention	19	63
Erosion into bowel/skin	3	1
Late removal	17	42
Difficult removal	16	7

TABLE 11. Complications of Wound Management

	Number of Patients	Died	Mortality Rate (Per Cent)
Wound sepsis/necrosis	63	31*	49
Peritoneal sepsis	30	7*	23
Bowel fistula	13	6	46
Total patients	65	39	60

* Five patients died of both wound and peritoneal sepsis.

TABLE 13. Cause of the 45 Deaths

Cause of Death	Number of Patients
Wound/peritoneal sepsis	33
Intestinal fistula	6
Hemorrhagic shock	3
Cerebral thrombosis	1
Pulmonary embolism	1
Alcoholic hepatitis	1

a pedicled subcutaneous flap or as a formal myocutaneous flap to provide surface closure.⁸ The donor area from which the flap has been rotated is closed at the same time by application of a split-thickness skin graft.

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DISCUSSION

DR. J. DAVID RICHARDSON (Louisville, Kentucky): In Louisville over the past five years we have treated over 40 patients with similar problems. We have had 31 patients survive.

(slide) The slide indicates the degree of infection seen in our 31 patients in whom we could not achieve fascial closure and subsequently placed polypropylene mesh. Basically, it parallels the experience that Dr. Stone presented. We excluded our tumor patients, and, as you can see, 29 out of 31 patients had contaminated wounds, 27 of the 31 patients had significant abdominal abscesses, and 23 had extensive fasciitis, prohibiting primary closure.

In terms of the immediate results, no patients eviscerated. There were no patients who actually required reoperation for fasciitis alone, if their initial operation was adequate. However, 23 patients did require at least one intra-abdominal operation, or repeat intra-abdominal operation, for persisting sepsis. And, again, the use of synthetic mesh allowed reoperations to be done with maintenance of at least a degree of abdominal wall integrity.

(slide) We have used primarily Marlex mesh, and have had significant late problems in patients in whom the mesh could not be completely removed with subsequent primary fascial closure. In nine patients in whom we did split-thickness skin grafting over the mesh, even when there appeared to be a very good granulation bed, all have had extrusion, three have had fistulas—one died as a result of fistula. Similarly, for patients in whom we tried to let the wound heal by secondary intention, there was a fairly significant rate of continuing wound problems. We have now had four patients in whom we have done elective full-thickness coverage, using musculocutaneous flaps, and it appears in that small experience that this is the way to go.

(slide) This is a patient who had a shotgun wound with a 9 cm defect, massive contamination by bowel and bladder injury. We closed the wound with Marlex to restore abdominal wall integrity after repairing intra-abdominal lesions. The bladder injury was closed with a suprapubic tube and brought directly through the mesh, since that appeared to be the most convenient way to drain the patient.

(slide) This shows, after the bladder has healed, the suprapubic cystostomy is removed and the patient has a good granulating bed. The patient still needs some type of synthetic coverage to provide abdominal wall integrity. (slide) In this particular case, we chose a myocutaneous flap. Rather than grafting that bed, we chose a myocutaneous flap even though the bed appeared adequate for grafting based on the lateral circumflex femoral artery. The patient healed well, as have our other four patients in which this has been done.

This is done electively, after contamination has been controlled, and it does seem to yield better long-term results.

I think the point that Dr. Stone made, that we would emphasize, in a fairly large experience in a five-year period, is that even in the face of significant contamination this synthetic material is well tolerated, but there are significant wound problems that must be dealt with at a later date.

DR. ROBERT M. MILES (Memphis, Tennessee): Dr. Stone has addressed a problem which few people write about, probably because their results are so poor. Even in Dr. Stone's hands, with the infectious types—that is, the necrotizing cellulitis and sepsis—the mortality rate was around 60%.

Although the use of fascial prostheses brought this down to about 20%, with the synthetic meshes the incidence of wound sepsis was still fairly high. With Marlex it was 50%; with Prolene, about 25%. A number of these developed fistulae, and necessitated eventual removal of the mesh.

In such cases, we have used a method for many years which is so simple I hesitate to mention it before this group, but, other things equal, it works most of the time. It's based on the principles of, first, containing the viscera, and, second, permitting adequate drainage. Assuming the source of infection is controlled, and adequate nutrition is maintained, granulation tissue will develop, wound contraction will occur, and grafting will be possible, with final repair of the defect at a later date.

(slide) This is a diagram of the method. The defect is covered with a simple sheet of polyethylene plastic and filled with gauze fluffs or cotton balls. Several abdominal pads are placed over this and the whole dressing is secured with a Velcro-lined binder wrapped around the whole torso, fairly tightly.

This is the principle of the Mikulicz pack, which we've all used for the perineal defect of an abdominoperineal resection. It permits drainage by capillary attraction and at the same time it contains the viscera and does not stick to them. This is changed every day or two, permitting the access of air into the wound, which I think is very helpful.

We had such a case recently. The patient had a gunshot wound which severely traumatized his transverse colon, which had to be resected. A proximal end colostomy was performed and the distal end was closed and dropped back. He also had a through-and-through wound of the duodenum, which was repaired.

Around the ninth day after operation, he developed a necrotizing cellulitis, which was opened and drained. Following this multiple