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Temporary Abdominal Closure (TAC) for Planned Relaparotomy (Etappenlavage) in Trauma

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Planned relaparotomy (temporary abdominal closure) was studied prospectively in 20 trauma patients. Four died in the first 24 hours from hypothermia, coagulopathy, shock (three), and septic shock (one). The 16 survivors had a Velcro-like prosthetic placed to facilitate abdominal closure and re-entry. Prosthetic was necessary in eight because bowel edema precluded fascial closure, and useful for removal of packing (three) and for the management of peritonitis (five). The prosthetic did not open spontaneously, nor was it associated with evisceration or bowel fistula. Temporary abdominal closure (TAC) permitted reappraisal and staged repair of intra-abdominal pathology, including bowel resection and anastomosis.

TAC identified 14 problems early: bleeding (five), bile leaks (two), GI complications (six), liver necrosis (one). Five patients developed superficial wound infections, and three went on to develop fascial necrosis.

Planned relaparotomy has been advocated in the management of diffuse suppurative peritonitis (19, 22), major hemorrhage requiring packing (4, 8, 9, 11), massive bowel edema preventing primary fascial reapproximation (5), pathologic conditions associated with progressive deterioration (17), and poor patient conditions precluding definitive operations (18). A variety of techniques have been utilized for temporary abdominal closure. The purpose of this study is to clarify the benefits and complications of planned relaparotomy in trauma utilizing an artificial burr (a Velcro®-like device) (21) to facilitate abdominal entry and closure.

MATERIALS AND METHODS

Over a 16-month period ending September 1989, 20 trauma patients underwent temporary abdominal closure for planned relaparotomy utilizing an artificial burr (burr). A protocol directed mandatory use of burr in cases of peritoneal edema where fascial reapproximation was not possible. It also recommended burr in patients requiring reoperation to remove packs or in cases where etappenlavage was thought to be necessary. Etappenlavage is defined as the need to perform multiple laparotomies at defined intervals.

The artificial burr consists of two separate sheets. One can be described as having a fuzzy (loop) side while the other side consists of hooks or mushrooms. The cohesive properties have been previously studied (20–22). A standard fuzzy sheet measuring 50 × 20 cm is sutured first to one fascial edge using monofilament suture. The loops of the burr face outward. Excesses in the width of the sheet are used to cover the bowel and slide beneath the opposite abdominal wall. The standard hook side measuring 50 × 10 cm is sutured to the opposite fascial edge with the hook side facing inward. The abdomen is closed by approximating the two pieces of burr. Any excesses of the hook sheet are easily excised. The skin and wound are not closed and roller gauze is used to cover the burr and the subcutaneous tissue.

Antibiotic choice is left to the discretion of the operating surgeon. Planned relaparotomy is performed in the operating room every 24 to 48 hours depending on the indications. After removing the dressing, the abdominal wall including the burr is prepped with povidone-iodine. Following appropriate draping, the burr is separated and the hooks of the burr are covered with a lap pad to avoid adherence of the omentum to the hooked burr portion. The fuzzy side is retracted and the entire abdominal cavity is inspected in detail to determine if the primary surgical problem has been satisfactorily managed. Previously placed packs are removed. Any bleeding is controlled, debridement completed, and dead and necrotic tissue removed.

Complications of anastomotic leak, bile leak, progression of ischemic bowel to necrotic bowel, or de novo complications such as gastrointestinal leaks from missed small or large bowel injuries and tissue necrosis and hematomas are identified and corrected. All intra-abdominal spaces are thoroughly explored, irrigated, and a determination is made to: 1) remove the burr and close the abdomen primarily; or 2) to reapproximate the burr and return for planned relaparotomy. These decisions are based on the ability to reapproximate the fascia without undue abdominal pressure, removal of packing without recurrent hemorrhage, and the perception that the suppurative process is resolving.

Patient demographic data such as age, sex, mechanism of injury, Injury Severity Score (ISS) (1), Acute Physiology and Chronic Health Evaluation Score (APACHE II Score) (14), Abdominal Trauma Index (ATI) (13), operative findings, indications for planned relaparotomy, course, and outcome were

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noted. Subsequently, the patients were classified into groups with regard to their primary indication for relaparotomy. Outcome criteria included mortality, definitive abdominal closure following burr removal, relative benefits from relaparotomy and adverse effects from burr use. Benefits from relaparotomy include recognition of intra-abdominal hemorrhage, hematoma or abscess formation, bile leaks from liver injuries, anastomotic leaks, progressive ischemic changes requiring surgical correction, and liver necrosis requiring additional debridement. Adverse effects from burr use were wound infections, wound dehiscence, or intra-abdominal infection.

RESULTS

Twenty patients were prospectively managed with planned relaparotomy utilizing burr to facilitate closing and opening the abdomen. Their median age was 29.5 years (range, 20–70 years). Eleven (55%) suffered blunt trauma of whom two were the only females in the study. All had abdominal trauma with a median ATI of 16.5 (range, 6–50). Six also had head injury (Abbreviated Injury Severity [AIS] range 2–5), nine chest injury (AIS range, 3–5), and nine extremity injuries (AIS range, 2–4). The median ISS was 30.5 (range, 9–66). The overall median APACHE II score was 16.5 (range, 3–44).

Four (20%) of the 20 patients (Table I) died within 24 hours of their operation; three from exsanguinating hemorrhage managed with packing but resulting in sustained shock, hypothermia, and clinical coagulopathy. The fourth died of septic shock from progressive small bowel ischemia and necrosis following total proctocolectomy for gangrene secondary to intestinal hypoperfusion. To permit review and evaluation of the benefits and complications of relaparotomy with burr, these four deaths were excluded from further review.

The 16 survivors are further described in Tables II and III. Eleven patients required packing as an adjunct to their operative management of hemorrhage. Because of extensive tissue edema, the abdominal fascia could not be reapproximated in eight patients (Group I). Velcro was used to bridge the fascial gap and to cover the intestines. A need for a prosthetic device to achieve abdominal closure was the specific indication for burr use. A second laparotomy was performed in four patients and the burr removed. A third laparotomy was necessary in three patients before burr removal and a single patient required six laparotomies to manage subsequent infectious complications resulting from colon injuries.

Three patients (Group II) of the 11 requiring packing had no peritoneal edema and the primary indication for burr use was to facilitate closure of the abdomen and reentry for pack removal. One had only a second laparotomy and the other two each required three.

Five survivors (Group III) had advanced diffuse suppurative peritonitis (two) and localized peritonitis, i.e., multiple intra-abdominal abscesses (three). Two of the five patients were admitted with blunt abdominal trauma and closed cranial injury. Their initial abdominal Computer Tomography (CT) was "normal" but unrecognized small bowel injury progressed to peritonitis. They each required six laparotomies before the abdominal fascia was closed. The remaining three patients in Group III had penetrating injuries and developed postoperative diffuse peritonitis (one) and multiple localized intra-abdominal abscesses (two). The primary indication for burr use was to facilitate re-entry and abdominal closure associated with multiple laparotomies. They required five, four, and six laparotomies, respectively, before burr removal and fascial closure.

The entire study population of 16 survivors underwent a total of 58 laparotomies (Table IV). Ten patients in Group I and II required two or three laparotomies each. The five who underwent two procedures did not develop any wound complications, but one did develop abdominal abscesses and, a second, a ruptured pseudoaneurysm of the epiploic artery. Three of the five patients requiring three laparotomies developed wound complications. Two wound infections ending in dehiscence occurred in patients with colon injuries managed with colostomies. One of these patients also went on to develop pelvic abscess and rupture a pseudoaneurysm of a repaired iliac artery.

A total of six patients (one from Group I and five from Group III) required more than four laparotomies. Three of these patients (50%) developed wound infections, and one an intra-abdominal abscess.

Fifteen of the 16 survivors all had their fascia closed after burr removal. One with a colon injury developed such a severe infection of the wound and fascia that the burr was removed and the fascia left open to be debrided. Five of 15 patients with primary closure developed superficial wound infection. Three went on to develop fascial necrosis with dehiscence. A total of ten patients had 30 operations without any wound infections. Twelve had a total of 42 operations without fascial necrosis or disruption.

There were a total of 14 apparent benefits from relaparotomy (Table V). Five pertained to identification of bleeding sites and coagulopathy, two bile leaks from liver

TABLE I
Mortality

	Age (yrs)	Mechanism	ISS	APACHE	ATI	Cause of Death
Male #1	27	Stab	25	44	16	Shock—hypothermia—coagulopathy
Male #2	52	GSW	66	30	19	Exsang.—hypothermia—coagulopathy
Male #3	30	Fall	29	16	20	Exsang.—hypothermia—coagulopathy
Female	70	MVA	19	42	35	Septic shock 8 days postinjury

TABLE II
Summary of cases

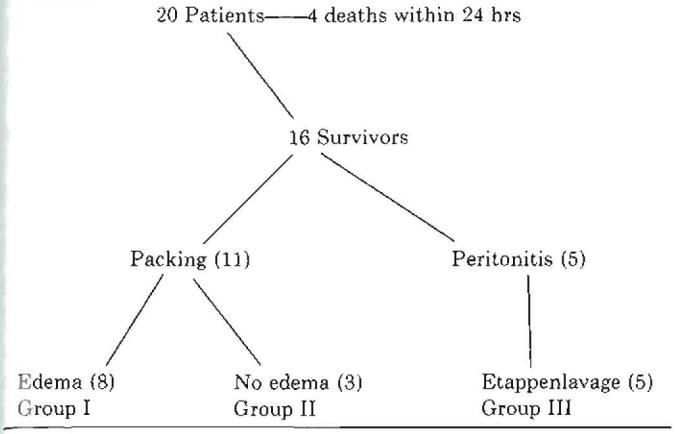

TABLE III
Patient characteristics

	Edema—Group I	Packing—Group II	Peritonitis—Group III	Totals
Number	8	3	5	16
Age (yrs) (range)	20–55	20–31	20–58	20–58
Blunt	4	2	2	8
ATI (range)	16–50	22–26	6–35	6–50
ISS (range)	25–50	32–50	9–43	9–50
APACHE II (range)	6–30	9–26	3–23	3–30

injuries, six pertained to identification of gastrointestinal complications, and one liver necrosis requiring debridement.

DISCUSSION

The need of temporary abdominal closure for planned relaparotomies (etappenlavage) should be identified at the first operation, and the decision should depend on the inability to complete the first procedure or the belief that the surgical conditions present are likely to result in complications necessitating further surgery.

In a multi-institutional study, Cogbill et al. (4) reported 210 patients with severe liver injuries comprising 16% of all liver injuries. Thirty-four of these severe injuries (16%) required packing. Cué et al. (5) recently reported 31 cases of liver packing for serious liver injuries, constituting 8% of the liver injuries admitted during that time. Eleven of our own 16 patients also required packing, reflecting only the severest of injuries.

A variety of suture materials and techniques can be utilized to close the fascia under these circumstances. Virtually all wounds associated with abdominal trauma can be closed at the first operation. Wound infection and dehiscence rates vary, and usually are associated with shock and gastrointestinal contamination. Infection and dehiscence rates may be impacted because of the need for planned relaparotomies Six of 16 (38%) patients in this study developed wound infections. Three had three laparotomies, and three had six laparotomies. Five of the six had GI tract injuries, of which three were colonic. However, the high incidence of wound infections is not unexpected, given the nature of the primary disease with many contributing factors: GI contamination, hypotension, multiple transfusions. It also has to be judged in the context of the life-threatening primary problem, and appears to be acceptable.

Attempts to close the abdominal fascia in the presence of peritoneal edema can be slow and tedious and carry an increased risk of bowel injury. It results in increased abdominal pressure which might be regarded as an abdominal compartment syndrome (3, 10, 12, 15, 16). This syndrome is associated with decreased tidal volumes, increase in ventilatory pressures, and increased pulmonary infection due to basal atelectasis.

Decreased urinary function and frank renal failure are also seen with increased abdominal pressure. Cué, et al. (5) reported that ten of 23 survivors of the initial operation required prosthetics to close the abdomen. Peritoneal edema may be sufficiently extensive to preclude even towel clip closures as advocated by Feliciano (7). In eight of our cases, a prosthetic device to bridge the gap was mandatory and temporary abdominal closure eliminated increased intra-abdominal pressure, and pulmonary and renal failure.

The burr was removed after the second operation in four, and in three patients it was removed after their third operation. Two of the patients requiring three operations developed wound infections. One was superficial and resulted in partial fascial dehiscence. The second patient suffered a complete abdominal dehis-

TABLE IV
Laparotomies (N = 58)

No. of Laparotomies	No. of Pts	Complications					
		None	Wound Inf.	Wound Dehisc.	Abd. Abscess	Abd. Hem.	Biloma
2	5	3	—	—	1	1	—
3	5	1	3	3	1	1	1
4	1	1	—	—	—	—	—
5	1	—	—	—	1	—	—
6	4	1	3	1	—	—	—
Totals		6	6	4	3	2	1

TABLE V
Benefits from planned relaparotomy (etappenlavage)

Benefits	Group I	Group II	Group III	Totals
Bleeding/primary problem	1	2		3
Bleeding/de novo	1		1	2
Anastomotic leak	1			1
Progression of ischemia	1	1	1	3
Bile leaks	1	1		2
Liver necrosis	1			1
GI complications/de novo			2	2
Totals	6	4	4	14

cence. In both patients, the skin wounds had been closed following burr removal.

The need for additional laparotomies to manage vascular and infectious complications must be decided at the initial operation. "Prophylactic" procedures have been proposed for mesenteric vascular disease (6). Sepsis-related mortality in pancreatic abscess or advanced suppurative peritonitis is frequently related to technical difficulties or delays in diagnosis (2). These have prompted the use of open management (2), and/or etappenlavage (22). The obligate need to remove packing and the necessity of removing prosthetic devices enables recognition of intra-abdominal complications and their prompt surgical management. Planned relaparotomy has resulted in reduced mortality as assessed by disease severity scoring. Our decision to perform temporary abdominal closure permitted us to diagnose 14 additional problems that would have been missed by standard protocol (Table V). While these complications would have progressed and subsequently mandated re-exploration, it is likely they would have resulted in increased morbidity and mortality. Predictors of mortality utilizing disease severity scoring have been established (14). The mean APACHE II score for Groups I, II, and III were 15, 15, and 20.5, respectively, with predicted mortalities of 34%, 34%, and 55%.

Besides suture and towel clips, a number of techniques are available to achieve abdominal closure (Table VI). The issues appear to be the ease of closure, as well as associated morbidity. The towel clip method is fast, but cannot be employed when substantial peritoneal edema is present. In addition, it has also been associated with evisceration. Standard fascial closure with a running suture is safe, and can be accomplished in 10 to 15 minutes. Less time is frequently necessary when using prosthetic devices, such as zippers, Ethizip, Marlex, Silastic, or burr. The zipper, Ethizip, and burr permit rapid and safe re-entry to the abdomen at re-exploration, and if an additional laparotomy is necessary, permit a rapid closure. Burr opening and closure take seconds and have the added advantage of accommodating decreases in abdominal distension, whereas the zipper and Ethizip must be removed and new materials inserted as edema decreases. While Marlex and Silastic excesses can be excised to accommodate edema decreases, they must be resutured to gain abdominal closure.

We conclude that planned relaparotomy in selected trauma cases can lead to improved survival, especially in managing established peritonitis. This improvement may be attributed to early identification of abdominal complications. The use of prosthetic devices in planned relaparotomy is helpful to bridge fascial gaps when edema precludes fascial closure. If several relaparotomies are likely, prosthetic devices can facilitate closure and re-entry. Specific adverse effects from multiple relaparotomies, with or without a prosthetic device, remain elusive and will require further study. Burr as a prosthetic device provides rapid and safe re-entry into the abdomen. Burr use provides a simple method to accommodate changing abdominal girth and has not been associated with spontaneous opening. Our experience with 16 survivors demonstrates several infectious complications whose relationship to gastrointestinal contamination and/or burr use demands further evaluation. Perhaps these infectious complications may be minimized by the use of third-generation cephalosporins, and leaving the skin wound open after burr removal.

A prospective randomized evaluation of artificial burr

TABLE VI
Methods of abdominal closure

	Sutures	Towel Clips	Zippers	Ethizip	Marlex Silastic	Burr
Useful in changing abdominal girth	No	No	Yes	Yes	Yes	Yes
Rapid replacement	10–15 minutes	3–5 minutes	10–15 minutes	10–15 minutes	10–15 minutes	10–15 minutes
Rapid re-entry	No	Yes	Yes	Yes	No	Yes
Must be replaced with decreasing peritoneal edema	—	—	Yes	Yes	No	No
Must be sutured at repeat laparotomy	Yes	Yes	No	No	Yes	No
Associated with evisceration	Yes	Yes	No	Yes	No	No

for planned relaparotomy in trauma and/or peritonitis has been approved by the Medical College of Wisconsin's Institutional Review Board. Application for investigational device exemption (IDE) has been made.

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