Benign Colorectal Disease Trauma of the Colon and Rectum

42

Reza Askari, Ali Salim, and Matthew Martin

Key Concepts

- Most colonic injuries are associated with penetrating trauma.
- Colonic injuries can often be treated by primary repair or resection with anastomosis.
- Extraperitoneal rectal injuries are usually treated with colostomy; washout and presacral drainage are not generally indicated.

Introduction and Historical Perspective

Over the past several decades, the management of colon trauma has changed dramatically. These changes have led to a significant improvement in colon-related mortality. Mortality rates have fallen from approximately 60% during World War I to <10% in the more recent conflicts in Iraq and Afghanistan. A recent multicenter study of modern civilian colon trauma found a colon-related mortality of only 1.3% [1]. Similarly, low morbidity and mortality rates have been reported from several combat operations in Iraq and Afghanistan [2, 3]. Many factors have led to the overall decline in mortality rates. These include quicker transport times, as well as improvements in resuscitation strategies, antibiotic use, and surgical techniques. However, morbidity rates of abdominal sepsis from colon-related injuries remain anywhere from 16 to 33% in various military and civilian studies [4–10].

Prior to World War I, mortality rates from bowel injury approached 100% as management of injuries was largely nonoperative. In fact, laparotomy was largely condemned as a treatment option [11]. By World War II, advances in causality transport and prehospital care led to abandonment of nonoperative management in favor of laparotomy and primary repair of the injured colon [12, 13]. This led to a decrease in the overall battlefield mortality but was still associated with a considerable risk of repair failure, sepsis, and death.

The next shift in the management of colorectal trauma management occurred following the publication of Ogilvie's classic analysis of the management of colon wounds from the North African campaign of 1942 [14]. Ogilvie strongly advocated either fecal diversion of all colonic injuries or repair/resection with proximal diversion. This approach led to a drastic decrease in mortality rates compared to World War I [14, 15]. In fact, the US surgeon general adopted proximal diversion as a formal policy directive for the treatment of all colonic injuries [15, 16]. During the Korean and Vietnam war era, the management of colonic injuries became more anatomically based. Selected right-sided injuries underwent resection and primary anastomosis versus routine colostomy formation for left-sided injuries [17].

For rectal injuries, the principles of wide local washout in addition to proximal diversion were adopted during World War II [17, 18]. This led to a significant decrease in mortality from pelvic sepsis. This approach was further modified during the Korean and Vietnam wars with the addition of distal rectal washout and presacral drain placement. This led to the "4 Ds" of rectal trauma: direct repair, divert, drain, and distal washout.

The more recent combat conflicts in Iraq and Afghanistan over the past decade have led to several published series [2, 3, 19]. The overall trend now is that the majority of colonic injures are being managed with primary repair or resection and anastomosis. Despite this paradigm shift, approximately one-third of patients still underwent diversion in the management of colon-related injuries. An important factor in recent decades is the introduction of the principles of damage control surgery. This has allowed a delay in decision-making as

R. Askari (✉) · A. Salim
Division of Trauma, Burns, Surgical Critical Care and Acute Care Surgery, Brigham and Woman's Hospital, Harvard Medical School, Boston, MA, USA
e-mail: raskari@bwh.harvard.edu

M. Martin
Scripps Mercy Hospital, Uniformed Services University of the Health Sciences, San Diego, CA, USA

S. R. Steele et al. (eds.), *The ASCRS Textbook of Colon and Rectal Surgery*, https://doi.org/10.1007/978-3-030-66049-9_42

it relates to anastomosis versus proximal diversion in the unstable patient. Combat damage control data assessing primary repair versus anastomosis have demonstrated comparable and acceptable morbidity rates [19, 20].

Colon Trauma

Epidemiology

Most injuries to the colon are due to penetrating abdominal trauma, with gunshot injuries the most common cause followed by stabbing and impalement. After the small bowel, the colon is the most commonly injured organ in penetrating abdominal trauma [21]. Blunt colonic injuries are less common and account for <10% of injuries found at laparotomy. Lap belt use, particularly without the concomitant use of the shoulder harness, increases the risk of visceral injury. Most colonic injuries secondary to blunt trauma result in superficial injuries from small hematomas or serosal tears. However, a third will have full-thickness colon perforation [22]. Mesenteric tears and ischemic necrosis of the colon should be suspected in injuries secondary to rapid deceleration. In rare cases, colonic injuries can present in a delayed presentation secondary to a colonic wall hematoma or contusion. Blast injuries such as explosions are more likely to lead to injuries to hollow viscera than solid organs, with the colon being the most susceptible. Sometimes, these injuries can present without external signs of abdominal trauma [23].

The American Association for the Surgery of Trauma has now published a grading scale for colonic injuries (Table 42.1) [23]. This is useful in predicating possible complications and evaluation of different therapeutic interventions.

Diagnosis

In penetrating abdominal trauma to the anterior abdominal wall, prompt abdominal exploration accurately identifies the majority of colonic injuries. The highest level of suspicion should be for gunshot wounds to the trunk that have passed from anterior to posterior or crossed the midline from side to side. Perineal or trans-pelvic gunshot wounds should be assumed to have a rectal injury until proven otherwise. For those undergoing a trial of nonoperative management, serial abdominal examinations and computed tomography (CT) scan evaluation with IV contrast are useful both for visualizing injuries and for reconstructing the projectile tract and assessing the structures at risk [24].

Wounds to the flank and back can lead to colonic injuries despite the absence of initial peritoneal irritation or hemodynamic instability. CT scan with triple contrast is useful for delineating such injuries, with 90% sensitivity and 96% specificity [25]. However, it is unclear whether a "triple-contrast" CT scan provides any more sensitivity or specificity versus standard CT with IV contrast only. In most cases, we have found that standard CT is adequate and avoids the inherent delays of administering oral and rectal contrast.

Diagnosis of colonic injury following blunt trauma can be difficult. This is particularly challenging in patients who are unevaluable secondary to drug or alcohol intoxication or the presence of concomitant brain or spinal cord trauma. CT scan remains the diagnostic modality of choice looking for the presence of free air, unexplained free peritoneal fluid, or thickened colonic wall. The presence of free intraperitoneal air mandates exploration for perforated hollow viscus. Free intraperitoneal fluid in the absence of solid organ injury should significantly raise the index of suspicion for bowel injury and mandate either surgical exploration or close serial examinations and possible repeat imaging. Diagnostic peritoneal lavage and laparoscopy have little utility in the contemporary evaluation of patients with suspected colonic injury. Laparoscopy could be useful in stable patients with back, flank, or pelvic wounds. Some of the key aspects of the initial evaluation of colorectal trauma are summarized in Table 42.2.

Table 42.1 Time from injury to surgical management in American wars

Grade	Injury description
I	A. Contusion or hematoma without devascularization B. Partial-thickness laceration
II	Laceration ≤50% of circumference
III	Laceration >50% of circumference
IV	Transection of the colon
V	Transection of the colon with segmental tissue loss

Management

Preoperative Consideration

Once the decision has been made for operative intervention for a suspected colorectal injury, the basic principles of emergency surgery and Advanced Trauma Life Support (ATLS) apply. Attention should be paid to hypothermia prevention and management with active warming devices. The possibility of ongoing bleeding should be anticipated. Emergency-release blood products should be standing by, and type and cross should be performed as soon as possible. A Foley catheter should be placed barring any signs of urethral injury. Antibiotics should be administered as soon as there is evidence of the injury or a decision for laparotomy has been made. The optimal goal is to administer antibiotics 30–60 minutes prior to skin incision. Re-dosing of antibiotics should be performed if the surgery is prolonged or in

Table 42.2 Key elements of the initial trauma evaluation for colorectal trauma

History	Physical examination	Diagnostic and imaging studies
Abdominal pain or complaints	Overall impression ("sick" or "not sick")	Chest x-ray – free air, elevated or blurred diaphragm
Allergies and medications	Vital signs	FAST exam – free fluid in the abdomen or pelvis
Prior abdominal surgery: particularly any prior bowel surgery, hernia repairs, mesh implantation, and aortoiliac surgery	Focused abdominal exam: tenderness, distension, rebound, guarding, bruising, "seat-belt sign." Identify all prior incisions and any hernias	CT scan of the abdomen/pelvic: diagnostic study of choice in most patients. No oral contrast required for initial study. Consider follow-up CT with oral contrast or "triple contrast" for equivocal initial study or concerning clinical picture
Major comorbidities: vasculopathy, congestive heart failure, high-dose steroid use, immunosuppressants	Location of all open penetrating wounds	"Triple-contrast" CT scan: may be useful for penetrating flank or back wounds with suspicion for retroperitoneal colonic injury, but usually standard CT is adequate
Injury mechanism (from high to low risk): Penetrating, missile Penetrating, stab Blunt, high velocity Blunt, low velocity	Logroll and full back/flank exam	Abdominal x-rays: not useful as routine study in blunt trauma. Can be very useful in gunshot wounds for identifying location of fragments and estimating trajectories. Place radiolucent markers on all external wounds
	Pelvic and perineal exam	Diagnostic peritoneal lavage: mainly of historical interest but can be used with equivocal CT findings (i.e., free fluid with no solid organ injury) in patients with unreliable exam
	Digital rectal exam (DRE)	Anoscopy, rigid proctoscopy: penetrating perineal trauma, open pelvic fracture, positive DRE, any other suspicion for rectal injury

Reused with permission from Complexities in Colorectal Surgery (p. 520, Table 34.1) by Steelee SR, Maykel JA, Champagne BJ, Orangio GR, editors. New York; 2014. Copyright © 2014 by Springer Nature

cases where blood loss and transfusion are approaching one whole blood volume. Antibiotics need to only be continued for 24 hours, and there is no benefit of continuing them any longer, even in the face of large-volume contamination [26]. The only exception to this would be the patient with a delayed presentation of a colonic injury, where there is now sepsis and an established intraabdominal infection.

Timing of Injury and Operative Decisions

Most traumatic colorectal injuries will present within the first few hours, and a short delay (2–8 hours) should not impact management decisions. However, occasionally there may be a significant delay to either diagnosis or intervention in a patient with a major colorectal injury. This can result in severe morbidity or mortality. These scenarios may occur in settings where there is a failure to recognize peritoneal signs or imaging findings at initial presentation, the presence of factors that compromise the abdominal exam (i.e., head injury or intoxication), or the masking of peritoneal signs by medications (i.e., steroids) or other patient factors. Generally, delays of more than 8–12 hours in the setting of fecal contamination will alter both the anatomy and the patient physiology, potentially altering surgical decision-making.

As a general principle, in the setting of fecal contamination and peritonitis as a result of delay to operation, there should be a much more liberal use of proximal diversion as opposed to primary anastomosis. However, this decision should be individualized based on the patient's age and comorbidities, the physiologic status during surgery, the location and severity of injury, and the local anatomic factors. Factors that can alter the operative approach in these cases include:

1. Hemodynamic instability secondary to septic shock from fecal contamination
2. Staple line compromise secondary to bowel wall induration and edema
3. Presence of significant bowel distension
4. Mesenteric thickening and shortening that can limit colostomy creation

Operative Management: When to Repair, Resect, or Divert

Several factors go into the decision to repair, resect, or divert. Classically, the teaching has been to categorize injuries as either destructive (>50% of bowel circumference or devascularized) or nondestructive. The recommendation for destructive injuries is to resect the injured area, whereas primary repair is recommended for nondestructive wounds. However, several other factors must be considered. These are outlined

in Table 42.3. Important factors include not only the size of the injury but the numbers and locations.

Injuries secondary to high-velocity gunshot wounds require that the wound edges be debrided back to healthy tissue before closure. It is important to remember that missile injuries can cause extensive tissue damage or even direct thermal injury (Fig. 42.1), which will often lead to breakdown of the closure if the edges have not been adequately debrided. Another important factor is the status of the mesentery, as this will determine the adequacy of the blood supply to the area. The classic "bucket-handle" deformity is a large tear in the mesentery without injury to the colon wall, which may occur in blunt trauma from rapid deceleration. The bowel will often appear uninjured but should be resected due to the large area of devascularization and the potential for delayed perforation or anastomotic leak (Fig. 42.2).

Table 42.3 Factors to guide primary repair versus resection for colon surgery

Primary repair	Resection
Small size (nondestructive)	Destructive (>50% circumference or devascularized)
Single injuries or multiple with adequate spacing	Multiple injuries with short spacing
Clean margins (after debridement of edges)	Inflamed or necrotic edges
Minimal or no mesenteric injury	Large mesenteric hematoma or laceration
Tension-free closure	Cannot be closed without tension
Healthy surrounding bowel	Major edema, inflammation, bowel wall hematoma
No major pathology present	Major pathology present (cancer, diverticulitis, etc.)
Closure leaves widely patent lumen	Closure would narrow lumen (>25%)
Low-velocity wound	High-velocity wound
At risk for short gut syndrome with resection	Adequate bowel length after resection
No adjacent pancreatic injury or leak	Pancreatic injury/leak adjacent to injury

Reused with permission from Complexities in Colorectal Surgery (p. 524, Table 34.2) by Steelee SR, Maykel JA, Champagne BJ, Orangio GR, editors. New York; 2014. Copyright © 2014 by Springer Nature

Fig. 42.1 Missile wound to the bowel with small perforation but significant thermal injury to the surrounding bowel wall. This injury should be completely debrided and then repaired or resected. (Reprinted [adapted] from Complexities in Colorectal Surgery (p. 524, Fig. 34.3) by Steele SR, Maykel JA, Champagne BJ, Orangio GR, editors. New York; 2014. Copyright © 2014 Springer Nature)

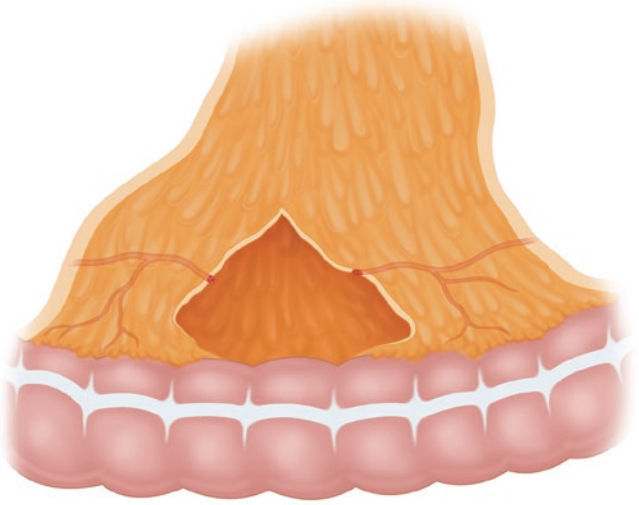

Fig. 42.2 Large tear of the mesenteric border of the bowel ("bucket-handle" deformity) from blunt deceleration forces. This usually requires resection of the now devascularized bowel segment to avoid subsequent ischemic complications

While each individual colon and rectal injury type and location may have an associated "textbook" answer for the most appropriate operation to perform, this often does not consider the wide variety of presentations, number of injuries, presence of associated injuries, and patient physiology.

Evidence and Practice Guidelines

In 1979, Stone [26] performed the first reported trial of patients randomized to exteriorization or colostomy versus primary repair for small colonic injuries (n = 268). This study demonstrated a tenfold reduction in the incidence of complications with primary repair and a significantly increased hospital stay and cost associated with colostomy. Several years later, studies by Chappuis [27], Sasaki [28], and Gonzalez [29] together randomized more than 300 patients to primary repair or colostomy. These studies showed that primary repair or anastomosis was safe and effective; in fact, they reported fewer complications in the repair group as compared to those who underwent proximal diversion (Table 42.4).

Table 42.4 Mortality rate of penetrating colorectal trauma in American wars

	Primary repair		Colonic diversion	
Study	No. of patients	Rate of abdominal septic complications (%)	No. of patients	Rate of abdominal septic complications (%)
Chappuis et al. [27]	28	14.3	28	17.9
Sasaki et al. [28]	43	2.3	28	28.6
Gonzalez et al. [29]	89	18	87	21
Total	100	13.1	143	21.7

A further randomized study by Kamwendo [30] in 2002 confirmed the safety of primary repair. This study was important in that it included patients with delayed presentation, contamination, associated injuries, and shock. In fact, similar to the outcomes of prior studies, it showed that primary repair/anastomosis was superior to colostomy even in the high-risk patients with contamination. In a sense, the colon trauma literature largely mirrors the diverticulitis literature, with better outcomes consistently reported with resection and primary anastomosis versus resection and colostomy or proximal colostomy alone.

Multiple other prospective observational trials have also added valuable evidence upon which to base recommendations [4, 7, 31–34]. The majority of these support the use of primary repair or anastomosis without diversion for all types of colonic injury. This has led to the abandonment of the dogma that right- and left-sided injuries should be treated differently and that left-sided injuries mandated a colostomy.

The American Association for the Surgery of Trauma (AAST) conducted a multicenter randomized prospective trial of diversion vs. resection and anastomosis for destructive colonic injuries that was published in 2001 [1]. In this study, there were 297 patients; 66% were managed with primary anastomosis and 33% by diversion. Colon-related mortality was 1.3%, all in the diversion group. Anastomotic leak rate was 6.6% with zero mortality. Risk factors for abdominal complications were severe fecal contamination, transfusion of more than four units of blood within the first 24 hours, and inappropriate antibiotic selection. If all three factors were present, the rate of abdominal complications reached 60%. The authors concluded that resection with anastomosis is the treatment of choice in all destructive colonic injuries regardless of severity of injury.

However, the low incidence of severe (destructive, high-velocity, etc.) colonic injuries in this trial does limit the conclusion about the potential benefit of fecal diversion in select high-risk cases. These findings have also been misinterpreted by some as indicating that colostomy should be performed in patients with certain risk factors (severe contamination, transfusion requirement, etc.). In actuality, these factors increased the risk for abdominal complications regardless of whether ostomy or primary anastomosis was performed and should not be used as independent criteria for performing a colostomy.

The evolution of damage control laparotomy (DCL) for devastating abdominal trauma has led to a significant reduction in morbidity and mortality. Abbreviated laparotomy and resuscitation in the intensive care unit help to avoid, or more rapidly correct, the lethal triad of coagulopathy, acidosis, and hypothermia [35]. The management of colonic injuries in these situations has evolved as well. Early in the DCL era, colostomy was considered the treatment of choice. However, several studies supported selected repair or resection and delayed anastomosis after DCL, citing the potential ability to inspect the suture or staple line at subsequent operations [36–38]. Others voiced more caution in this patient population, particularly if there was a persistent need for vasopressors [39]. In 2009, Weinberg's retrospective review showed DCL patients that had resection with anastomosis had higher rates of complications compared to colostomy [40]. In 2011, Ott reported an enteric leak rate of 27% for patient who had a DCL, with higher leak rates associated with transfusion requirements and left-sided colonic injuries [41].

More recently, however, several studies have refuted the higher rates of complications for delayed anastomosis in patients that undergo DCL [42]. A recent multicenter retrospective cohort study performed across three Level I centers by Tatebe in 2017 indicated that DCL was not associated with increased enteric leaks, fistula, SSI, or intraperitoneal abscess despite nearly two-third having delayed repair. However, the study was underpowered, and a prospective trial was still recommended [43].

The Eastern Association for the Surgery of Trauma published its initial guidelines for the management of penetrating colonic injuries in 1998 [44]. More recently, in 2018, a meta-analysis was performed, and the guidelines were updated. The most recent guidelines recommend repair or repair and anastomosis in low-risk patients (no signs of shock, hemorrhage, severe contamination, or delay to surgical intervention). In high-risk civilian trauma patients (delay >12 hours, shock, associated injury, transfusion >6 units of blood, contamination, or left-sided colonic injuries), including those who undergo DCL, the society *conditionally* recommends that colon repair or resection and anastomosis be performed rather than mandatory colostomy except in patients with the most severe injuries [45].

Technical Considerations

In managing traumatic injuries, the surgeon is often faced with the need to make decisions rapidly with imperfect and incomplete information, often in suboptimal and chaotic settings. The patient should be widely prepped and draped, including the lateral abdominal wall in case a colostomy or ileostomy is needed. For the unstable or actively bleeding patient, a generous midline incision should be made at the start to allow rapid access to all quadrants of the abdomen. For the stable patient, a smaller laparotomy incision can be considered and may be extended based on the injuries that are identified. If a large amount of hemoperitoneum is discovered on entering the abdominal cavity, even in the "stable" patient, then all attempts at a "minilaparotomy" should be abandoned, and the incision should be extended from the xiphoid to several centimeters above the pubic symphysis.

During the initial exploration for penetrating trauma, it is important to optimize the operative exposure and visualization. This can often be obtained by taking a few minutes to set up a self-retaining retractor of choice. Gross spillage should be controlled with quick suturing or stapling as soon as exsanguinating hemorrhage is stopped. This does not have to be a definitive resection or repair. In penetrating trauma, paracolic and retroperitoneal hematomas should be fully explored. Primary repair can be safely accomplished utilizing a number of methods. There is little difference between single- and double-layered suture techniques, with attention to careful suture placement and complete defect closure more important than how many layers are performed. Perforations that are within a few centimeters of each other are best treated by removing the intervening bridge of tissue and performing a single repair (Fig. 42.3) or resecting the involved segment. There is little difference between stapled and sutured anastomosis in terms of leak rates, anastomotic complications, or function. There is no need for colonic lavage even with left-sided anastomosis. In general, ileocolostomy is associated with fewer leaks than colocolostomy.

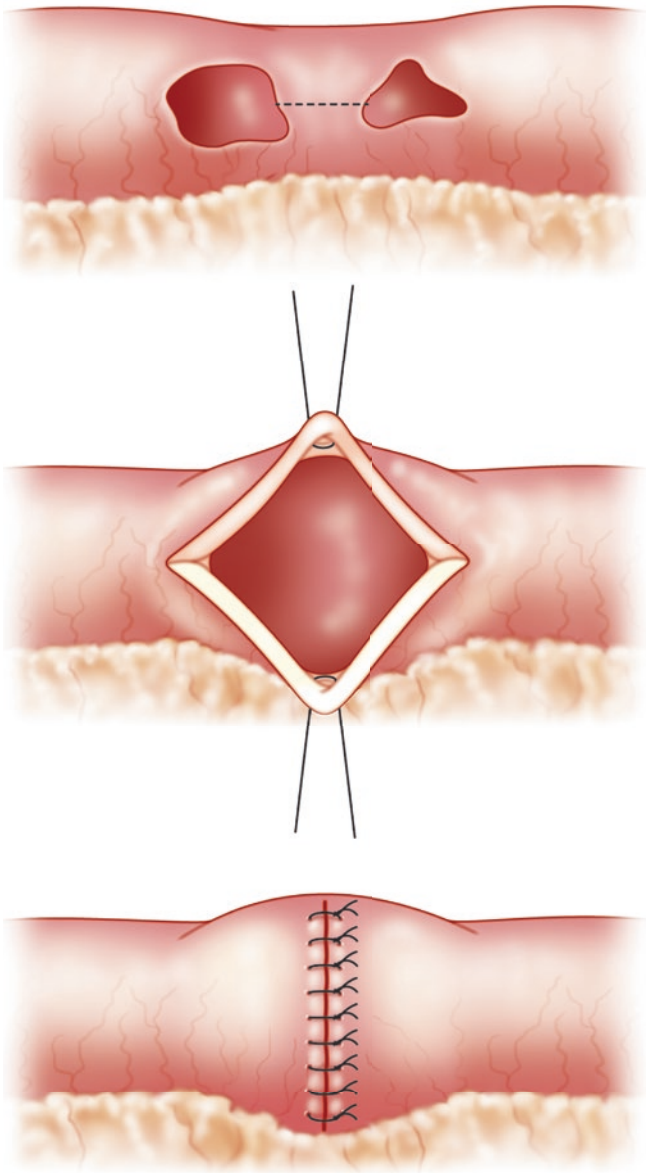

Fig. 42.3 The intervening bridge of tissue between two closed perforations can be removed, and the resulting single defect can be closed transversely

Should DCL be necessary, the colon can be left in discontinuity at the initial exploration. The key concept of DCL is to perform an abbreviated laparotomy that addressed only active bleeding and control of gastrointestinal contamination. The classic indications for DCL are alteration in patient physiology marked by acidosis, hypothermia, and coagulopathy. Detailed exploration and reconstruction are deferred to a later time. Other indications include the presence of multiple complex injuries that will require prolonged surgical reconstruction and the presence of questionably viable bowel that will need a second-look operation. The abdomen is temporarily closed, and resuscitation is continued in the intensive care unit. Once restoration of normothermia and correction of acidosis and coagulopathy are accomplished, the patient is returned to the operating room for further treatment. Every attempt should be made to close the abdomen early, as earlier closure has been shown to decrease complication rates. There is also no optimal or standard time interval between operations that should be utilized. This decision should be based on the patient's injuries and response to resuscitation, and not a predetermined time interval. We strongly recommend avoiding intervals longer than 48 hours in the presence of stapled-off bowel, as this inevitably leads to proximal dilation, edema, and increased fluid requirements.

In most cases, there are multiple intraoperative decisions that need to be made quickly which will have a significant impact on both short-term and long-term outcomes. Table 42.5 provides a summary of these key decisions with

Table 42.5 Key intraoperative management issues and decision in colorectal trauma

Key decision	Factors to consider	Technical issues/pearls
Primary repair or resection?	Size of injury Shape of injury (linear, round/stellate) Single or multiple Tissue quality Mesentery status (rents, hematomas, devascularized segment)	Debride injury or burned tissue Connect close injuries rather than leaving "bridges" Evacuate large mesenteric hematomas Close mesenteric tears Resect segment with "bucket-handle" mesenteric defect
Damage control?	Patient stability Transfusion requirement Acid/base getting better or worse? Multiple injuries? Another reason for a "second look" (i.e., borderline bowel visibility)	Make decision early in case Proceed if patient improving; terminate if getting worse Vacuum-assisted temporary closure works best Usually no need for other drains
Anastomosis or ostomy?	Patient baseline status (age, comorbidities, meds) Physiologic status Quality of the tissues Other injuries and proximity to anastomosis Body habitus, ability to properly site an ostomy	Consider difficulty and risk of ostomy takedown Be wary of anastomosis with an associated pancreatic injury! Obesity increases difficulty and complications with ostomy
Anastomosis: hand-sewn or stapled?	Operative time Other injuries to address Personal experience and comfort Tissue quality, edema Anatomic area and bowel alignment Available equipment	No difference in leak or complication rates in most series Hand-sewn potentially more secure with suboptimal tissue quality, bowel wall edema Laparoscopic staplers great for pelvis, hard to reach areas, or sharp angles
Ostomy: loop, end, or others?	High-risk anastomosis that needs protection? Need access to distal bowel segment? Body habitus Mesentery – shortened, edematous	Loop may reach the skin easier with obesity or shortened mesentery May not get complete fecal diversion with a loop Remember the "end-loop" option (see text) Use an ostomy bar if any tension or obese patient Wrap ostomy in Seprafilm® for easier takedown
Leave a drain?	No indication for routine drainage of bowel anastomosis Widely drain any other adjacent injuries (pancreas, bladder, etc.) Other reasons: associated abscess cavity, control ascites in cirrhotic patient	Avoid direct contact of drain with anastomosis Larger sump drains usually not beneficial Make exit site remote from incision and any ostomy
Place a feeding tube?	Degree of bowel injuries and surgery Estimated need for prolonged NPO status Estimated inability to take oral nutrition Need for feeding access as well as gastric decompression? Pancreatic or duodenal injury?	Generally avoid making additional holes in the bowel in the trauma setting Stamm gastrostomy relatively safe and secure Higher complications with jejunostomy tubes with little benefit Consider intraoperative placement of nasojejunal tube

the associated factors and technical pearls that should be considered. This table is by no means all-inclusive but does highlight many of the common decisions.

Rectal Trauma

Epidemiology

Rectal injuries, while infrequent, are associated with a higher risk of missed or delayed diagnosis, as well as a significant risk of morbidity and mortality. These injuries are most often seen in the setting of penetrating trauma in the civilian population. Gunshot wounds account for greater than 80% of these injuries [3]. Accidental or intentional impalement, iatrogenic endoscopic and urologic injuries, and rectal foreign bodies account for the rest. In the military setting, rectal traumatic injuries occur at a higher rate and are typically more destructive, as they are often due to higher-velocity missile or blast mechanism [46].

Diagnosis

A high degree of suspicion is required to avoid the significant morbidity and mortality that can occur with a missed or delayed diagnosis. While the overall incidence of these injuries is low, certain injury patterns or mechanisms should

raise suspicion and prompt particular attention to the anorectal evaluation. Any penetrating trauma to the buttock, groin, proximal thighs, perineum, or sacra area should raise concern for an associated anorectal injury. Additionally, any trans-pelvic gunshot wound should be assumed to have a rectal injury until proven otherwise. Also, any injuries to any of the other closely associated organs or structures such as the bladder, uterus, vagina, or iliac vessels should prompt an evaluation for concomitant rectal injuries. In blunt trauma, an isolated anorectal injury is rare and is almost always associated with other major pelvic/perineal injuries and a high-velocity mechanism. Any pelvic fractures, particularly an "open-book" fracture, or those with major posterior pelvic/sacral disruption, can cause rectal injury from bone fragments or shearing forces (Fig. 42.4). Additional scenarios that are risks for blunt rectal trauma include straddle-type injuries and any fall with perineal impalement.

The presence of gross blood on digital rectal examination is highly suggestive of rectal injury and should mandate further evaluation. However, this exam finding lacks adequate sensitivity or specificity and should not be considered a definitive test to rule in or rule out a rectal injury. Sigmoidoscopy, either rigid or flexible, should be performed and has an expected diagnostic accuracy of 80–95% [47]. Care must be taken not to worsen a potential defect during the exam by aggressive scope advancement or insufflation [48]. A careful endoscopic exam with full 360-degree circumferential inspection must be performed, as often the signs of injury can be subtle. Visualization of a full-thickness defect of the rectal wall is relatively uncommon, and frequently the only endoscopic finding is a small hematoma at the site of injury.

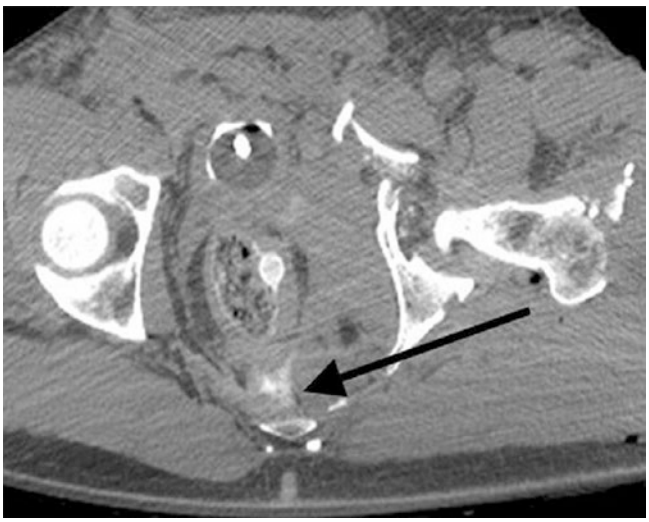

Fig. 42.4 Computed tomography showing rectal injury with contrast extravasation from a severe pelvic fracture

Table 42.6 AAST organ injury grading scale for injury to the rectum

Grade	Type of injury	Description of injury
I	Hematoma	Contusion or hematoma without devascularization
	Laceration	
II	Laceration	Laceration <50% of circumference
	Laceration	
III	Laceration	Laceration ≥50% of circumference
IV	Laceration	Full-thickness laceration with extension into the perineum
V	Vascular	Devascularized segment

Reused with permission from Fundamentals of Anorectal Surgery (Chap. 29, Table 28.1) by Beck DE, et al. (eds). 2019. Copyright © 2019 by Springer Nature

Computed tomography (CT) is now the most common radiologic adjunct in the trauma setting. It is often ordered with only IV contrast. However, should a rectal injury be suspected, the use of triple-contrast CT imaging (IV, oral, and rectal) can improve its diagnostic accuracy [49, 50]. The American Association for the Surgery of Trauma (AAST) has defined injuries to the rectum based on the degree of injury thickness and extent of circumference involved (Table 42.6) [51]. Similar to colonic injuries, rectal injuries are classified as either "destructive" or nondestructive." Any injury involving greater than 50% of the circumference of the bowel wall or with associated mesenteric injury that compromises the perfusion of the segment of bowel is considered "destructive."

Anatomic Considerations

The anatomy of the rectum is unique. The proximal anterior and lateral portions of the upper two-third of the rectum are covered with peritoneum, while the posterior surface is extraperitoneal. The distal third of the rectum lies completely extraperitoneal. This portion of the rectum is surrounded by a thick connective tissue and fat layer which contains the neurovascular supply. Since the dissection required to expose the extraperitoneal rectum is much more extensive and difficult compared to the intraperitoneal portion, the optimal operative strategy in rectal injuries differs vastly between intraperitoneal and extraperitoneal injuries.

It is also important to have a clear understanding of the anatomic locations and relationships of other key pelvic structures and organs in the operative exposure and repair of a rectal injury. These structures include the bladder anteriorly, the sacrum and sacral venous plexus posteriorly, and the iliac vessel and ureters posterolaterally. In males, the prostate and seminal vesicles and, in females, the uterus and vagina will also be found anteriorly.

Management of Intraperitoneal Rectal Injuries

These injuries have historically been managed like that of a distal left colon, with near-universal use of a diverting colostomy even for relatively small isolated injuries. However, there is little reason to treat these injuries any differently than injury to other portions of the colon, and a diverting ostomy should no longer be considered mandatory or "standard of care." The use of primary repair without diversion is a safe option in most nondestructive injuries in hemodynamically stable patients. A larger, more destructive injury to the intraperitoneal rectum should be managed with segmental resection of the injured portion. Following segmental resection, a decision for anastomosis versus ostomy must be made.

Using the same risk scaling approach described earlier in the chapter, we recommend an ostomy without anastomosis or an anastomosis with a protective proximal stoma in high-risk and select moderate-risk patients. Low-risk patients and select moderate-risk patients can safely undergo primary anastomosis as described previously for colonic injuries. Another important factor to consider is the location of the resection that is required. In general, if the resection has to be carried out down to the mid or lower third of the rectum, we recommend an anastomosis with a protective loop ileostomy. Subsequent elective return to the operating room and ileostomy reversal can be done as early as 4–6 weeks after the initial surgery. This can almost always be performed as a local procedure without the need for a repeat laparotomy.

Management of Extraperitoneal Rectum

Classically the teaching for the management of extraperitoneal rectal injuries has involved the "4 Ds": diversion, direct repair, distal washout, and drain placement. In reality, very few patients require all four (or even three) of these interventions, and the mainstay of care for most rectal extraperitoneal rectal injuries should be primary repair (if easily accessible) and proximal diversion. The most important of Ds will be proximal diversion as primary repair of an extraperitoneal rectal injury can be challenging due to its location, presence of bleeding, and proximate anatomic structures. Whether an end or loop colostomy is performed depends on the extent of the injury, associated injuries, body habitus, and operative approach. Creation of a loop colostomy as opposed to an end colostomy has been shown to provide appropriate fecal diversion and avoids the added risk of complicated takedown procedures [52, 53]. As with the loop ileostomy, a loop colostomy can frequently be reversed via a local procedure without the need for repeat laparotomy.

It is recommended that direct repair of extraperitoneal injuries be performed only when they are easily accessible without significant dissection or if the injury is encountered during the exposure of an associated injury [54]. While injuries to the proximal extraperitoneal rectum can be carried out via abdominal mobilization, a very distal injury will be best approached from inside the rectum.

Another option that can be considered is to resect the damaged segment, perform a primary anastomosis, and protect it with a diverting loop ileostomy [55]. While there may be some debate as to whether a loop ileostomy provides adequate diversion for a distal anastomoses, a modification of it to create a stapled end-loop ileostomy (or colostomy), with the distal stapled end buried in the subcutaneous tissue for future identification can be considered (Fig. 42.5) [56, 57]. This modification will provide complete fecal diversion and obviate the need for a future laparotomy when it comes to time for reversal.

When it comes to the other 2 Ds, distal washout and drain placement need only to be used infrequently. When there is a large volume of retained stool in the rectal vault and the injury has been controlled or excluded, then a distal washout can be performed. Similarly, presacral drainage has lost significant support over the years, and in fact it is not necessary in the vast majority of the cases. A prospective trial in 1998 randomized patients with extraperitoneal rectal injury to presacral drain placement versus no drain and found that there was no benefit of presacral drains in reducing infectious complications [58]. Some still advocate for the use of a presacral drain for those injuries that are inaccessible and cannot be repaired or that have a heavy degree of presacral contamination. This should be done in conjunction with a diverting ostomy [59, 60]. Figure 42.6 shows the location of a properly placed presacral drain. This can be placed by making a curved transverse incision posterior to the anus and bluntly dissecting the presacral space to the level of the injury.

Similarly, distal washout of the rectum has not shown to have any benefit in the routine management of penetrating civilian rectal trauma. Those supporting distal rectal washout claim that removal of remaining stool in the defunctionalized rectal vault will decrease the risk of sepsis. Others argue that forceful irrigation of liquid into the rectal vault will only increase the amount of local spillage and can push fecal material into otherwise unaffected tissue planes. Overall, the authors of this chapter do not routinely employ distal rectal washout in the setting of rectal trauma.

Guidelines

The Eastern Association for the Surgery of Trauma (EAST) has released practice guidelines for the management of nondestructive extraperitoneal rectal injuries. They *conditionally* recommend *for* proximal diversion and *against* presacral drainage and distal rectal washout. Keep in mind that these

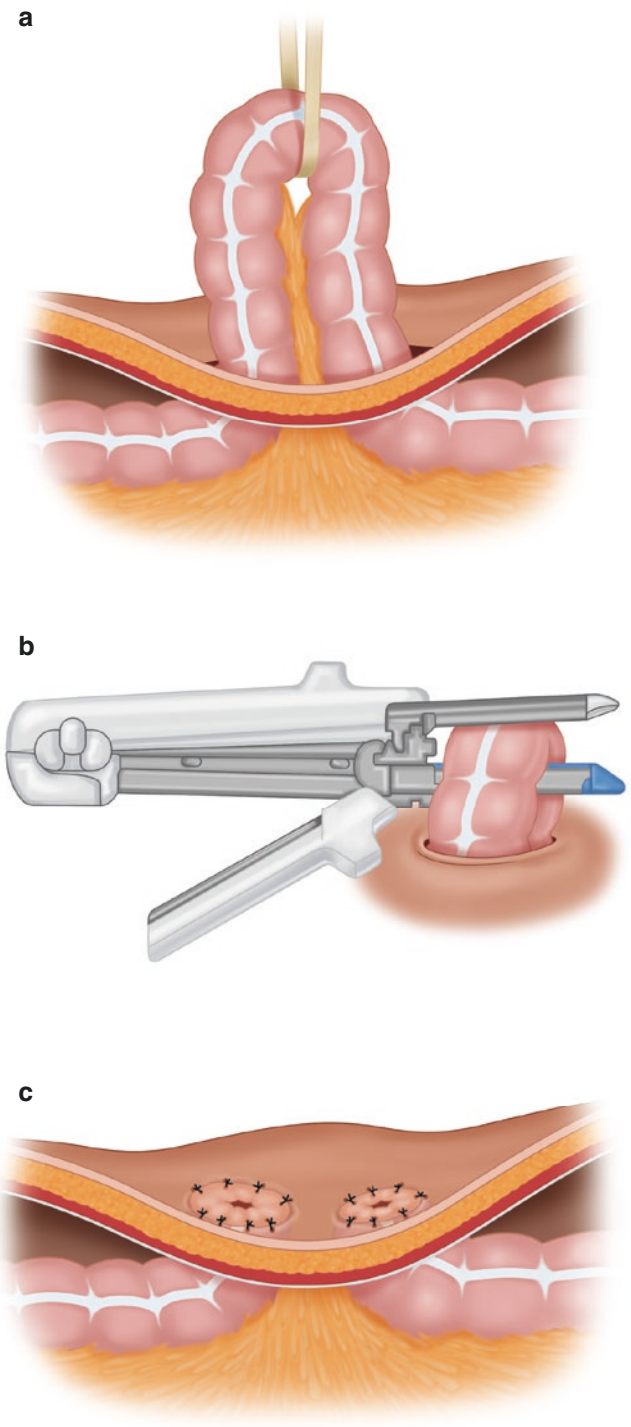

Fig. 42.5 Technique for end-loop ostomy (colon or ileum). (**a**) Loop of the bowel is delivered, (**b**) the bowel is divided at the site of the planned ostomy, and (**c**) proximal end is matured, and the distal stapled end is secured in the subcutaneous position for easy future access and restoration of continuity

recommendations are based on evidence graded as "very low" by the committee [61]. However, this represents the best currently available evidence and synthesis of the disparate literature on this topic.

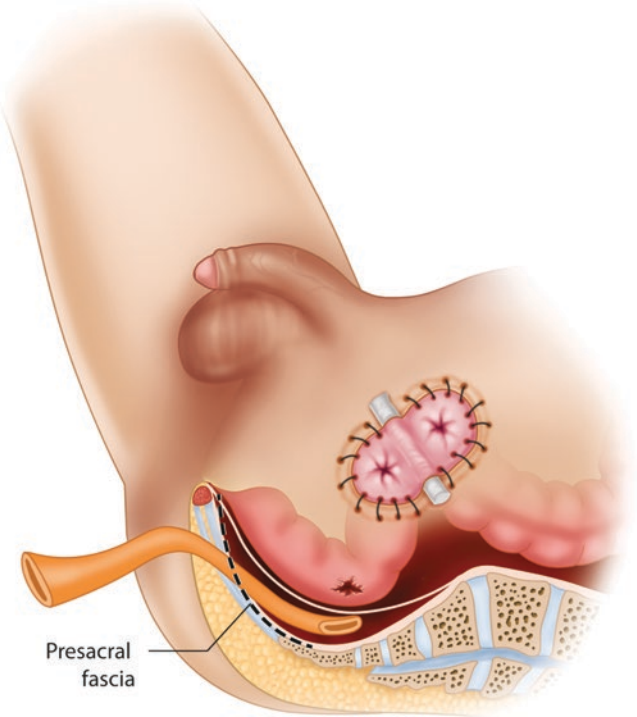

Fig. 42.6 Placement of drains in the presacral space, anterior to Waldeyer's fascia, up to the level of colorectal injury. (Reprinted (adapted) from Fundamentals of Anorectal Surgery (Chap. 29, Fig. 28.2) by Beck DE, et al. (eds). 2019. Copyright © 2019 Springer Nature)

The American Association for the Surgery of Trauma [62] published a recent large multicenter study of traumatic rectal injuries in 2017. This analysis of 758 rectal injuries is the largest in the literature and provides additional support for the current trends outlined above. For intraperitoneal rectal injuries, those managed with a diverting colostomy had twice the complication rate (22% vs. 10%) compared to those managed with primary repair or primary anastomosis without diversion. For the extraperitoneal rectal injuries, the majority were managed with proximal diversion with or without direct repair of the injury. On multivariate analysis, the use of distal rectal washout and presacral drainage were independent risk factors for increased abdominal complications (odds ratios of 3.4 and 2.6, respectively) [62].

We recommend that if the injury is limited and easily accessible with minimal dissection with either transanal or abdominal exposure, then primary repair with or without loop colostomy diversion should be performed. Destructive or inaccessible injuries should be diverted with loop colostomy. Distal rectal washout and presacral drainage are not routinely recommended but can be considered in highly select indications.

Anal Trauma

Epidemiology

While non-obstetric trauma to the anus or sphincter is rare, the onset of the recent wars in Iraq and Afghanistan has led to an increase in perianal and pelvic wounds due to ground-level improvised explosive devices (IEDs). These injuries are often seen in conjunction with other massive destructive injures to the perineum, extremities, and trunk. In the civilian trauma setting, the majority of anal trauma is seen with penetrating injuries to the perineum and straddle or impalement injuries or in association with complex open pelvic fractures.

Diagnosis

The diagnosis of anal injuries is usually readily apparent on history and physical exam during the secondary survey. If the patient is awake and able to respond appropriately, then a history of perineal trauma can usually be elicited as well as any current complaints of anal or perianal pain or pressure. The perineum and anus should be evaluated thoroughly; the majority of clinically significant injuries are readily diagnosed by visual inspection. The perineum should be carefully inspected and palpated. The sphincter tone and voluntary function should be assessed with a digital rectal examination. Females should undergo a vaginal exam as well.

If an injury is suspected or identified, a careful examination in the operating room should be done to assess for involvement of the anal sphincters. Gentle anoscopy/proctoscopy should be performed both to evaluate the anal canal and look for associated rectal injury. Particular care should be taken in patients with obesity as even major injuries can be remained hidden until the buttocks and any redundant tissue is adequately retracted to expose the perianal area. It is also critical to obtain a detailed history (as possible) from the patient regarding any prior trauma, preexisting anal/perineal problems, and existing problems with fecal continence. These factors may have significant impact on the evaluation and subsequent management decisions.

Management

Minor injuries to the anal canal can be treated with either local wound care alone or a transanal debridement back to healthy tissue and primary suture repair. Care must be taken to preserve the anal sphincter mechanism to the extent possible and to avoid narrowing of the anal orifice or canal. Simple lacerations to the anal canal involving the sphincter muscles can be repaired primarily with absorbable suture. In all anal injuries, it is critical to clearly identify and document the exact size of the wound, the location relative to the anal verge and dentate line, and the presence and extent of injury to any related structures such as the urethra, penis or scrotum, vagina, bladder, pelvic nerves, bony pelvis/sacrum, and spine/spinal cord.

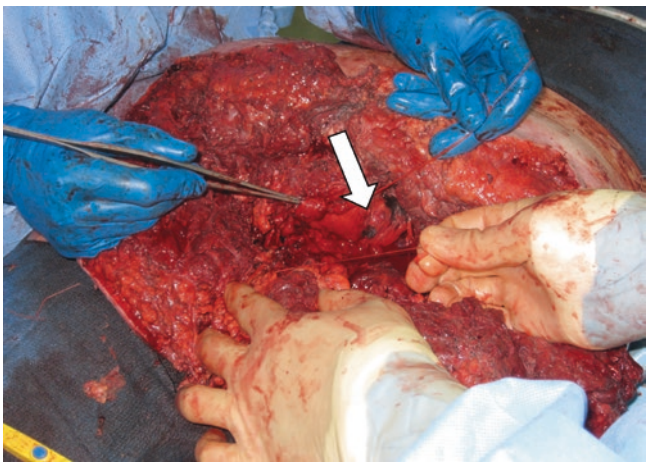

Fig. 42.7 Massive perineal blast wound with destruction of the sphincter complex and exposed distal rectum (arrow). These patients warrant immediate operative intervention to prevent exsanguination, perform debridement, and in this case perform diverting colostomy. (Reprinted (adapted) from Fundamentals of Anorectal Surgery (Chap. 29, Fig. 28.4) by Beck DE, et al. (eds). 2019. Copyright © 2019 Springer Nature)

Massive injures to the perineum can result in significant loss of tissue and complex wounds (Fig. 42.7). Nonviable tissue should be debrided to healthy tissue, but excessive debridement should be avoided at the first operation in order to minimize the loss of sphincter muscle and maximize future options for wound closure. The cut ends of the sphincter muscles should be tagged with sutures for future repair if not repaired at the initial operation. A colostomy is usually indicated in complex perineal wounds involving the anal sphincters and should be performed as early as possible. Although relatively uncommon, large destructive wounds (as seen with military blast injuries) with injury to both the anus and extraperitoneal rectum may require a proctectomy to control contamination and pelvic sepsis.

A vacuum-assisted wound closure device can be used on the perineum while serial debridement is ongoing (Fig. 42.8). It is imperative to investigate the genitourinary tract as many patients will have combined injuries. Older studies have shown good functional outcomes with delayed sphincter repair [63]. Anorectal manometry has been shown to predict functional outcome and should be performed prior to colostomy reversal. Due to the complex nature of these injuries and the local anatomy, we recommend early involvement of a multidisciplinary team including a colorectal surgeon to

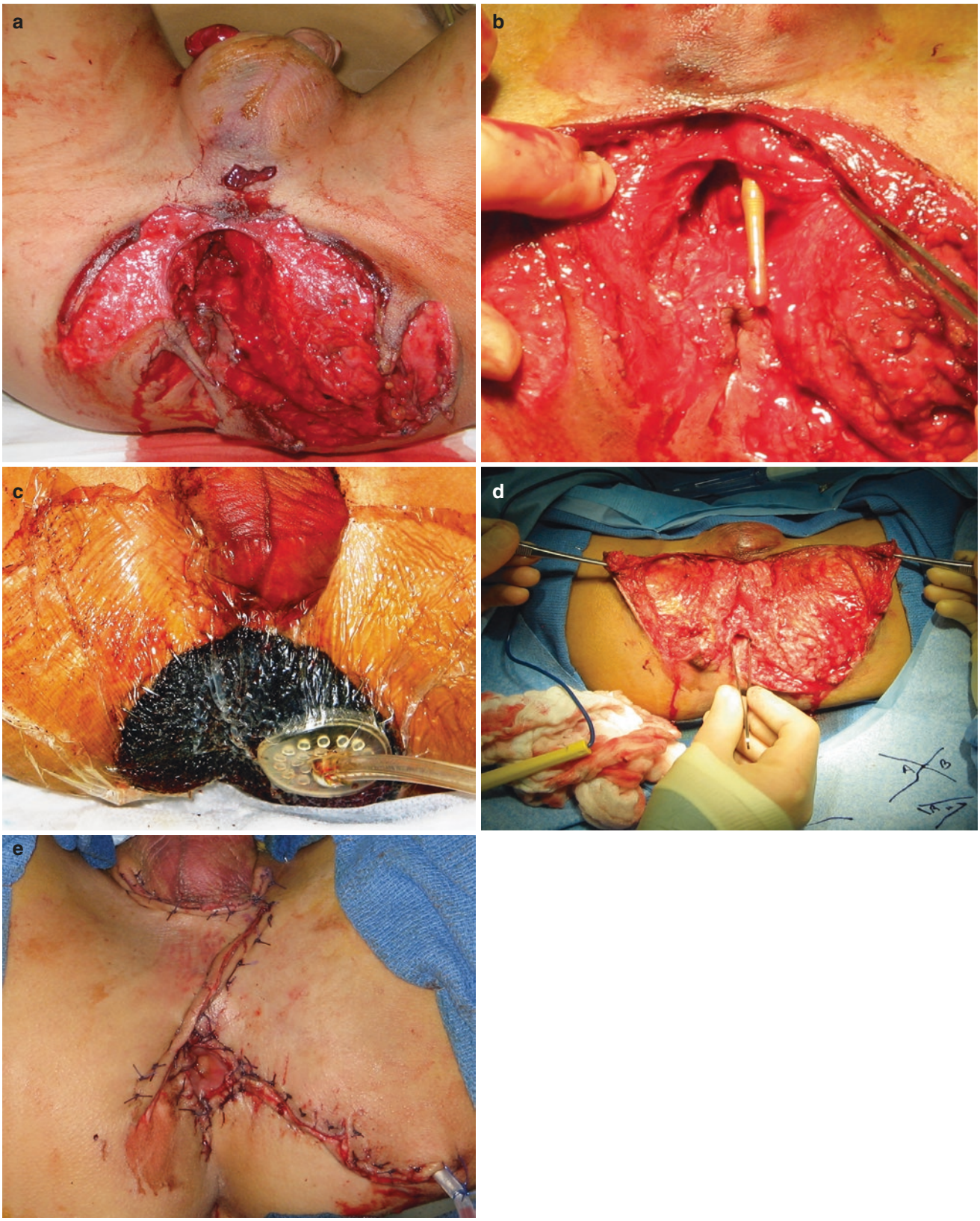

Fig. 42.8 (**a**–**e**). Destructive perineal and anal injury. (**a**) Mortar fragment entered the right hemiscrotum and exited the perineum, causing a massive injury. (**b**) Urethral transection was repaired through the perineum. (**c**) Serial debridements and wound vacuum-assisted closure changes created a healthy wound bed. (**d**) Flaps were constructed to facilitate closure. (**e**) After sphincteroplasty, the final wound closure. Colostomy was closed 6 weeks later and patient had excellent continence

assist with planning and subsequent management. The use of pelvic floor physical therapy with sphincter exercises and biofeedback can improve tone and squeeze mechanics, with improvement of continence in the setting of minor traumatic sphincter injuries [63, 64]. Those individuals with poorly or non-functioning sphincter complexes (or preexisting incontinence) are usually best served with a permanent colostomy.

References

1. Demetriades D, Murray JA, Chan L, Ordonez C, Bowley D, et al. Penetrating colon injuries requiring resection: diversion or primary anastomosis? An AAST prospective multicenter study. J Trauma. 2001;50(5):765–75.
2. Steele SR, Wolcott KE, Mullenix PS, Martin MJ, Sebesta JA, et al. Colon and rectal injuries during Operation Iraqi Freedom: are there any changing trends in management or outcome? Dis Colon Rectum. 2007;50(6):870–7.
3. Cho SD, Kiraly LN, Flaherty SF, Herzig DO, Lu KC, Schreiber MA. Management of colonic injuries in the combat theater. Dis Colon Rectum. 2010;53(5):728–34.
4. George SM Jr, Fabian TC, Voeller GR, Kudsk KA, Mangiante ED, Britt LG. Primary repair of colon wounds: a prospective trial in nonselected patients. Ann Surg. 1989;209(6):728–33; 733–34.
5. Chappuis CW, Frey DJ, Dietzen CD, Panetta TP, Buechter KJ, Cohn I Jr. Management of penetrating colon injuries: a prospective randomized trial. Ann Surg. 1991;213(5):492–7.
6. Demetriades D, Charalambides D, Pantanowitz D. Gunshot wounds of the colon: role of primary repair. Ann R Coll Surg Engl. 1992;74(6):381–4.
7. Ivatury RR, Gaudino J, Nallathambi MN, Simon RJ, Kazigo ZJ, Stahl WM. Definitive treatment of colon injuries: a prospective study. Am Surg. 1993;59(1):43–9.
8. Gonzalez RP, Merlotti GJ, Holevar MR. Colostomy in penetrating colon injury: is it necessary? J Trauma. 1996;41(2):271–5.
9. Demetriades D, Murray JA, Chan L, et al. Penetrating colon injuries requiring resection: diversion or primary anastomosis? An AAST prospective multicenter study. J Trauma. 2001;50(5):765–75.
10. Hatch Q, Causey M, Martin M, et al. Outcomes after colon trauma in the 21st century: an analysis of the U.S. National Trauma Data Bank. Surgery. 2013;154(2):397–403.
11. MacCormac W. Some points of interest in connection with the surgery of war. Br Med J. 1895;ii:278–84.
12. Bennett JD. Abdominal surgery in war – the early story. J R Soc Med. 1991;84(9):554–7.
13. Derby AC. Wounds of the abdomen. Part 1: in war. Can J Surg. 1988;31(4):213–8.
14. Ogilvie WH. Abdominal wounds in the Western Desert. Bull US Army Med Dep. 1946;6(4):435–45.
15. Edwards DP. The history of colonic surgery in war. J R Army Med Corps. 1999;145(2):107–8.
16. Office of the Surgeon General: Circular Letter No. 178; 1943.
17. Perry WB, Brooks JP, Muskat PC. The history of military colorectal trauma management. Semin Colon Rectal Surg. 2004;15(2):70–9.
18. Welch CE. War wounds of the abdomen. N Engl J Med. 1947;237(6):187–94.
19. Vertrees A, Wakefield M, Pickett C, Greer L, Wilson A, Gillern S, et al. Outcomes of primary repair and primary anastomosis in war-related colon injuries. J Trauma. 2009;66(5):1286–91; discussion. 91–3.
20. Sambasivan CN, Underwood SJ, Cho SD, Kiraly LN, Hamilton GJ, Kofoed JT, et al. Comparison of abdominal damage control surgery in combat versus civilian trauma. J Trauma. 2010;69 Suppl 1:S168–74.
21. Demetriades D, Velmahos G, Cornwell E III, et al. Selective nonoperative management of gunshot wounds to the anterior abdomen. Arch Surg. 1997;132(2):178–83.
22. Ross SE, Cobean RA, Hoyt DB, et al. Blunt colonic injury—a multicenter review. J Trauma. 1992;33(3):379–84.
23. Moore EE, Cogbill TH, Malangoni MA, et al. Organ injury scaling II, pancreas, duodenum, small bowel, colon, and rectum. J Trauma. 1990;30(11):1427–9.
24. Velmahos GC, Constantinou C, Tillou A, et al. Abdominal computed tomographic scan for patients with gunshot wounds to the abdomen selected for nonoperative management. J Trauma. 2005;50(5):1155–60.
25. Goldberg SR, Anand RJ, Como JJ, Dechert T, Dente C, Luchette FA, et al. Prophylactic antibiotic use in penetrating abdominal trauma: an Eastern Association for the Surgery of Trauma practice management guideline. J Trauma Acute Care Surg. 2012;73(5 Suppl 4):S321–5.
26. Stone HH, Fabian TC. Management of perforating colon trauma: randomization between primary closure and exteriorization. Ann Surg. 1979;190(4):430–6.
27. Sasaki LS, Allaben RD, Golwala R, et al. Primary repair of colon injuries: a prospective randomized study. J Trauma. 1995;39(5):895–901.
28. Gonzalez PR, Falimirski ME, Holevar MR. Further evaluation of colostomy in penetrating colon injury. Am Surg. 2000;66(4):342–6.
29. Kamwendo NY, Modiba MC, Matlala NS, Becker PJ. Randomized clinical trial to determine if delay from time of penetrating colonic injury precludes primary repair. Br J Surg. 2002;89(8):993–8.
30. Musa O, Ghildiyal JP, Pandey MC. 6 year prospective clinical trial of primary repair versus diversion colostomy in colonic injury cases. Indian J Surg. 2010;72(4):308–11.
31. Cornwell EE 3rd, Velmahos GC, Berne TV, Murray JA, Chahwan S, Asensio J, et al. The fate of colonic suture lines in high-risk trauma patients: a prospective analysis. J Am Coll Surg. 1998;187(1):58–63.
32. Edwards DP. Prospective audit of multiple penetrating injuries to the colon: further support for primary closure. J R Coll Surg Edinb. 1997;42(1):62.
33. Thomson SR, Baker A, Baker LW. Prospective audit of multiple penetrating injuries to the colon: further support for primary closure. J R Coll Surg Edinb. 1996;41(1):20–4.
34. Crookes B. An evidence-based approach to damage control laparotomy for trauma. In: Cohn SM, editor. Acute care surgery and trauma: evidence based practice. 1st ed. London: Informa; 2009.
35. Miller PR, Chang MC, Hoth JJ. Colonic resection in the setting of damage control laparotomy: is delayed anastomosis safe? Am Surg. 2007;73(6):606–9.
36. Georgoff P, Perales P, Laguna B, et al. Colonic injuries and the damage control abdomen: does management strategy matter? J Surg Res. 2013;181(2):293–9.
37. Kashuk JL, Cothren CC, Moore EE, et al. Primary repair of civilian colon injuries is safe in the damage control scenario. Surgery. 2009;146(6):663–70.
38. Weinberg JA, Griffin RL, Vandromme MJ, et al. Management of colon wounds in the setting of damage control laparotomy: a cautionary tale. J Trauma. 2009;67(4):929–35.
39. Weinberg JA, Griffin RL, Vandromme MJ, Melton SM, George RL, Reiff DA, Kerby JD, Rue LW 3rd. Management of colon wounds in the setting of damage control laparotomy: a cautionary tale. J Trauma. 2009;67(5):929–35.
40. Ott MM, Norris PR, Diaz JJ, Collier BR, Jenkins JM, Gunter OL, Morris JA Jr. Colon laparotomy: recommendations from 174 trauma colectomies. J Trauma. 2011;70(3):595–602.

41. Smith IM, Beech ZK, Lundy JB, Bowley DM. A prospective observational study of abdominal injury management in contemporary military operations: damage control laparotomy is associated with high survivability and low rates of fecal diversion. Ann Surg. 2015;261(4):765–73.
42. Tatebe LC, Jennings A, Tatebe K, Handy A, Prajapati P, Smith M, Do T, Ogola GO, Gandhi RR, Duane TM, Luk S, Petrey LB. Traumatic colon injury in damage control laparotomy – a multicenter trial: is it safe to do a delayed anastomosis. J Trauma Acute Care Surg. 2016;82(4):742–9.
43. Cayten CG, Fabian TC, Garcia VF, Ivatury RR, Morris JA. Penetrating colon injuries, management of. J Trauma. 1987;27(11):1237–9.
44. Cullinane DC, Jawa RS, Corno JJ, Moore AE, Morris DS, et al. Management of penetrating intraperitoneal colon injuries: a meta-analysis and practice management guidelines from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg. 2019;86(3):505–15.
45. Demetriades D, Murray JA, Chan LS, et al. Hand sewn versus stapled anastomosis in penetrating colon injuries requiring resection: a multicenter study. J Trauma. 2002;52(1):117–21.
46. Ivatury RR, Lieata J, Gundunz Y, et al. Management options in penetrating rectal injuries. Am Surg. 1991;57(1):50–5.
47. Herzig DO. Care of the patient with anorectal trauma. Clin Colon Rectal Surg. 2012;25:210–3.
48. Anderson SW, Soto JA. Anorectal trauma: the use of computer tomography scan in diagnosis. Semin Ultrasound CT MR. 2008;29(6):472–82.
49. Shanmuganathan K, Mirvis SE, Chiu WC, Killeen KL, Hogan GJ, Scalea TM. Penetrating torso trauma: triple-contrast helical CT in peritoneal violation and organ injury - a prospective study in 200 patients. Radiology. 2004;231:775–84.
50. Moore EE, Cogbill TH, Malangoni MA, Jurkovich GJ. Scaling system for organ specific injuries. Available at: http://www.aast.org/library/traumatools/injuryscoringscales.aspx.
51. Burch JM, Feliciano DV, Mattox KL. Colostomy and drainage for civilian rectal injuries: is that all? Ann Sug. 1989;209:600–11.
52. Rombeau JL, Wilk PJ, Turnbull J, Fazio VW. Total fecal diversion by the temporary skin-level loop transverse colostomy. Dis Colon Rectum. 1978;21:223–6.
53. Hoyt DB, Lekawa ME. Trauma of the colon and rectum. In: Beck DE, Roberts PL, Saclarides TJ, Senagore AJ, Stamos MJ, Wexner SD, editors. The ASCRS textbook of colon and rectal surgery. 2nd ed. New York: Springer; 2007.
54. Martin MJ, Beekley A. Front line surgery: a practical approach. 1st ed. New York: Springer; 2011.
55. van der Sluis FF, Schouten N, de Graaf PW, Karsten TM, Stassen LP. Temporary end ileostomy with subcutaneously buried efferent limb: results and potential advantages. Dig Surg. 2010;27(5):403–8.
56. Prasad ML, Pearl RK, Orsay CP, Abcarian H. End-loop ileocolostomy for massive trauma to the right side of the colon. Arch Surg. 1984;119(8):975–6.
57. Gonzalez RP, Falimirski ME, Holevar MR. The role of presacral drainage in the management of penetrating rectal injuries. J Trauma. 1998;45(4):656–61.
58. McGrath V, Fabian TC, Croce MA, Minard G, Pritchard FE. Rectal trauma: management based on anatomic distinctions. Am Surg. 1998;64:1136.
59. Weinberg JA, Fabian TC, Magnotti LJ, et al. Penetrating rectal trauma: management by anatomic distinction improves outcome. J Trauma. 2006;60:508–14.
60. Bosarge PL, Como JJ, Fox N, Falck-Ytter Y, Haut ER, Robinson BRH, McGwin GJ, Conzalez RP. Management of penetrating extraperitoneal rectal injuries: an Eastern Association for the Surgery of Trauma practice management guideline. J Trauma Acute Care Surg. 2016;80(3):546–51.
61. Engel AF, Kamm MA, Hawley PR. Civilian and war injuries of the perineum and anal sphincters. Br J Surg. 1994;81:1069–73.
62. Brown CVR, Teixeira PG, Furay E, Sharpe J, Musonza T, et al. Contemporary management of rectal injuries at level 1 trauma centers: the results of an American Association for the Surgery of Trauma multi-institutional study. J Trauma. 2017 [Podium paper]. https://doi.org/10.1097/TA.0000000000001739.
63. Critchlow JF, Houlihan MJ, Landolt CC, Weinstin ME. Primary sphincter repair in anorectal trauma. Dis Colon Rectum. 1985;28(12):945–7.
64. McCune WS. War wounds of the rectum and anal sphincter. Surgery. 1948;23:653–64.