Colon Trauma: Evidence-Based Practices

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Abstract

Colon injury is not uncommon and occurs in about a half of patients with penetrating hollow viscus injuries. Despite major advances in the operative management of penetrating colon wounds, there remains discussion regarding the appropriate treatment of destructive colon injuries, with a significant amount of scientific evidence supporting segmental resection with primary anastomosis in most patients without comorbidities or large transfusion requirement. Although literature is sparse concerning the management of blunt colon injuries, some studies have shown operative decision based on an algorithm originally defined for penetrating wounds should be considered in blunt colon injuries. The optimal management of colonic injuries in patients requiring damage control surgery (DCS) also remains controversial. Studies have recently reported that there is no increased risk compared with patients treated without DCS if fascial closure is completed on the first reoperation, or that a management algorithm for penetrating colon wounds is probably efficacious for colon injuries in the setting of DCS as well.

Keywords

- nondestructive colon injury
- destructive colon injury
- blunt colon injury
- damage control surgery
- ostomy

Epidemiology

The colon is commonly injured from penetrating trauma in the civilian setting, where the vast majority of injuries are because of gunshot wounds and the remaining injuries from stabbings.[1] Colon injury occurs in approximately 51% of patients with penetrating hollow viscus injuries, and the transverse colon is the most commonly injured segment.[1,2] In penetrating colon injuries requiring colonic resection, the right colon is involved in approximately 49% of cases and the left colon injury is found in approximately 39% of patients, while both sides of the colon injuries are diagnosed in approximately 12% of patients.[3] High-velocity gunshot wounds create destructive injury to the colon and require segmental colon resection in most of the settings. Low-velocity gunshot wounds or stab wounds rarely cause major tissue damage and usually can be managed by primary repair.

Blunt colon injury is infrequent and is often the result of motor vehicle collisions, followed by assault injuries, pedestrian collisions, and falls.[4] Although seat belt injuries and direct blows to the colon are common mechanism, the massive deceleration force may result in mesenteric tears and ischemic necrosis of the colon. In rare settings, a colonic wall contusion may cause delayed perforation several days after the injury.[5] Blunt injury to the colon is found in approximately 0.5% of patients with major blunt trauma and is diagnosed in approximately 10% of patients undergoing laparotomy. About a half of patients with blunt colon injuries undergoing laparotomy have serosal wounds involving 50% or greater of the colon wall circumference, mesenteric devascularization, or full-thickness perforations.[4,5] The right colon is the most commonly injured segment followed by the transverse colon or the sigmoid colon, and the left colon.[2,4]

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Table 1 CT findings of penetrating abdominal trauma

CT findings indicating peritoneal penetration[a]
Trajectory of the stab or missile clearly penetrating the peritoneal cavity
Free intraperitoneal fluid or air
Intraperitoneal extravasation of contrast material
Injury to an intraperitoneal solid organ or hollow viscus

Source: Data Adapted from Chiu et al.[6]
[a]A positive CT scan is defined as one with any evidence of peritoneal violation.

Diagnosis and Injury Scales

The diagnosis of colon injury is based on physical examination findings of abdominal tenderness or peritoneal signs and relies heavily on computed tomographic (CT) evaluation. The sensitivity and specificity of triple-contrast (oral, rectal, and intravenous) CT scan are found to be 97 and 98%, respectively, in diagnosing intra-abdominal organ injuries requiring surgical intervention (►**Table 1**),[6] albeit lower for blunt colonic trauma. The intravenous contrast-only CT scan also shows high sensitivity and specificity, 91 and 96%, respectively.[7] The diagnosis of colon injury after blunt trauma can be challenging since physical examination is not accurate in detecting hollow viscus injury. Although contrast CT scan has been the mainstay for diagnosis of blunt colon injury, CT diagnosis is difficult and careful scrutiny of CT images for extraluminal gas or fluid and bowel wall thickening is required. Extraluminal gas has been reported to be detectable in only approximately 50% of patients with hollow viscus injury, and extraluminal contrast is even more unusual than free air, being in only 19% of cases.[8]

Digital rectal exams (DRE) are routinely used on trauma patients and the presence of gross blood on DRE can be significant for a colorectal injury. However, the sensitivity of the DRE for the diagnosis of colon injury is poor and the DRE is not recommended as a screening tool for traumatic colon injuries.[9] Most colonic injuries are diagnosed during the initial exploration and mobilization of the colon. The segment of injured colon needs to be examined with great attention, particularly for through-and-through injury, which may require adequate mobilization of the colon to inspect the entire circumference of the bowel wall.

The most commonly reported grading system for colon injuries that fundamentally incorporates anatomic description, scaled from 1 to 5, represents the least to the most severe injury (►**Table 2**). This colon injury scale is useful to quantify the risk of an outcome after trauma including complications, for both clinical and research purposes.[10] However, its clinical applicability is limited in determining optimal treatment.

Surgical Approach for Colon Injury

General Principles and Historical Perspective

The initial goal of exploratory laparotomy for trauma is to stop bleeding. Once major bleeding is temporarily controlled, the extent of the colon injury needs to be assessed by adequate mobilization. Penetrating injury to the right or left colon requires mobilization of the entire injured side of the colon to examine its posterior wall, as well as the adjacent ureter. Although there is no need for mandatory exploration of paracolic hematomas in blunt trauma, in penetrating trauma every paracolic hematoma should be explored and the underlying colon should be thoroughly inspected. Some occult injuries can be diagnosed by air or bowel contents, leaking following compression of the suspected colonic segment.

There still remains discussion regarding the appropriate treatment of colon injuries, with the significant amount of scientific evidence supporting primary closure of simple colonic wounds and segmental resection with primary anastomosis in most patients with destructive injuries.[3] The first guidelines for the management of colon injuries were published in 1944 and mandatory colostomy was recommended for all colon wounds since they were associated with a high mortality rate.[11] The obligatory colostomy had remained the acceptable standard until 1979 when a prospective randomized study was reported by Stone and Fabian, in which primary repair was associated with fewer complications than fecal diversion in select patients. The authors of this study excluded patients with hypotension, delayed operation, multiple associated injuries, and

Table 2 Colon injury scale

Grade[a]	Type of injury	Description of injury	AIS-90
I	Hematoma	Contusion or hematoma without devascularization	2
	Laceration	Partial thickness, no perforation	2
II	Laceration	Laceration $<$50% of circumference	3
III	Laceration	Laceration $\geq$50% of circumference without transection	3
IV	Laceration	Transection of the colon	4
V	Laceration	Transection of the colon with segmental tissue loss	4
	Vascular	Devascularized segment	4

Source: Adapted from Moore et al.[10]
[a]Advanced grade I for multiple injuries up to grade III.

destructive colon injuries requiring resection.[12] The validity of contraindications for primary repair was investigated in subsequent studies, and primary repair has become the standard of care in the vast majority of minor or nondestructive penetrating colon injuries.

Various investigators also challenged the optimal management of destructive colon injuries requiring resection. Although most of the results made a recommendation in favor of resection and primary anastomosis, there was a paucity of cases and the limitations of primary anastomosis had been an unresolved issue until 2001 when the American Association for the Surgery of Trauma (AAST)-sponsored prospective multicenter study was published. In this study, the method of colon management did not influence the incidence of colon-related abdominal complications and authors suggested that destructive colon injuries requiring resection should be managed by resection with anastomosis.[3] In contrast, clear management schemes for blunt colon injuries are inconsistent, since the literature regarding outcomes of these injuries is scant. Our approach to the management of colon trauma is depicted in ►**Fig. 1** and discussed in greater detail in the coming sections.

Nondestructive Colon Injury and Primary Repair

Nondestructive colon injures are wounds that involve less than 50% of the colon wall circumference and occur without devascularization. After the prospective randomized study concluded primary repair was shown to be a viable alternative, risk factors including hypotension, delayed operation, or multiple associated injuries were considered indications for diversion. However, multiple small prospective studies have now demonstrated the safety of primary repair in this setting. Chappuis et al[13] performed a prospective randomized study of 56 patients with penetrating colon injuries in 1991. No exclusionary criteria were used in randomization and complications developed with equal frequency in both primary repair group and diversion group. In 1995, Sasaki et al[14] in a randomized study of 71 patients without any exclusion criteria reported a higher complication rate in patients with diversion and concluded that primary repair should be considered in all colon injuries irrespective of any associated risk factors. In a subsequent study in 1996, Gonzalez et al[15] randomized 109 patients with penetrating colon injuries to either primary repair or diversion. The incidence of septic complications in the primary repair group was not greater than that of the diversion group and this result suggested that primary repair was at least as successful as diversion, even when patients presented with shock, delayed operation, or sever grade of colon injury. They concluded again that primary repair should be performed in all civilian with penetrating colon injuries. There are also several prospective observational studies (class II evidence) supporting primary repair in nondestructive penetrating colon wounds and there has been approximately a 1% failure rate for all primary repairs.[16–18] In summary, evaluation of class I and II studies indicates a standard for primary repair of nondestructive penetrating colon injuries.

If primary repair of penetrating colon trauma is to be performed, the first step is adequate debridement of all penetrating wounds, particularly gunshot wounds. It is

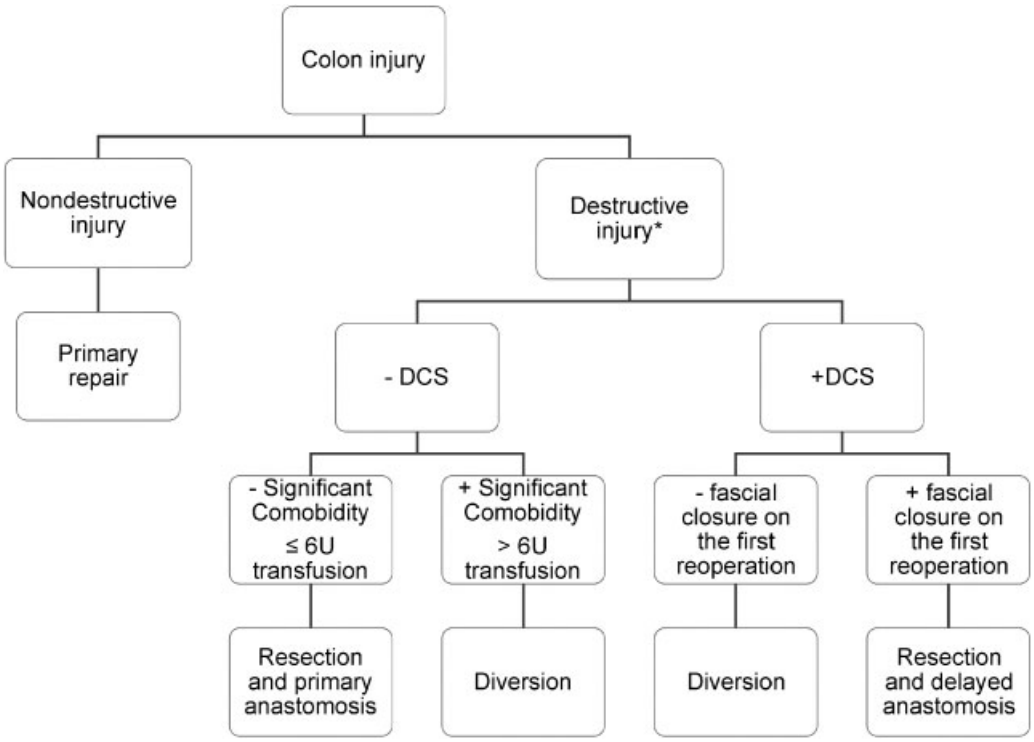

Fig. 1 Management of colon injury. *Penetrating destructive colon injury includes wounds involving 50% or greater of the colon wall circumference or devascularization. Blunt destructive colon injury includes serosal wounds involving 50% or greater of the colon wall circumference, devascularization, or full-thickness perforations. DCS, damage control surgery; U, unit.

critical to ensure well-perfused and not contused edges before any repair is performed. Sharp debridement back to bleeding tissue is essential. Wounds are then typically closed in two layers using absorbable sutures. Drains should not be routinely employed for the sole indication of colon trauma and repair.

Destructive Colon Injury and Resection with Anastomosis

Destructive colon injures are wounds that involve 50% or greater of the colon wall circumference or occur with segmental devascularization. These generally require segmental resection. Despite major advances in the operative management of penetrating colon wounds, controversy persists regarding the decision to perform an anastomosis over diversion for destructive penetrating colon injuries. The four prospective randomized studies (class I evidence) that investigated destructive colon injuries included only approximately 40 patients with colon resection and anastomosis collectively. Of these cases, there was one anastomotic leak (2.5%) and no deaths occurred. These studies concluded that the resection and primary anastomosis is the procedure of choice in destructive colon wounds, although there was a paucity of cases.[13–15,19] However, another prospective observational class II study that included 25 patients treated by resection and anastomosis reported two fatal anastomotic leaks (8%) and concluded that diversion should be recommended for high-risk patients with Penetrating Abdominal Trauma Index (PATI) of 25 or greater, 6 or more units of blood transfusions, or delayed surgery.[20] Some retrospective studies (class III evidence) also suggested that diversion should be considered in patients with serious concurrent injuries or significant underlying diseases. These parameters were confirmed in several small retrospective series. Stewart et al[21] performed a retrospective study of 43 patients with destructive colon injuries and reported a 33% leak rate was in the patients who had greater than 6 units of blood transfused, while the overall anastomotic leak rate was 14%. Murray et al[22] in another retrospective study of 140 patients with severe colon wounds requiring resection identified PATI $\geq$25 or hypotension in the emergency room which was associated with increased risk of developing a leak after colo-colonic anastomosis. The authors concluded that diversion might be appropriate in these high-risk patients.

In 2001, the AAST performed a multicenter prospective trial including 297 patients with destructive colon injuries, where two-thirds of cases were managed with resection and anastomosis. They reported no difference in colon-related complications, including anastomotic leak and intra-abdominal abscess, between patients who were treated with resection and anastomosis and those who received diversion. A higher mortality was measured in those patients who underwent diversion. They concluded that the method of colon wound management was not related to the development of complications, and noted that more than 4 units of blood transfusion, severe fecal contamination, and single-agent antibiotic prophylaxis were independent risk factors for abdominal complications.[3]

Although this AAST study noted complications occurring regardless of the method of management, some clinical pathways have been developed and evaluated in the recent medical literature in which patients who have destructive colon wounds with comorbidities or large transfusion requirement undergo diversion. Miller et al[23] performed a retrospective review of 56 patients with destructive colon injuries that were managed based on their clinical pathway. Per algorithm, patients with significant comorbidities or perioperative transfusion requirements greater than 6 units underwent diversion, while remaining patients underwent resection and anastomosis. They reported similar colon-related complication and mortality rates with primary anastomosis or diversion. In 2012, Sharpe et al[24] in another retrospective review of 102 cases with destructive colon wounds implemented an algorithm and found again that the incidence of complication in the anastomosis group was not greater than that of the diversion group. These studies also suggested that adherence to a defined algorithm would improve outcomes following penetrating destructive colon injuries.

On performing resection with anastomosis, the basic tenets of colorectal surgery should be followed. Resection to expose healthy viable edges and creation of a tension-free anastomosis are mandatory. Further protection of the anastomosis with omental wrap is a relatively common practice, although there is no class I evidence. Regarding the method of anastomosis, in a prospective AAST study of 207 patients with destructive colon wounds, the incidence of anastomotic leak was equal in both of hand-sewn group and stapled anastomosis group.[25]

Blunt Colon Injury

Literature is sparse concerning the management of blunt colon injuries and clear management schemes are inconsistent as wounding of the colon by blunt trauma occurs rarely. Traditionally, management strategies for penetrating colon injuries were not applied to blunt trauma because crush injury may be associated with more ischemia, putting patients at a higher risk for suture line leak. However, Ricciardi et al[26] retrospectively reviewed patients with blunt abdominal trauma and found that the grade of colon injury and the management of colon wounds including diversion were not associated with increased morbidity or mortality. Sharpe et al[4] performed another retrospective study of 151 blunt colon injuries in which operative management for all colon wounds followed a defined algorithm that was essentially same as the clinical pathway for penetrating colon injuries reported by Stewart et al.[21,24] In this study, blunt destructive colon injuries were defined as serosal defects involving 50% or greater of the colon wall circumference, mesenteric devascularization, or full-thickness perforations. The authors reported higher colon-related mortality in patients with diversion and concluded that nondestructive wounds should be repaired primarily and the treatment approach should generally follow the same algorithm as for penetrating injury.

Wound Management and Antibiotic Prophylaxis

Primary closure of the skin incision in colon injuries is associated with a high incidence of wound infection that is occasionally complicated by fascia dehiscence or necrotizing fasciitis. In a prospective randomized study, Velmahos et al[27] reported that primary closure of the wound following operation for colon injuries almost doubles the incidence of wound infection compared with leaving the wound open, and wound infection was also identified as an independent risk factor for fascia dehiscence and necrotizing fasciitis. Cohn et al[28] performed a prospective randomized study that included 9 traumatic wounds in addition to 40 other diseases to compare delayed primary closure with primary skin closure in dirty abdominal wounds. The authors found no difference in the length of hospital stay between the two groups and a lower rate of wound infection in delayed primary closure group, in which surgical incisions were approximated with adhesive strips at postoperative day 4 if appropriate. Based on this literature, the authors' practice is to leave the skin open, and delayed closure can be performed a few days later.

Since the AAST study of destructive colon injuries identified inadequate empiric antibiotic coverage as an independent risk factor for abdominal sepsis, effective antibiotic prophylaxis is critical.[3] Antibiotic prophylaxis for septic complication after colon injuries should provide coverage against both aerobes and anaerobes, although the optimal regimen and the duration of antibiotic therapy are not well defined. According to guidelines for antimicrobial prophylaxis in elective colorectal procedures,[29] a single dose of second-generation cephalosporin with both aerobic and anaerobic activities (cefoxitin or cefotetan) or cefazolin plus metronidazole is adequate. In institutions where there is increasing resistance to first- and second-generation cephalosporins among gram-negative isolates from surgical site infections (SSIs), a single dose of ceftriaxone plus metronidazole is recommended.

Abdominal Complications and Risk Factors

The most common abdominal complications after surgery for colon trauma include anastomotic leak, intra-abdominal abscess, and wound infection. There remains a belief that left colon injuries are associated with a higher incidence of abdominal complications than right colon injuries. An analysis of National Trauma Data Bank reported an ongoing propensity to divert distal colon injuries.[2] However, no study has proved that the two anatomical sides should be treated differently. A recent retrospective study by Sharpe et al[30] examined colon trauma outcomes in relation to segment of colon injured. No independent association was found between segment injured and abdominal complications. In contrast, there is evidence that ileocolostomy is associated with significantly fewer leaks than colocolostomy and it should be the procedure of choice in patients with right hemicolectomy following destructive right colon injuries. In a retrospective review of destructive colon wounds, Murray et al[22] identified a leak rate of 4% in 56 patients with ileocolostomies and 13% in 56 colocolostomies.

Fecal contamination is a major independent risk factor for abdominal complications.[3,5,18,22,31] Extensive fecal contamination remains a relative contraindication for primary repair in the minds of some surgeons. One option in these patients is resection or repair of the colon injury, aggressive abdominal washout, and second-look laparotomy. During the second operation, decision can be made regarding primary anastomosis versus diversion. A primary anastomosis can be considered if fascial is able to be closed at this same operation.[32] The common belief that retained missiles that passed through the colon are associated with increased risk of intra-abdominal abscess is supported by no evidence. In the study of 84 patients with gunshot wounds of the colon, Demetriades et al[33] concluded retained bullets do not contribute to abdominal complications.

Ostomy Management

While ostomies eliminate the risk of anastomotic leak, they are not without complications, including parastomal herniation, parastomal abscess, retraction, prolapse, and necrosis of ostomy. Patients with ostomies after colon surgery are more likely to require readmission and consume more health care resources than nondiverted patients. Additionally, an often difficult second laparotomy is needed to restore gastrointestinal continuity. In a retrospective review of 1,085 colostomy closures, Berne et al[34] reported 14.8% of overall complication rate at the time of closure.

The optimal timing of colostomy closure remains controversial. Although it has been suggested to wait for 3 months until colostomy matures, early colostomy closure can be safely undertaken in a vast majority of patients in the absence of severe intra-abdominal sepsis, malnutrition, or major wound problems. There are reports of stoma reversal during the initial hospitalization, sometimes within 2 weeks of the original surgery.[35]

Conclusion

Colon injuries requiring surgery are considerably more common in the setting of penetrating abdominal trauma than blunt injuries. Current practice is to perform primary repair of all nondestructive injuries to the colon (those injuries that involve less than 50% of the circumference of the colon and are without significant devascularization). Patients with destructive injuries to the colon may be treated with segmental resection and primary anastomosis if the patient does not have significant medical comorbidities and has undergone transfusion of 6 or fewer units of blood. Patients not meeting both of these criteria should undergo some form of diversion due to the higher risk of anastomotic complications. While these management schemes were derived primarily in the setting of penetrating colon injuries, the best available evidence would suggest that they are applicable in the setting of blunt colon injuries as well. Subsequent wound complications can be minimized by

appropriate perioperative antibiotics and leaving the skin open to heal by secondary intention or delayed primary closure.

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