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The Impact of Prior Laparotomy and Intra-abdominal Adhesions on Bowel and Mesenteric Injury Following Blunt Abdominal Trauma

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Abstract

Background—Early recognition of bowel and mesenteric injury following blunt abdominal trauma remains difficult. We hypothesized that patients with intra-abdominal adhesions from prior laparotomy would be subjected to visceral sheering deceleration forces and increased risk for bowel and mesenteric injury following blunt abdominal trauma.

Methods—We performed a multicenter retrospective cohort analysis of 267 consecutive adult trauma patients who underwent operative exploration following moderate-critical (abdominal injury score 2–5) blunt abdominal trauma, comparing patients with prior laparotomy ($n = 31$) to patients with no prior laparotomy ($n = 236$). Multivariable regression was performed to identify predictors of bowel or mesenteric injury.

Results—There were no significant differences between groups for injury severity scores or findings on abdominal ultrasound, diagnostic peritoneal aspirate/lavage, pelvic radiography, or preoperative CT scan. The prior laparotomy cohort had greater incidence of full thickness bowel injury (26 vs. 9%, $p = 0.010$) and mesenteric injury (61 vs. 31%, $p = 0.001$). The proportion of bowel and mesenteric injuries occurring at the ligament of Treitz or ileocecal region was greater in the no prior laparotomy group (52 vs. 25%, $p = 0.003$). Prior laparotomy was an independent predictor of bowel or mesenteric injury (OR 5.1, 95% CI 1.6–16.8) along with prior abdominal inflammation and free fluid without solid organ injury (model AUC: 0.81, 95% CI 0.74–0.88).

Conclusions—Patients with a prior laparotomy are at increased risk for bowel and mesenteric injury following blunt abdominal trauma. The distribution of bowel and mesenteric injuries among

Compliance with ethical standards

Conflict of interest
The Authors declare that they have no conflict of interest.

patients with no prior laparotomy favors embryologic transition points tethering free intraperitoneal structures to the retroperitoneum.

Introduction

The incidence of intra-abdominal injury among adult patients with blunt abdominal trauma is approximately 13% [1], with bowel and mesenteric injuries occurring in 1–5% [2, 3]. Identifying patients who will benefit from operative exploration remains difficult. With the development of several prediction models [4–11] and the introduction of multidetector computed tomography (CT) technology [12, 13], the reported rate of non-therapeutic laparotomy has decreased from 27.1% in 1995 to 3.9% in 2012 [14, 15]. Despite these advances, the incidence of complications following non-therapeutic laparotomy ranges from 15 to 41%, and the incidence of incisional ventral hernia or small bowel obstruction requiring hospital admission within 10 years of trauma laparotomy is at least 15%, underscoring the potential benefits of more precise patient selection [14–16]. In addition, delayed or missed diagnosis of a bowel or mesenteric injury remains a significant problem and is associated with increased morbidity and mortality [17].

Clinicians cannot rely on imaging findings alone in diagnosing bowel and mesenteric injury following blunt trauma. The sensitivity and specificity of multidetector CT for bowel and mesenteric injury are approximately 64 and 80%, respectively, and 13% of all patients with small bowel perforations following blunt abdominal trauma have normal preoperative CT scans [18, 19]. Diagnosis by history and physical exam is also difficult, especially in cases of altered mental status due to traumatic brain injury, distracting injuries, drug and alcohol use, and analgesic and sedative medications [10, 20]. Regardless of mental status, the presence of soft tissue bruising in the distribution of a seatbelt may be elicited by inspection of the abdomen and has been associated with bowel injury following blunt abdominal trauma [21, 22]. Similarly, abdominal inspection may reveal a scar from a prior laparotomy. Although prior laparotomy has not been previously described as a risk factor for bowel or mesenteric injury following blunt trauma, the pathogenesis of blunt traumatic aortic injury suggests that investigation of this relationship is warranted. In high-speed deceleration injuries, the aorta is most commonly injured just distal to the left subclavian artery, where it is tethered by the ligamentum arteriosum; the next most common sites of injury are the aortic root and diaphragmatic hiatus, also representing transition points from fixed to mobile tissue [23–25].

We hypothesized that patients with a prior laparotomy, who are likely have to developed adhesions at the operative site [26] and between the viscera and abdominal wall [27], would be vulnerable to shearing forces on the visceral block, placing them at increased risk for bowel and mesenteric injury following blunt abdominal trauma.

Methods

We performed a multicenter retrospective cohort analysis of 267 consecutive adult trauma patients who underwent operative exploration following blunt abdominal trauma. Derivation of the study population is illustrated in Supplementary Fig. 1. Institutional review board

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approval was obtained. Data registries at St. Mary's Medical Center in West Palm Beach, Florida, and University of Florida Health in Gainesville, Florida, were searched for patients age ≥18 years who had abdominal injury score 2 (moderate), 3 (serious), 4 (severe), or 5 (critical) and Current Procedural Terminology codes for laparotomy or laparoscopy from July 2011–January 2017, excluding patients with penetrating injuries, burn injuries, or incomplete records. Patients who had a history of laparotomy prior to traumatic injury (n = 31) were compared to patients with no history of prior laparotomy (n = 236), and prior laparotomy was assessed for the ability to predict bowel and mesenteric injuries identified on operative exploration.

Data were collected from institutional data registries and by retrospective review of the electronic medical record. Baseline demographics included age, sex, injury severity score, abdominal injury score, vital signs, and history of an abdominal inflammatory process (e.g., diverticulitis, pelvic inflammatory disease, bacterial peritonitis), laparotomy, or laparoscopy. Risk factors for intra-abdominal injury identified by previous studies were assessed, including low Glasgow Coma Scale score, anemia, seatbelt sign, and computed tomography (CT) scan evidence of pelvic fracture or free fluid in the absence of solid organ injury [4–11, 21, 22, 28]. Initial findings on focused assessment with sonography for trauma (FAST), diagnostic peritoneal aspirate/lavage (DPA/DPL), and pelvic radiography were also assessed. Abdominal pain and tenderness were not considered in this analysis because the history and physical examination of a trauma patient is often hindered by altered mental status due to traumatic brain injury, distracting injuries, drug and alcohol use, and analgesic and sedative medications, such that the absence of abdominal pain and tenderness has limited utility in ruling out abdominal injury [10]. Assessment of intra-operative findings included solid organ injury, diaphragmatic hernia, partial and full thickness bowel injuries, mesenteric injuries, and the location of bowel and mesenteric injuries. Assessment of intra-operative management included the performance of bowel repair, bowel resection, and mesentery hemostasis or repair.

Statistical analysis was performed in SPSS version 24 (IBM, Armonk, NY). Continuous variables were compared by the Kruskal–Wallis test and reported as median [interquartile range]. Discrete variables were compared by Fisher's Exact test and reported as n (%). The association between history of an abdominal inflammatory process and prior laparotomy was assessed by Spearman's rank correlation coefficient. Univariable logistic regression was performed to identify conditions present on admission that were associated with bowel or mesenteric injury identified on operative exploration, reported as odds ratios (OR) with 95% confidence intervals (CI). To avoid false positive results due to the family-wise error rate associated with multiple comparisons, the regression analysis was limited to prior laparotomy, prior laparoscopy, prior abdominal inflammation, factors which were significantly different between prior laparotomy and no prior laparotomy cohorts, and previously identified risk factors for bowel and mesenteric injury, as above. Factors that were statistically significant on univariable analysis were entered into a multivariable regression model to identify independent predictors of bowel or mesenteric injury. A multivariable regression model should contain approximately ten outcome events for each variable in the model [29]. There were 107 patients with a bowel or mesenteric injury and

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four model covariates, indicating that this analysis was adequately powered. Model strength was assessed by calculating area under the receiver operating characteristic curve.

Results

Baseline patient characteristics are listed in Table 1. The prior laparotomy cohort was older (age 58 vs. 38 years, $p < 0.001$) and had lower admission hemoglobin levels (11.1 vs. 12.2 g/dL, $p = 0.010$) than the no prior laparotomy cohort. There was a greater proportion of patients with a history of an abdominal inflammatory process in the prior laparotomy cohort (32 vs. 9%, $p = 0.001$), which correlated directly with prior laparotomy ($r = 0.226$, $p < 0.001$). Of the 32 patients with prior abdominal inflammation, the etiology was appendicitis in ten patients, diverticulitis in seven patients, cholecystitis in four patients, pancreatitis in three patients, spontaneous bacterial peritonitis in three patients, granulomatous disease in three patients, and tubo-ovarian abscess in two patients. There were no significant differences between groups for injury severity score, abdominal injury score, or admission vital signs. There were no significant differences in the incidence of positive FAST, DPA, DPL, pelvic fractures, or open book deformities between groups.

Preoperative CT scan findings are listed in Table 2. One hundred and seventy-six patients (66%) had a preoperative CT scan. Four scans (2%) identified no injuries; operative exploration demonstrated that one of these patients had a full thickness bowel injury at the ligament of Treitz, one had a partial thickness cecal injury, one had a jejunal mesenteric injury, and one had a splenic laceration. Free fluid was identified in the absence of a solid organ injury on 29% of all CT scans, including 38% of all scans in the prior laparotomy cohort and 28% of all scans in the no prior laparotomy cohort. Mesenteric stranding was more frequent in the prior laparotomy cohort, though the difference was not statistically significant (33 vs. 14%, $p = 0.053$). CT evidence of bowel injury was similar between groups.

Operative findings and management are listed in Table 3. Laparoscopy was attempted for two patients in the prior laparotomy cohort, both of whom required conversion to laparotomy. Laparoscopy was attempted for eleven patients in the no prior laparotomy cohort, eight of whom required conversion to laparotomy. Adhesions were noted in 55% of all patients with prior laparotomy, compared with 5% of all patients with no prior laparotomy ($p < 0.001$). The incidence of solid organ injury was higher in the no prior laparotomy cohort, though the difference was not statistically significant (65 vs. 48%, $p = 0.079$). Partial and full thickness bowel injuries were identified in 14 and 11% of all patients, respectively, with greater incidence of full thickness bowel injury in the prior laparotomy cohort (26 vs. 9%, $p = 0.010$). Mesenteric injuries were identified in 34% of all patients, with greater incidence in the prior laparotomy cohort (61 vs. 31%, $p = 0.001$). Forty percent of all patients had a bowel or mesenteric injury, including 77% of all patients in the prior laparotomy cohort and 35% of all patients in the no prior laparotomy cohort ($p < 0.001$).

Distributions of bowel injuries are illustrated in Fig. 1. Jejunal and proximal ileal injuries accounted for one-third of all bowel injuries in the prior laparotomy cohort. The most common sites of bowel injury in patients with no prior laparotomy were the terminal ileum and cecum, with 36% of all injuries occurring at these locations. The proportion of bowel injuries occurring at the ligament of Treitz, terminal ileum, or cecum was greater among patients with no prior laparotomy, though the difference was not statistically significant (50 vs. 27%, $p = 0.147$). Distributions of mesenteric injuries are illustrated in Fig. 2. Jejunal and proximal ileal injuries accounted for 32% of all mesenteric injuries in the prior laparotomy cohort. The most common location for mesenteric injury in the no prior laparotomy cohort was the terminal ileum, accounting for 38% of all mesenteric injuries. The proportion of mesenteric injuries occurring at the ligament of Treitz, terminal ileum, or cecum was significantly greater among patients with no prior laparotomy (54 vs. 24%, $p = 0.019$). Considering all bowel and mesenteric injuries, among patients with no prior laparotomy, 52% of all injuries occurred at the ligament of Treitz, terminal ileum, or cecum; among patients with prior laparotomy, 25% of all injuries occurred at these locations ($p = 0.003$).

Predictors of bowel or mesenteric injury are listed in Table 4. On univariable regression, prior laparotomy was associated with increased odds of identifying a bowel or mesenteric injury on operative exploration (OR 6.3, 95% CI 2.6–15.3). A prior abdominal inflammatory process, a seatbelt sign, and CT evidence of a solid organ injury without free fluid were each associated with increased odds of bowel or mesenteric injury on univariable analysis and were included in the multivariable model. Intra-operative identification of adhesions was associated with increased odds of bowel or mesenteric injury (OR 6.6, 95% CI2.6–17.0), but was not considered in the multivariable model because this information is not available preoperatively. Seatbelt sign did not contribute significantly to the multivariable model, but the other three factors were independent predictors of bowel or mesenteric injury. CT evidence of free fluid without solid organ injury was the strongest predictor (OR 10.8, 95% CI 4.6–25.2) followed by prior laparotomy (OR 5.1, 95% CI 1.6–16.8) and prior abdominal inflammation (OR 3.8, 95% CI1.2–11.8). Together, these factors composed a strong prediction model with area under the receiver operating characteristic curve 0.81 (95% CI 0.74–0.88).

Discussion

These results suggest that patients with intra-abdominal adhesions from a prior laparotomy may be at increased risk for bowel and mesenteric injury following blunt abdominal trauma. CT scan evidence of free fluid without solid organ injury was also a strong predictor of bowel or mesenteric injury. The clinical significance of this finding remains controversial, with recommendations for [30, 31] and against [32, 33] routine laparotomy. Adjunctive imaging studies like the FAST exam and DPA/DPL may not detect small amounts of enteric contents or a large mesenteric defect with devascularized bowel. Therefore, the history and physical examination is essential, but is often hindered by altered mental status due to traumatic brain injury, distracting injuries, drug and alcohol use, and analgesic and sedative medications. However, similar to the seatbelt sign, the presence of a laparotomy scar is readily apparent on inspection of the abdomen, indicating the likely presence of intra-abdominal adhesions and increased probability of bowel or mesenteric injury. These findings have impacted our clinical practice. Among patients with blunt abdominal trauma, history of prior laparotomy is now an indication for close observation and consideration of interval CT scan with oral contrast.

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Patients with no history of abdominal surgery also suffer bowel and mesenteric injuries following blunt trauma. In our study, more than half of these injuries occurred at the ligament of Treitz, terminal ileum, or cecum, representing embryologic transition points tethering free intraperitoneal structures to the retroperitoneum. Among patients with a prior laparotomy, only one quarter of all bowel and mesenteric injuries occurred at these sites.

Previous studies have investigated the relationship between prior abdominal surgery and adhesive disease in non-trauma patients. Twelve years after Dr. Harrith M. Hasson [34] described his technique for open trocar placement under direct vision, Chi et al. [35] reported that previous abdominal surgery was associated with difficult abdominal entry. Rafii et al. [36] subsequently performed a prospective analysis of 477 patients undergoing laparoscopy and found that subjects with previous abdominal surgery had increased risk for complicated port placement and failure to achieve pneumoperitoneum. In our study, prior laparoscopy was not associated with increased risk for bowel or mesenteric injury following blunt abdominal trauma. Laparoscopy may induce less adhesion formation than laparotomy by decreasing the total length of incised parietal peritoneum, limiting tissue desiccation, and providing a magnified view of the operative field, which may allow for more precise tissue handling [37, 38]. In a porcine model of laparoscopic versus open nephrectomy, Moore et al. [26] found that adhesions occurred at the operative site in 75% of open nephrectomies and 13% of all laparoscopic nephrectomies. A similar phenomenon occurs at the abdominal wall. In a rabbit model of laparoscopic versus open cecal deserosalization, Jorgensen et al. [27] identified no abdominal wall adhesions in the laparoscopic group; adhesions to the abdominal wall developed in 70% of the open group. The impact of abdominal inflammatory processes is less clear, with the weight of evidence suggesting that generalized peritonitis involving visceral and parietal peritoneum may be more likely to produce adhesions.

This study was limited by a small sample size and selection bias inherent to its retrospective design. The prior laparotomy cohort had advanced age and a greater proportion of female subjects; although age and sex were not associated with bowel or mesenteric injury on the uni-variable analysis, a larger sample may detect a difference. Patients from two centers were included to increase sample size and improve generalizability, and the power analysis indicates that the sample size was adequate to build the multivariable model. All consecutive patients meeting study criteria were included to limit selection bias. In addition, the lack of long-term follow-up and surveillance hinders assessment of the long-term morbidity associated with laparotomy and bowel or mesenteric injury in this study. Future research should seek to validate these findings in a larger dataset and should continue to investigate aspects of the history and physical examination that may be useful for decision-making.

Conclusions

Patients with a prior laparotomy and intra-abdominal adhesions were at increased risk for bowel and mesenteric injury following blunt abdominal trauma. The distribution of bowel and mesenteric injuries among patients with no prior laparotomy favored embryologic transition points tethering free intraperitoneal structures to the retroperitoneum at the ligament of Treitz and ileocecal region. CT evidence of free fluid without solid organ injury was a strong predictor of bowel or mesenteric injury and may be used in combination with history and physical exam findings for optimal prognostication.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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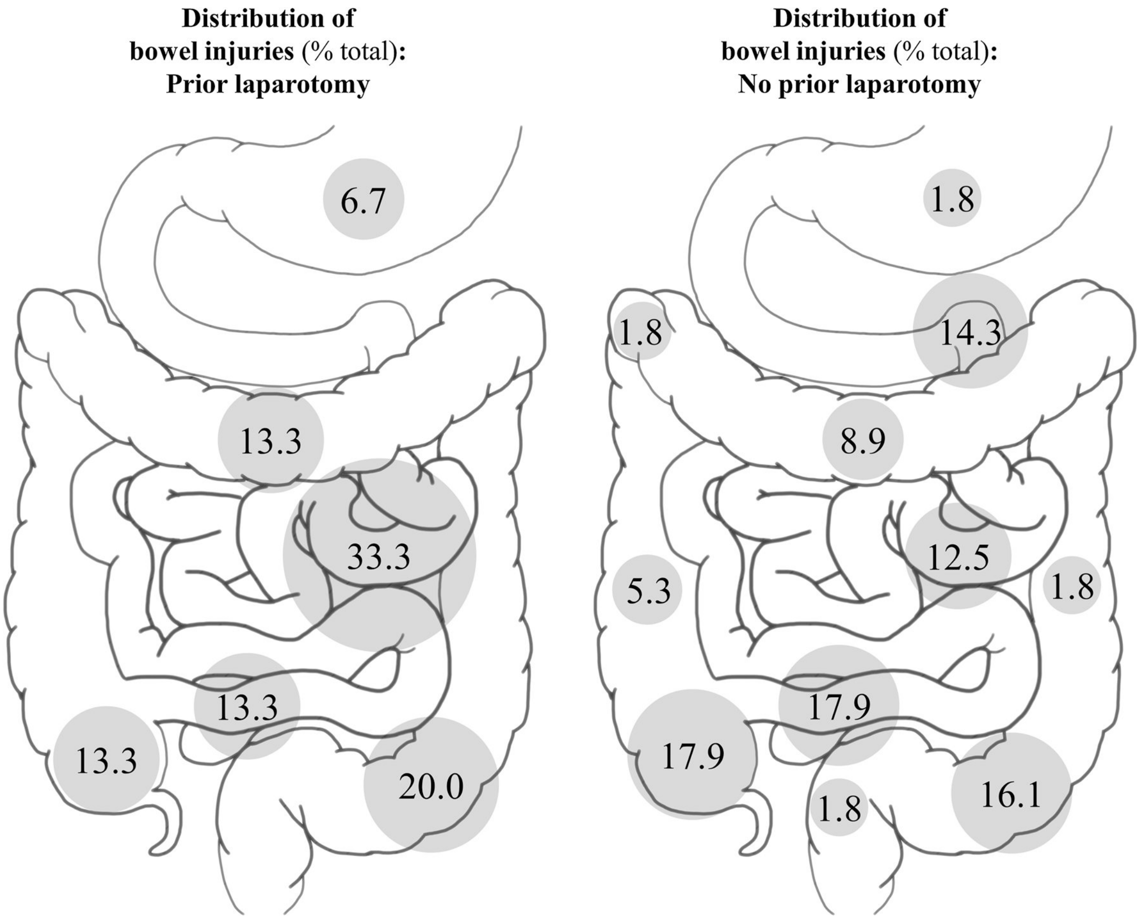

Fig. 1.
Distribution of bowel injuries identified on operative exploration for patients with and without a history of laparotomy prior to traumatic injury

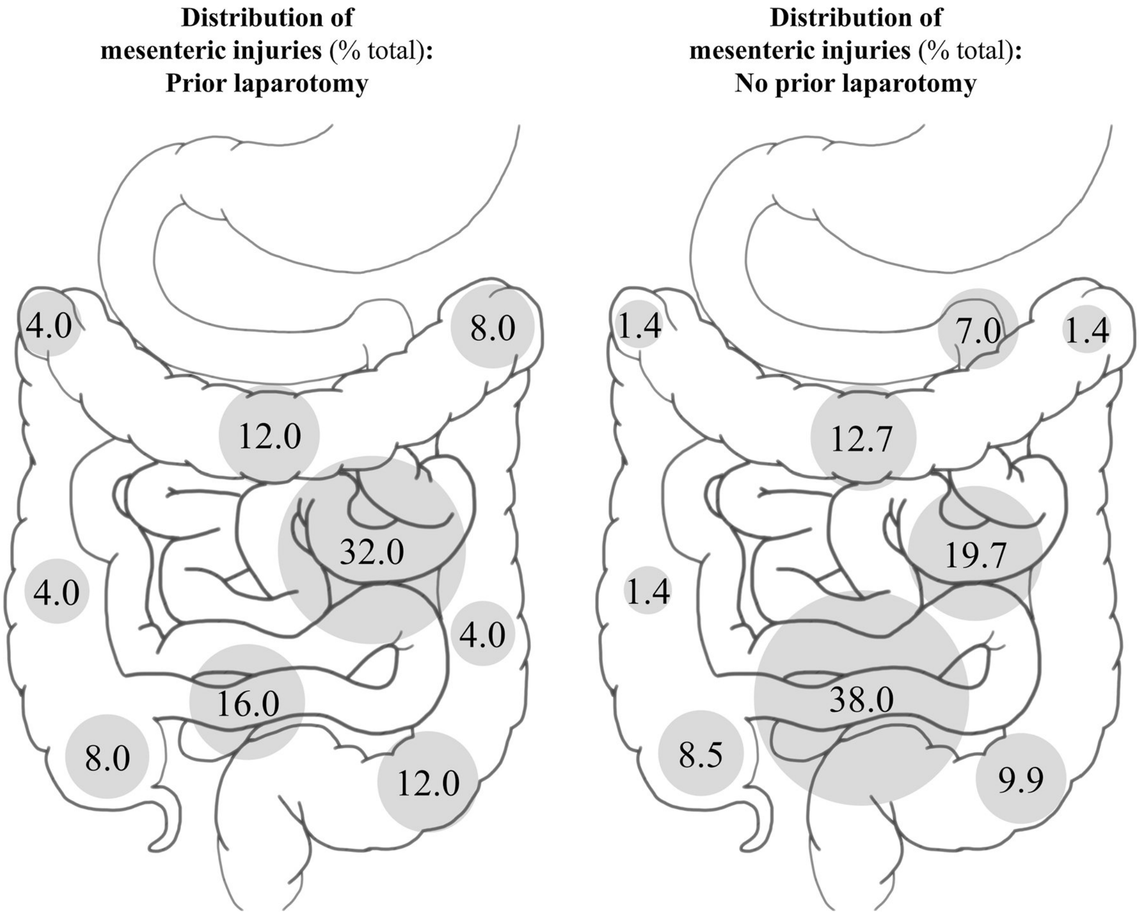

Fig. 2.

Distribution of mesenteric injuries identified on operative exploration for patients with and without a history of laparotomy prior to traumatic injury

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Table 1

Summary of baseline characteristics for the study population

Patient characteristics	All patients (n = 267)	Prior laparotomy (n = 31)	No prior laparotomy (n = 236)	p
Age (years)	40 [26–58]	58 [52–74]	38 [25–54]	<0.001
Female/male	81/186	18/13	63/173	0.001
Prior abdominal inflammation	32 (12%)	10 (32%)	22 (9%)	0.001
Prior laparoscopy/laparotomy	14 (5%)	3 (10%)	11 (5%)	0.213
Injury severity score	29 [18–38]	24 [22–41]	29 [17–38]	0.508
Abdominal injury score	3 [3, 4]	3 [3, 4]	3 [3, 4]	0.192
Glasgow Coma Scale score	15 [3–15]	15 [5–15]	14 [3–15]	0.414
Intubated in field	82 (31%)	7 (23%)	75 (32%)	0.408
Intubated in trauma bay	43 (16%)	7 (23%)	36 (15%)	0.302
Cardiac arrest in field	16 (6%)	2 (6%)	14 (6%)	>0.999
Cardiac arrest in trauma bay	4 (1%)	1 (3%)	3 (1%)	0.391
Admission heart rate	101 [83–118]	100 [76–119]	101 [83–118]	0.770
Admission SBP (mmHg)	119 [97–138]	127 [104–140]	119 [95–138]	0.179
Admission Hb (g/dL)	12.0 [10.4–13.7]	11.1 [9.1–12.3]	12.2 [10.4–13.7]	0.010
Seatbelt sign	29 (11%)	4 (13%)	25 (11%)	0.757
FAST performed	173 (65%)	25 (81%)	148 (63%)	0.070
Negative	79 (30%)	10 (32%)	69 (29%)	0.836
Equivocal	9 (3%)	1 (3%)	8 (3%)	>0.999
Positive	85 (32%)	14 (45%)	71 (30%)	0.151
DPA/DPL performed	29 (11%)	1 (3%)	28 (12%)	0.220
Negative	8 (3%)	0 (0%)	8 (3%)	0.602
Positive	21 (8%)	1 (3%)	20 (9%)	0.485
FAST or DPA/DPL positive	106 (40%)	15 (48%)	91 (39%)	0.331
Pelvic radiography performed	219 (82%)	25 (81%)	194 (82%)	0.806
Normal	160 (60%)	19 (61%)	141 (60%)	>0.999
Pelvic fracture	54 (20%)	7 (23%)	47 (20%)	0.812
Open book deformity	17 (6%)	2 (6%)	15 (6%)	>0.999

Data are presented as median [interquartile range] or n (%)

SBP systolic blood pressure, *Hb* hemoglobin, *FAST* focused assessment with sonography for trauma, *DPA* diagnostic peritoneal aspirate, *DPL* diagnostic peritoneal lavage

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Table 2

Summary of abdominal and pelvic computed tomography (CT) scan findings

CT findings	All patients (*n* = 267)	Prior laparotomy (*n* = 31)	No prior laparotomy (*n* = 236)	*p*
Had a preoperative CT scan[a]	176 (66%)	21 (68%)	155 (66%)	>0.999
Normal CT scan	4 (2%)	1 (5%)	3 (2%)	0.401
Solid organ injury	106 (60%)	9 (43%)	97 (63%)	0.099
Bleeding pseudoaneurysm	29 (16%)	4 (19%)	25 (16%)	0.755
Free fluid	131 (74%)	14 (67%)	117 (75%)	0.426
Without solid organ injury	51 (29%)	8 (38%)	43 (28%)	0.318
Free air	14 (8%)	3 (14%)	11 (7%)	0.224
Pelvic fracture	47 (27%)	8 (38%)	39 (25%)	0.291
Bladder injury	10 (6%)	0 (0%)	10 (6%)	0.363
Intraperitoneal	7 (4%)	0 (0%)	7 (5%)	>0.999
Extraperitoneal	3 (2%)	0 (0%)	3 (2%)	>0.999
Mesenteric stranding	29 (16%)	7 (33%)	22 (14%)	0.053
Mesenteric hematoma	28 (16%)	4 (19%)	24 (15%)	0.750
Bowel injury	28 (16%)	6 (29%)	22 (14%)	0.111
Equivocal	25 (14%)	6 (29%)	19 (12%)	0.087
Probable/diagnostic	3 (2%)	0 (0%)	3 (2%)	>0.999

Data are presented as *n* (%) or median [interquartile range]

[a]Subsequent analyses in this table consider only subjects who had a preoperative CT scan (176 total patients, 21 patients with prior laparotomy, and 155 patients with no prior laparotomy)

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Table 3

Summary of operative findings and management

Operative findings and management	All patients (*n* = 267)	Prior laparotomy (*n* = 31)	No prior laparotomy (*n* = 236)	*p*
Laparotomy	254 (95%)	29 (94%)	225 (95%)	0.213
Laparoscopy	3 (1%)	0 (0%)	3 (1%)	>0.999
Converted to open	10 (4%)	2 (6%)	8 (3%)	0.327
Days from admission to surgery	0 [0–1]	0 [0–1]	0[0–1]	0.155
Identified solid organ injury	168 (63%)	15 (48%)	153 (65%)	0.079
Missed on CT scan[a]	6 (3%)	1 (5%)	5 (3%)	0.539
Identified diaphragm hernia	21 (8%)	3 (10%)	18 (8%)	0.720
Missed on CT scan[a]	5 (3%)	1 (5%)	4 (3%)	0.474
Identified bowel injury	66 (25%)	11 (35%)	55 (23%)	0.182
Partial thickness	37 (14%)	3 (10%)	34 (14%)	0.590
Full thickness	29 (11%)	8 (26%)	21 (9%)	0.010
Missed on CT scan[a]	36 (20%)	7 (33%)	29 (19%)	0.148
Required bowel repair	32 (12%)	5 (16%)	27 (11%)	0.393
Required bowel resection	24 (9%)	5 (16%)	19 (8%)	0.173
Identified mesenteric injury	91 (34%)	19 (61%)	72 (31%)	0.001
Missed on CT scan[a]	24 (14%)	4 (19%)	20 (13%)	0.495
Required hemostasis/repair	60 (22%)	13 (42%)	47 (20%)	0.010
Required bowel resection[b]	17 (6%)	4 (13%)	13 (6%)	0.120
Any bowel or mesenteric injury	107 (40%)	24 (77%)	83 (35%)	<0.001
Non-diagnostic laparotomy	7 (3%)	0 (0%)	7 (3%)	>0.999
Non-therapeutic laparotomy	18 (7%)	0 (0%)	18 (7%)	0.608

Data are presented as *n* (%) or median [interquartile range]

CT computed tomography

[a]Considering only patients with a preoperative CT scan (176 total patients, 21 patients with prior laparotomy, and 155 patients with no prior laparotomy)

[b]Devascularizing mesenteric injuries that required bowel resection in the absence of a full thickness bowel injury

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Table 4

Predictors of bowel or mesenteric injury

Factors	Univariable regression			Multivariable regression		
	OR	**95% CI**	***p***	**OR**	**95% CI**	***p***
Prior laparotomy	6.32	2.61–15.29	<0.001	5.11	1.56–16.81	0.007
Age (years)	1.01	1.00–1.02	0.218	–	–	–
Female sex	1.30	0.76–2.20	0.337	–	–	–
Prior abdominal inflammation	3.88	1.76–8.58	0.001	3.75	1.19–11.83	0.024
Prior laparoscopy	1.13	0.38–3.35	0.827	–	–	–
Glasgow Coma Scale score	1.03	0.99–1.08	0.163	–	–	–
Hemoglobin (g/dL)	1.03	0.93–1.15	0.531	–	–	–
Seatbelt sign	5.66	2.32–13.79	<0.001	2.32	0.70–7.71	0.168
FAST/DPA/DPL positive	1.03	0.63–1.71	0.894	-	-	-
Any pelvic fracture	0.68	0.38–1.19	0.173	–	–	–
Open book pelvic deformity	1.75	0.65–4.68	0.268	–	–	–
CT free fluid, no solid organ injury	11.43	5.15–25.38	<0.001	10.76	4.60–25.18	<0.001

Factors that were statistically significant on univariable analysis were entered into the multivariable regression model. Area under the receiver operating characteristic curve for the multivariate model was 0.81 (95% CI 0.74–0.88)

OR odds ratio, *CI* confidence interval, *FAST* focused assessment with sonography for trauma, *DPA* diagnostic peritoneal aspirate, *DPL* diagnostic peritoneal lavage, *CT* computed tomography of the abdomen and pelvis