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Rates and risk factors for anastomotic leak following blunt trauma-associated bucket handle intestinal injuries: a multicenter study

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ABSTRACT

Objectives The risk factors for anastomotic leak (AL) after resection and primary anastomosis for traumatic bucket handle injury (BHI) have not been previously defined. This multicenter study was conducted to address this knowledge gap.

Methods This is a multicenter retrospective study on small intestine and colonic BHIs from blunt trauma between 2010 and 2021. Baseline patient characteristics, risk factors, presence of shock and transfusion, operative details, and clinical outcomes were compared using R.

Results Data on 395 subjects were submitted by 12 trauma centers, of whom 33 (8.1%) patients developed AL. Baseline details were similar, except for a higher proportion of patients in the AL group who had medical comorbidities such as diabetes, hypertension, and obesity (60.6% vs. 37.3%, p=0.015). AL had higher rates of surgical site infections (13.4% vs. 5.3%, p=0.004) and organ space infections (65.2% vs. 11.7%, p<0.001), along with higher readmission and reoperation rates (48.4% vs. 9.1%, p<0.001, and 39.4% vs. 11.6%, p<0.001, respectively). There was no difference in intensive care unit length of stay or mortality (p>0.05). More patients with AL were discharged with an ostomy (69.7% vs. 7.3%, p<0.001), and the mean duration until ostomy reversal was 5.85±3 months (range 2–12.4 months). The risk of AL significantly increased when the initial operation was a damage control procedure, after adjusting for age, sex, injury severity, presence of one or more comorbidities, shock, transfusion of >6 units of packed red blood cells, and site of injury (adjusted RR=2.32 (1.13, 5.17)), none of which were independent risk factors in themselves.

Conclusion Damage control surgery performed as the initial operation appears to double the risk of AL after intestinal BHI, even after controlling for other markers of injury severity.

Level of evidence III.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ A recent study has found that the rates of anastomotic leak among bucket handle injuries are significantly higher in colonic injuries versus the small intestine, but little else is known about specific risk factors for anastomotic leak following these blunt-related trauma injuries.

WHAT THIS STUDY ADDS

⇒ Our study has established that classification as a damage control surgery significantly increases the risk of anastomotic leak.
⇒ Other factors such as delay in diagnosis and anastomotic technique were not found to be significant factors in predicting an anastomotic leak.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Despite finding leak rates of between 6% and 14%, the authors do not have sufficient information to recommend a lower threshold for ostomy creation in patients with bucket handle injury and continue to recommend an initial attempt at primary anastomosis for these patients.

INTRODUCTION

Bucket handle injury (BHI) is defined as a traumatic abdominal injury in which the mesentery is avulsed from its corresponding segment of the bowel, causing devascularization with subsequent ischemia and postinjury intestinal perforation.[1] BHI commonly occurs during deceleration injuries, such as a motor vehicle crash, or from blunt force trauma, such as contact with a bicycle handlebar. BHIs may be initially identified on physical examination via a "seat belt sign," which presents as bruising across the abdomen where the seat belt lies; however, BHI remains a challenging clinical diagnosis due to its vague symptom presentation, such as diffuse abdominal pain.[2 3] On CT scanning, BHI can also be hard to detect due to the lack of typical findings associated with bowel injury, leading to difficulty differentiating between those that require surgery and those that can be managed conservatively.[4] Once a patient is determined to require surgical intervention, BHIs can be repaired primarily, resected with primary anastomosis, or resected with placement of a temporary or permanent ostomy.[5 6]

Anastomotic leak (AL) is a dreadful complication related to bowel resection with primary anastomosis. There is a wide range of reported AL rates related to bowel anastomosis. Previous literature suggests that the AL rate after primary intestinal anastomosis ranges from 0.5% to 30%, but many of these studies include a wide variety of indications for anastomosis, such as elective operations,[7 8] with fewer focusing solely on trauma patients.[6 9] In studies that also include elective operations, such as resection for colonic malignancy, there are additional challenges due to the multitude of additional factors involved that may be associated with ALs.[10 11] Among these studies, few provide information on possible predictors of AL and the rates of this complication after bowel anastomosis in the context of blunt-related traumatic injury.

Furthermore, due to the rarity of BHIs, there is a lack of evidence defining the risk factors for AL in patients with BHI who undergo repair with primary anastomosis. Having inadequate evidence in the literature complicates planning of surgical intervention for BHIs, creating more difficulty for surgeons to choose the best option, primary anastomosis versus ostomy creation, for higher-risk patients. A previous study has analyzed BHIs in the colon versus the small intestine and found that, although colonic BHI leak rates were significantly higher, the clinical outcomes were still similar between these different injury subtypes.[12] We conducted a multicenter retrospective cohort study to identify other factors, such as diagnostic delay, anastomosis type, and surgical classification as a damage control surgery (DCS), that could potentially contribute to an AL after traumatic BHI. We hypothesized that diagnostic delay and classification as DCS would be associated with increased risk of AL and that the anastomotic technique would not be significantly different between those with AL and those without.

METHODS

A multicenter retrospective cohort study was conducted by chart review on patients with bowel and colonic injury due to blunt trauma who had an operation to resect injured bowel between January 1, 2010, and April 1, 2021. Twelve centers participated in this multicenter study.

Data acquisition

A list of patients aged 18 to 89 years who had either a small bowel or colonic injury, or both, due to blunt trauma and had one or more operations was obtained. The International Classification of Diseases (ICD) codes used to identify the patients were ICD-10 S36.4, S36.5, and S36.899A, and ICD-9 863.29 and 863.39. Data were retrieved from the medical records of patients who qualified for the study and recorded by each center. Ultimately, data without any private health information identifiers were transmitted to the coordinating center for analysis.

Patients with BHIs were identified based on the presence of predefined terms mentioned in their operative notes or radiology reports. BHIs were defined as "injuries to a portion of the intestine that led to separation from its mesentery." Terms in operative notes included "bucket handle injury," "intestinal/mesenteric devascularization," "mesenteric avulsion," "having a mesenteric defect," and/or "telescoping avulsion injury." Radiological findings that identified BHIs were mesenteric hematoma with active hemorrhage, bowel wall hematoma or hypoenhancement on CT, and/or associated traumatic abdominal wall hernias.[1] Patients managed by resection and primary anastomosis were identified from their individual record and included in the study. An AL was identified based on operative findings and diagnostic imaging.[13] Intraoperative findings of a leak included intra-abdominal contamination with enteric contents, gas, or a visible defect at the site of surgical connection between two sections of the bowel. Imaging techniques (eg, CT scans and radiographic rectal contrast studies) were used to detect leaks by the presence of contrast extravasation, pneumoperitoneum, or an abscess adjacent to a suture/staple line.

Data collected included demographic parameters such as age, sex, body mass index, Injury Severity Score (ISS), and presence of comorbidities (diabetes, hypertension, and obesity); clinical features such as "presented in shock"; and the site of bowel injury. We also collected biochemical parameters on the day of the index surgery when the bowel repair was done; management details, such as whether the index surgery was done as an emergency surgery/DCS; technique of anastomosis, whether handsewn or stapled; and the creation of ostomy. We included outcome variables such as total length of hospital stay, number of ventilator days, length of intensive care unit stay, need for blood transfusions, creation of ostomy, and total number of laparotomies. Complications such as AL, surgical site infection (SSI), organ space infection, in-hospital mortality, 30-day unplanned readmissions, and reoperation in 30 days were included. Finally, details of the AL and the time from the first operation to the time to AL were found in the patients' medical records. Definitions of each variable are available in the data key provided in the online supplemental table S1 .

Sample size justification

Our power calculation was based on effect sizes derived from a recently conducted study which showed the percentage of the overall AL to be near 16%.[6] According to these preliminary data, the AL in BHIs is high. Therefore, the number of subjects needed for each group is 1447. However, if the overall AL is closer to 10%, the number of subjects required for each group is 199. Therefore, to show a significant difference with 80% power at an alpha of 0.05, each group would need 99 to 1477 subjects.

Statistical analyses

Descriptive statistics were calculated. χ^2 or Fisher's exact test was used for categorical variable analyses, and independent samples t-test or Wilcoxon rank-sum test was used for continuous variables. To identify the factors that could contribute to an AL, quasi-Poisson regression modeling[14] was used to calculate unadjusted and adjusted relative risks (RRs). This creates the ratio of risk of AL in those who are exposed to certain variables versus those who are not . AL was the outcome of interest in the model, whereas DCS as the first surgery, technique of anastomosis, and hospital day of surgery were the predictors.[15] Patients' characteristics were a priori selected as clinically important covariates to control for potential confounding variables. Before entering variables into the model, a Pearson correlation matrix was used to identify potential multicollinearity. The variables included in each model were age, sex, ISS, presence of one or more comorbidities, injury site, whether the patient presented in shock, and transfusion of >6 units of packed red blood cells.[9 12] Due to collinearity, we used the presence of one or more comorbidities as a variable instead of American Society of Anesthesiologists classification, which uses categorization of physical status to predict operative risk. P values of ≤0.05 were considered statistically significant. All analyses were conducted using R statistical software (V.4.1.3).[16]

Table 1 Baseline Characteristics of the whole cohort

Variable	Anastomotic leak (n=33) mean±SD/n (%)	No leak (n=372) mean±SD/n (%)	p-value
Age	44.12±15.18	39.08±16.11	0.077
Sex (males)	25 (75.76)	260 (69.89)	0.611
BMI	29.15±7.44	27.93±5.55	0.363
ISS	26.21±11.84	22.85±11.86	0.127
TRISS	0.84±0.25	0.88±0.22	0.388
AIS abdomen	3.27±0.84	3.23±0.85	0.790
≥ 1 comorbidity	20 (60.61)	135 (37.29)	**0.015**
Site of injury*			0.136
Small intestine only	15 (45.45)	220 (59.14)	
Colonic injury	11 (33.33)	71 (19.09)	
Small and colonic injuries	7 (21.21)	77 (20.70)	
ASA			**0.044**
1	1 (3.03)	23 (6.18)	
2	2 (6.06)	96 (25.81)	
3	13 (39.39)	101 (27.15)	
4	15 (45.45)	120 (32.26)	
5	2 (6.06)	24 (6.45)	
Presented with shock	15 (45.45)	130 (35.14)	0.320
WBC	15.66±7.48	15.65±7.21	0.994
Hb	11.96±2.54	12.62±2.19	0.175
BE	−3.96±6.47	−4.74±4.66	0.566
Transfusion of>6 packed red blood cells*	9 (27.27)	74 (20)	0.444
Technique of anastomosis			0.459
Hand-sewn	12 (37.5)	103 (29.5)	
Staples	20 (62.5)	246 (70.49)	
Total number of abdominal surgeries†	2 (1)	1 (1)	0.581
First surgery being a DCS	24 (72.73)	168 (47.32)	0.009

*Fisher's exact test.
†Non-parametric Wilcoxon rank-sum test was used expressed with median and IQR in parenthesis.
AIS, Abbreviated Injury Scale (Abdomen); BMI, Body Metric Index; ISS, Injury Severity Score; TRISS, Trauma and Injury Severity Score.

RESULTS

All the participating centers together reported complete data on 395 patients with BHIs who underwent bowel resection and primary anastomosis. Of these patients, 33 (8.15%) developed an AL. The rate of AL in patients with injuries limited to the small intestine was 6.38%. Patients with injuries isolated to the colon had an AL of 13.41%. Baseline patient-related factors and biochemical parameters on the day of the index operation were similar in both groups, except for a higher proportion of patients in the AL group who also had comorbidities (60.6% vs. 37.3%, p=0.015) (table 1). An AL was diagnosed 11±5.45 days (range 1–23 days) from the index operation.

When we explored potential factors that could predict an AL, the risk of AL increased significantly when the first surgery was a DCS (adjusted RR=2.32 (1.13, 5.17)). However, the baseline characteristics of those who underwent DCS and developed an AL and those who did not were similar (online supplemental table S2). All patients in this cohort who had DCS had their resection and anastomosis performed at the initial operation; there were no cases where the intestine was left in discontinuity for subsequent anastomosis at a later operation. Neither anastomotic technique (handsewn vs. stapled) nor hospital day of diagnosis of BHI was a significant predictor of AL following resection and primary anastomosis (table 2).

There were notable differences in outcomes between the AL group and the no leak group. Patients who developed ALs had a higher surgical site and organ space infection rates (13.4% vs. 5.31%, p=0.004, and 65.22% vs 11.7%, p<0.001). Similarly, higher readmission and reoperation rates were reported with an AL (48.39% vs. 9.09%, p<0.001, and 39.39% vs. 11.59%, p<0.001, respectively) (table 3). Following AL, 17 (51.51%) had reanastomosis and new ostomy creation, 3 (9.09%) received a drain, 4 (12.12%) underwent reanastomosis with primary repair, 3 (9.09%) had a resection and were left in discontinuity, and 2 (6.06%) were managed non-operatively. As a result, a higher proportion of patients who had developed an AL were

Table 2 Exploration of factors associated with an anastomotic leak in primary repair

	Unadjusted RR	p-value	Adjusted RR*	p-value
Technique of anastomosis (staples)	0.72(0.36, 1.44)	0.350	0.73(0.37, 1.50)	0.375
First surgery being a DCS	2.72(1.3, 5.69)	**0.008**	2.33(1.11, 5.28)	**0.033**
Hospital day of surgery	1.14(0.87, 1.48)	0.343	1.08(0.77, 1.36)	0.565

* Adjusted for age, sex, injury severity score, presence of ≥ 1 comorbidities, presentation with shock, having transfusion of >6 packed red blood cells of and the site of injury

Table 3 Outcomes of the patients with bucket handle injury

Variable	Anastomotic leak (n=33) mean±SD/n (%)	No leak (n=372) mean±SD/n (%)	p-value
SSI*	7 (13.04)	21 (5.31)	**0.004**
Organ space infection*	22 (65.22)	45 (11.70)	**<0.001**
LOS†	12.5 (13.75)	11 (17)	0.512
ICU†	4 (8.02)	4 (11)	0.625
Ventilator days†	2 (4)	2 (6)	0.692
Discharged with Ostomy	23 (69.70)	27 (7.34)	**<0.001**
Ostomy reversed‡	11 (47.83)	17 (62.96)	0.430
Readmission*	15 (48.39)	32 (9.09)	**<0.001**
Reoperation	13 (39.39)	43 (11.59)	**<0.001**
Mortality*	2 (6.06)	20 (5.38)	0.698

*Fisher's exact test.
†Non-parametric Wilcoxon rank-sum test was used expressed with median and IQR in parenthesis.
‡only few reports were available on information on ostomy reversal.
BE, Base Excess; DCS, Damage Control Surgery; Hb, Hemoglobin; ICU, Intensive Care Unit; LOS, Length of Stay; SSI, Surgical Site Infection; WBC, White Blood Cells.

discharged with ostomies compared with the no leak group (69.7% vs. 7.34%, p<0.001). The mean time from injury to ostomy reversal was 5.85±2.95 months (range 2–12.4 months).

DISCUSSION

BHIs remain difficult to diagnose after blunt force abdominal trauma due to vague clinical presentations and non-specific imaging findings on CT, making them challenging to rule in without a high index of suspicion.[2 17] After a bowel resection and anastomosis, the AL rate and major factors affecting these ALs in patients with BHI are still not well defined. In this retrospective cohort study, we used data from multiple trauma centers to better predict specific determining factors that could influence the risk of an AL following resection and primary anastomosis for BHIs.

Our cohort found an overall 8.15% leak rate. Patients with BHIs limited to the small intestine (6.38%) occurred at nearly half the rate of those limited to the colon (13.41%). This leak rate is consistent with the literature, where colonic AL rates have been found to be higher than those of the small intestine. This difference is expected due to the colon's higher level of bacterial flora, less vascularity, and increased intraluminal pressure.[9] Our overall leak rate is within the published range for trauma patients, with ALs of 4.65% to 20.5% reported in the emergent setting.[6 9] Broader studies representing all clinical indications for bowel resection with anastomosis report lower rates, around 3.6%,[7] whereas those focusing on elective surgery report even lower rates at 2.8%.[8]

Of the potential predictors of AL we explored, we found that the classification of the index procedure as a DCS was most significantly associated with an increased risk of AL. These operations typically occur in cases of significant bleeding or contamination, and they must be followed by a second procedure for definitive management once the patient has been stabilized.[18 19] Initially, DCS was only used to prevent prolonged operations in unstable trauma patients. This technique was developed to prevent death caused by the 'lethal triad' of hypothermia, acidosis, and coagulopathy.[20] However, as the concept became widely accepted as a potentially lifesaving approach for the most critically injured, the pendulum swung to the other extreme, where DCS is used in nearly all trauma patients. Many trauma surgeons consider DCS currently overused; even patients who are relatively stable and could tolerate a slightly longer operation with definitive abdominal closure often receive abbreviated operations with temporary abdominal closure. A retrospective review is hypothesis-generating and not the correct study design to explore why DCS may be associated with higher leak rates. However, there are a few potential biomechanical theories that might explain this association: the potential complications of an open abdomen have been previously well described,[21] and it is possible that increased AL may be another association.

Despite finding leak rates of between 6% and 14%, the authors do not have sufficient information to recommend a lower threshold for ostomy creation with these procedures—these data have shown primary anastomosis can be attempted in these patients. Patients with an AL experienced increased morbidity, including both organ space infections and SSIs, which further complicated their hospital stays.[15 22] These patients were also more likely to be discharged with an ostomy, require reoperation, and be readmitted to the hospital for reasons other than ostomy reversal. However, these patients did not differ from those without an AL in terms of 30-day mortality, nor in terms of length of stay. In addition, those with an AL were not found to be any less likely to have their ostomy eventually reversed. Ostomy creation remains an important treatment option due to the possible reduction in patient morbidity through minimizing the risk of AL and its associated complications. However, an ostomy is a significant psychological burden for patients, with concerns about resuming sexual and social function.[23] Therefore, the authors have shown in this study that primary anastomosis may safely remain the default option for BHI in both small and large intestines.

Other factors that we explored included diagnostic delay and anastomotic technique. Delay in diagnosis of traumatic bowel injury has been associated with additional complications due to possible septic shock and other injuries secondary to ischemic bowel perforation,[24] but a recent study did not find an association between complications and diagnostic delay.[25] Anastomotic technique, namely sutured versus handsewn methods, has also been studied extensively, with many studies finding the AL rate equivocal.[26] However, we found no significant difference between the AL rate based on the technique of anastomosis nor the hospital day of surgery. Adjusted analysis using multiple patient characteristics, such as age, injury severity, and comorbidities, did not show significant variability in the calculated RR for these predictors. This suggests that the technique and timing of the anastomosis may be less influential in predicting an AL than other variables.

There have also been a multitude of patient characteristics proposed to be associated with the development of bowel ALs following both elective and emergent procedures: leukocytosis, ASA score of >2, and (but not limited to) comorbidities, such as congestive heart failure and peripheral vascular disease.[9 27] These factors were partially consistent with those in the group with an AL (8.15%) compared with the no leak group, where patients with AL were more likely to have been diagnosed with at least one comorbidity and have a higher ASA score. However, we did not find any other patient presentation variables associated with an increased risk of ALs, such as the presence of shock, lactate, or base excess, in this population. White cell count was also not significantly different between the two groups; many patients developed leukocytosis. This suggests that the risk of AL in patients with BHI may be better predicted by the patient's past medical history or other measurements obtained immediately prior to surgical intervention.

Other studies have also found that the need for blood transfusion, whether preoperatively or postoperatively, may be an independent predictor of increased risk of AL.[13 27] Our data showed that the measured hemoglobin on presentation was not significantly different between those with AL and those without. In addition, significant blood loss, which we defined as transfusion of >6 units of packed red blood cells during the entire hospitalization, was not significantly different between those who developed AL and those who did not. This lack of significance may be secondary to the limited sample size. Further research is necessary to investigate the role of blood loss and vascular injury on the risk of AL, specifically for patients with BHI.

This study is limited due to its retrospective nature and focus on a specific subset of complications that occur after traumatic bowel injury. This creates multiple limitations that should be considered. Due to its retrospective review, results are hypothesis-generated rather than hypothesis-tested. In addition, information accuracy relies on proper and timely documentation within every electronic medical record. BHIs also remain a relatively rare diagnosis, with a smaller overall patient population; this study included many busy trauma centers but found less than 500. Because of the relatively small sample size of patients with BHI with an AL, many baseline characteristics and presenting characteristics were not found to be statistically significant. In addition, our study did not include all factors that have been found to be associated with AL in the literature, such as vasopressor requirement and volume overload. These factors have the potential to impact AL rate in many patients, specifically those admitted for significant trauma. We tried to mitigate this limitation by incorporating having shock during presentation and transfusing >6 units packed red blood cells as variables into the model. Furthermore, we intended to include hours of surgery as a variable to predict AL. However, due to limitations in data availability, we have to limit our analysis to hospital day of surgery.

In conclusion, this multicenter study focused on the factors impacting AL among patients with BHI who underwent resection and primary anastomosis. Interestingly, diagnostic delay and anastomotic method were not associated with AL, but DCS significantly increased the relative risk of AL among patients with BHI in this study. These findings provide a potential avenue for further exploration and research.

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