Original Article

Assessing Diverting Ostomy in Colorectal Injury Management: A Feasible Algorithm Based on 17 Years of Medical Center

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Key Words
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Purpose. The objective of this study was to validate the role of diversion in colorectal injuries and to identify the risk factors associated with bowel leakage following surgical management. Additionally, we provide treatment recommendations based on our findings.
Methods. We conducted a retrospective study of the clinical data of patients diagnosed with colorectal injuries who underwent surgical interventions from January 2006 to December 2022. These patients were divided into two groups, one with diverting ostomy and the other without. Our analysis encompassed a comprehensive examination of the patients' general demographics, clinical conditions, and outcomes.
Results. In this study, we investigated the clinical data of 65 patients who underwent surgical treatment for colorectal injuries. While the need for ostomy creation appeared to be associated with certain factors, no statistically significant differences were observed in the demographics, preoperative variables, or clinical characteristics of the patients. Moreover, the outcomes of patients, including complications and mortality, did not significantly differ between patients with and without ostomies. Logistic regression analysis failed to identify significant risk factors for bowel leakage in patients with significant colonic injuries who did not undergo ostomy creation initially.
Conclusion. Deciding whether to create an ostomy in colorectal injury patients is difficult. Most patients with significant colorectal injuries can undergo primary repair or colectomy safely without the need for an ostomy. However, for complex injuries, a diverting ostomy does not lead to longer hospital stays or more complications. Surgeons can still consider it a valid option based on their clinical judgment.

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Colorectal injuries have garnered significant attention due to the diversity in their nature and management. Colorectal injuries can be classified into two categories, namely, nondestructive and destructive, based on the severity of the injury.[1,2] Most of the current guidelines provide separate management recommendations for colonic and rectal injuries. The treatment approach primarily depends on the severity of the injuries, with additional consideration given to the location (intraperitoneal or extraperitoneal) in the case of rectal injuries.

Dealing with nondestructive colonic injuries th-

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rough primary repair and opting for resection in the case of destructive injuries are widely accepted practices.[3] Level I evidence suggests that diverting ostomy should not be performed in cases of nondestructive colonic injuries, while the indications for diverting ostomy in cases of destructive colonic injuries remain a subject of debate.[1,4]

Rectal injuries are diagnosed and managed through a variety of approaches. The principles of surgical intervention for intraperitoneal rectal injuries closely mirror those for colonic injuries. However, it is important to note that only low-quality evidence is available to guide the management of extraperitoneal rectal injuries, and the role of diverting ostomy in such cases remains a matter of uncertainty.[5]

In the present study, we conducted a retrospective review and analysis of patients with colorectal injuries to evaluate the role of diverting ostomy. The aim of this study was to validate the risk factors for bowel leakage after surgical management and provide treatment suggestions based on current studies and our findings.

Materials and Methods

This study protocol was approved by the institutional review board of Far Eastern Memorial Hospital (FEMH, project approval no.112162-E), a level I trauma center in New Taipei City, Taiwan. Severely injured patients are admitted to our hospital by emergency medical transportation or transferred from other hospitals.

Patients with colorectal injuries admitted to our hospital from January 2006 to December 2022 were included. Those who were younger than 18 years old, pregnant, and received selective nonoperative management (SNOM) were excluded from the study. We retrospectively reviewed the medical records of patients who were diagnosed with colorectal injuries by physical examination, computed tomography (CT) scan, or operative findings over a 17-year period. Patients were categorized into nonsignificant and significant colorectal injuries based on the American Association for the Surgery of Trauma (AAST) classification, with grade II or higher considered significant in our data. Our analysis focused on those with significant injuries, dividing them into 2 groups based on their initial surgical intervention: one group underwent primary repair or resection without proximal diversion, and the other group received diverting ostomy creation. Comparisons between the ostomy and no ostomy groups were conducted for patients with colonic and rectal injuries, respectively. We conducted a comprehensive analysis encompassing a range of variables, including general demographics (age, sex, Charlson Comorbidity Index, and trauma mechanism), clinical conditions observed in the emergency department (ED), such as vital signs, Glasgow Coma Scale scores, laboratory data, intricate surgical details (severity and injury site, surgical approach, duration of the procedure, and intraoperative blood loss), and a comprehensive assessment of outcomes, including the length of stay in the intensive care unit (ICU), hospital length of stay (LOS), incidence of delayed perforations and complications, and mortality rates.

All patients received a primary survey and management according to Advanced Trauma Life Support (ATLS) principles in the emergency department of FEMH, with emergency physicians and trauma surgeons responsible for the trauma service. An extended focused assessment with sonography for trauma (eFAST) was performed on all severely injured patients. Patients showing obvious signs of shock and unresponsiveness to fluid resuscitation (persistent systolic blood pressure < 90 mmHg) were immediately taken to the operating room for surgery. CT scans of the abdomen were scheduled for all patients who responded positively to fluid resuscitation. After initial resuscitation, all patients underwent further treatment based on the surgeon's preferences, which depended on hemodynamic stability, imaging findings, and response to resuscitation. Hemodynamic instability was defined as a persistent systolic blood pressure < 90 mmHg. A massive transfusion protocol was initiated with fluid resuscitation when patients became hemodynamically unstable. For unstable patients, a damage control laparotomy was performed. For stable patients, exploratory laparotomy, diagnostic laparoscopy, or transanal

management was performed to address colorectal injuries. The techniques for emergency laparotomy, exploratory laparotomy, and transanal management were the same as conventional techniques. A four-port technique was employed for diagnostic laparoscopy.[6] The surgical approaches for addressing colorectal injuries included primary repair, resection with or without anastomosis, and diversion. A diversion procedure was defined as any surgical intervention that involved creating an ostomy at or proximal to the injured site. After the operation, all patients were admitted and placed under active surveillance.

Nonparametric statistics, specifically the Mann-Whitney U test, were utilized for continuous variables due to nonnormal distributions, as revealed by the Kolmogorov-Smirnov test. For categorical variables, Fisher's exact test was applied. The analysis was conducted using IBM SPSS Statistics 28.0 software (IBM Corp. in Armonk, NY).

Results

Over the course of the 17 years, a total of 79 patients with colorectal injuries were identified. Fourteen individuals who met the exclusion criteria (those under the age of 18, pregnant patients, t, or patients who underwent SNOM) were subsequently excluded from the study. Consequently, our current investigation focused on 65 patients with colorectal injuries that necessitated surgical intervention. Among this cohort, 38 patients (58.5%) had significant colorectal injuries, while the remaining 27 patients (41.5%) did not. Out of the 38 patients with significant injuries, 25 (65.8%, 25/38) had colonic injuries, and 13 patients (34.2%, 13/38) had rectal injuries. A diverting ostomy was performed in 7 patients (28.0%, 7/25) with significant colonic injuries and in 8 patients (61.5%, 8/13) with significant rectal injuries. The distribution of patients is visually represented in Fig. 1.

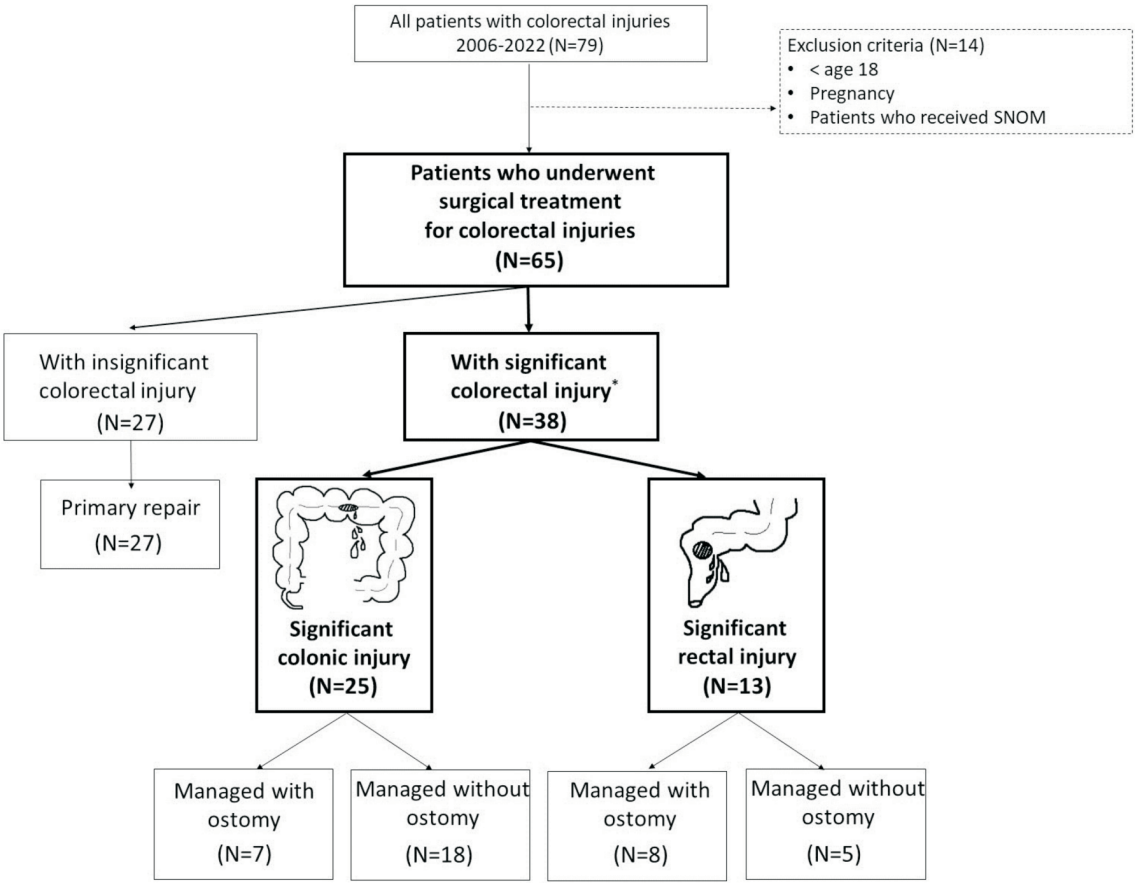

Fig. 1. A study design chart. * Significant colorectal injury = AAST Classification ≥ Grade II. SNOM = selective non-operative management.

Overall, among the 25 patients with significant colonic injuries, the median age was 47.0 years and 20 of them were male. Of these cases, 52.0% (13/25) were caused by a penetrating mechanism, with a median Abbreviated Injury Scale (AIS) of 4 for the abdomen and a median Injury Severity Score (ISS) of 16.0. Additionally, 68.0% (17/25) of these patients had associated injuries. Regarding the 13 patients with significant rectal injuries, the median age was 34.0 year, and 2 of them were male. Of these patients, 46.2% (6/13) were caused by a penetrating mechanism, with a median AIS of 3 for the abdomen and a median ISS of 16.0. Furthermore, 61.5% (8/13) of these patients had associated injuries. All patients who underwent surgical intervention with insignificant colorectal injuries received primary repair. We compared patients who had surgery with or without the use of a diverting ostomy for those with significant colonic and rectal injuries, respectively. In patients with significant colonic and rectal injuries, there were no significant differences in terms of general demographics, preoperative conditions, or clinical characteristics between the groups that received ostomy and those that did not (Table 1, all $p > 0.05$). Although the differences did not reach statistical significance, we observed a tendency toward a higher incidence of penetrating mechanisms (85.7% vs. 38.9%, $p = 0.073$) and a lower ISS (9.0 vs. 17.5, $p = 0.074$) in patients who underwent ostomy creation. To demonstrate the diversity of associated injuries, we conducted a review focusing on the affected organs. Among patients with significant colonic injuries, lung injuries (28.0%, 7/25), liver/spleen injuries (28.0%, 7/25), and small bowel injuries (20.0%, 5/25) were the most common associated injuries. Meanwhile, among patients with significant rectal injuries, pelvis fractures (38.5%, 5/13), extremity fractures (30.8%, 4/13), and urinary bladder injuries (30.8%, 4/13) were also found. It is not surprising that a high percentage of patients with significant colonic injuries exhibited involvement of solid organs, whereas a substantial number of those with significant rectal injuries experienced urinary bladder injuries, extremity fractures, and pelvic fractures.

Perioperative characteristics and operative findings were analyzed. In significant colonic injuries, destructive injuries accounted for 64.0% (16/25), whereas in significant rectal injuries, they comprised 38.5% (5/13) of patients. Laparoscopic surgery was performed

Table 1. The demographic and clinical characteristics of the patients at the time of arrival to the emergency department

	Significant colonic injuries [a]			Significant rectal injuries [a]		
	With ostomy (N = 7)	Without ostomy (N = 18)	*p* value	With ostomy (N = 8)	Without ostomy (N = 5)	*p* value
Age	56.0 (50.0)	44.5 (30.3)	0.220[b]	38.0 (22.3)	34.0 (33.5)	0.724[b]
Male (N, %)	6 (85.7%)	14 (77.8%)	1.000[c]	0 (0%)	2 (40.0%)	0.128[c]
Mechanism of injury-penetrating (N, %)	6 (85.7%)	7 (38.9%)	0.073[c]	3 (37.5%)	3 (60.0%)	0.592[c]
CCI	3.0 (4.0)	0 (1.0)	0.158[b]	0 (0.0)	0 (2.0)	0.435[b]
GCS	15.0 (1.0)	15.0 (1.3)	0.836[b]	15.0 (0.0)	15.0 (0.5)	0.622[b]
SBP (mmHg)	153.0 (75.0)	118.5 (29.8)	0.198[b]	107.0 (45.8)	99.0 (49.5)	0.622[b]
Pulse (BPM)	83.0 (41.0)	93.5 (33.8)	0.615[b]	100.0 (18.3)	89.0 (17.5)	0.127[b]
WBC (10^3/μL)	8.0 (4.7)	10.9 (4.6)	0.085[b]	12.2 (6.0)	17.4 (10.0)	0.284[b]
Hb (g/dL)	14.2 (1.9)	13.3 (4.8)	0.110[b]	14.1 (1.9)	14.3 (4.4)	0.524[b]
ISS	9.0 (11.0)	17.5 (16.0)	0.074[b]	19.0 (19.0)	10.0 (26.5)	0.284[b]
AIS of abdomen	3.0 (1.0)	4.0 (1.0)	0.198[b]	3.5 (1.0)	3.0 (2.0)	0.435[b]
Associated injuries (N, %)	3 (42.9%)	14 (77.8%)	0.156[c]	6 (75.0%)	2 (40.0%)	0.293[c]

Numerical data: median (interquartile range); Nominal data: N (percentage within the group).

[a] AAST Classification ≥ Grade II, indicating a contusion or hematoma without devascularization and a partial-thickness laceration, were not included in the analysis.

[b] Mann-Whitney U test; [c] Fisher's exact test.

CCI = Charlson comorbidity index; GCS = Glasgow Coma Scale; SBP = systolic blood pressure; BPM = beat per minute; ISS = injury severity score; AIS = Abbreviated Injury Scale.

in 28.0% (7/25) of significant colonic injuries and 7.7% (1/13) of significant rectal injuries. The median operation time was 161.7 minutes for significant colonic injuries and 152.7 minutes for significant rectal injuries. Among patients with significant colonic injuries, there were no significant differences in perioperative characteristics or operative findings between the groups (Table 2). However, in patients with significant rectal injuries who underwent ostomy creation, a tendency toward a higher rate of destructive injury was observed (62.5% vs. 0%, $p = 0.075$).

Among the 25 patients with significant colonic injuries, the median length of ICU stay was 7.0 days, and the median hospital stay was 18.0 days. There were 8.0% (2/25) of cases that presented with a delayed perforation. Additionally, 40.0% (10/25) of patients were diagnosed with complications. Among those patients with complications, we observed 5 bowel leakage, 1 colon ischemia, and 4 wound infection or intra-abdominal infection without evidence of bowel leakage in significant colonic injuries. Regarding the 13 patients with significant rectal injuries, the median hospital stay was 14.0 days. None of these patients presented with delayed perforation. Only 1 complication was associated with significant rectal injuries, which was an incisional hernia occurring 6 months after colostomy closure. There were 2 mortalities were observed. One patient died from adult respiratory distress syndrome (ARDS) after treatment of severe associated injuries and colectomy for colonic injuries. The other patient died from disseminated intravascular coagulation (DIC) after management of severe rectal injury and an associated pelvic fracture with active bleeding. There were no significant differences observed between the groups in terms of outcomes, including the length of ICU stay, the length of hospital stay, the occurrence of delayed perforation, complications, and mortality rates. These results remained consistent for both patients with significant colonic injuries and those with rectal injuries, as shown in Table 3.

Out of patients with significant colonic injuries who underwent primary repair or resection and anastomosis, 5 patients experienced bowel leakage. Among these cases, 2 were related to leakage at the repair site, while 3 were associated with leakage at the anastomosis site. In the point of view of trauma surgeons, factors such as patients' hemodynamic status, mechanism of injury, destructive colorectal injury, or multiple sites of injury might have an impact on the healing status of anastomosis. We utilized logistic regression to investigate the risk factors for bowel leakage in individuals with significant colonic injuries who did not undergo ostomy creation initially. The objective of this analysis was to identify factors that might increase the likelihood of bowel leakage. The equation included variables such as initial unstable status, injury mechanism, destructive injury, and the presence of multiple colonic injury sites. The Hosmer and Lemeshow test was conducted, and the results were non-significant ($p = 0.492$), indicating a good fit of the

Table 2. Comparisons of perioperative characteristics and operative findings in patients with significant colonic and rectal injuries who underwent surgery with or without a diverting ostomy

	Significant colonic injuries[a]			Significant rectal injuries[a]		
	With ostomy (N = 7)	Without ostomy (N = 18)	*p* value	With ostomy (N = 8)	Without ostomy (N = 5)	*p* value
Destructive injury[a] (N, %)	3 (42.9%)	13 (72.2%)	0.205[c]	5 (62.5%)	0 (0%)	0.075[c]
Intraperitoneal injury (N, %)	7 (100%)	18 (100%)	-	5 (62.5%)	1 (20.0%)	0.266[c]
Multiple colorectal injury (N, %)	5 (71.4%)	7 (38.9%)	0.202[c]	4 (50.0%)	0 (0%)	0.105[c]
Laparoscopic surgery (N, %)	2 (28.6%)	5 (27.8%)	1.000[c]	1 (12.5%)	0 (0%)	1.000[c]
Operative time (min)	180.0 (75.0)	158.4 (68.8)	0.270[b]	166.4 (135.0)	120.0 (161.4)	0.222[b]
Blood loss (mL)	600.0 (1700.0)	500.0 (1575.0)	0.976[b]	510.0 (2760.0)	100.0 (643.9)	0.222[b]

Numerical data: median (interquartile range); Nominal data: N (percentage)

[a] AAST Classification ≥ Grade II, which means that contusion or hematoma without devascularization and partial-thickness laceration were not included in the analysis.

[b] Mann-Whitney U test; [c] Fisher's exact test.

model to the data. This suggests that the model accurately represents the relationship between the variables and the occurrence of bowel leakage. The results, presented as odds ratios and 95% confidence intervals in Table 4, indicate that none of the factors we examined significantly increased the incidence of bowel leakage.

Discussion

Historically, diverting ostomy was considered a measure to prevent bowel leakage following primary repair or resection in colorectal injuries. However, controversy emerged in the 1970s when the first prospective, randomized study reported higher complication rates, longer hospitalization periods, and increased costs in patients who underwent colostomy for perforating colon trauma.[7] Currently, the use of diverting ostomy is recommended only for selected patients with civilian colorectal injuries who are likely to benefit from the procedure.

In our institution, we observed a low prevalence of colorectal injuries but a high rate of associated injuries within this population. The results likely indicate the diversity of injuries in the patient population. To provide a more in-depth discussion of the nature and outcomes of colorectal injuries, we specifically focused on significant injuries categorized as AAST Classification ≥ Grade II. This classification excludes contusion or hematoma without devascularization and partial-thickness lacerations from the analysis.

Management of colonic injury

There is a tendency to suggest managing colorectal trauma without a diverting ostomy, not only in nondestructive injuries but also in certain conditions involving destructive injuries (a laceration > 50% of circumference or devascularized injury).[8] Strong evidence suggests that primary repair is more effective than proximal diversion in patients with nondestruc-

Table 3. Comparisons of outcomes between patients who underwent surgery with or without a diverting ostomy in cases of significant colonic and rectal injuries

	Significant colonic injuries [a]			Significant rectal injuries [a]		
	With ostomy (N = 7)	Without ostomy (N = 18)	*p* value	With ostomy (N = 8)	Without ostomy (N = 5)	*p* value
Length of ICU stay (days)	4.0 (19.0)	7.0 (18.5)	0.615[b]	3.0 (7.5)	0.0 (11.0)	0.943[b]
Length of hospital stay (days)	11.0 (29.0)	19.0 (17.8)	0.270[b]	14.0 (31.3)	23.0 (52.0)	0.943[b]
Delayed perforation (N, %)	0 (0.0%)	2 (11.1%)	1.000[c]	0 (0.0%)	0 (0.0%)	-
Complications (N, %)	3 (42.9%)	7 (38.9%)	1.000[c]	1 (12.5%)	0 (0.0%)	1.000[c]
Death (N, %)	0 (0.0%)	1 (5.6%)	1.000[c]	1 (12.5%)	0 (0.0%)	1.000[c]

Numerical data: median (interquartile range); Nominal data: N (percentage).
[a] AAST Classification ≥ Grade II, which means that contusion or hematoma without devascularization and partial-thickness laceration were not included in the analysis.
[b] Mann-Whitney U test; [c] Fisher's Exact test.
ICU = intensive care unit.

Table 4. Odds ratios for the effects of pre-operative characteristics on bowel leakage in patients with perforating colonic injuries managed by primary repair or resection and anastomosis without diverting ostomy

	Odds ratio	95% confidence interval (lower, upper)	*p* value
Initial unstable status	9.252	0.226, 379.589	0.240
Mechanism (penetrating injury)	1.100	0.076, 15.935	0.944
Destructive colonic injury	1.735	0.086, 34.804	0.719
Multiple sites of colonic injury	5.380	0.354, 81.685	0.225

Hosmer and Lemeshow test = 0.492.

tive colonic injuries.[9-11] While current prospective studies on destructive penetrating colon injuries have indicated no significant differences in complications between primary repair/anastomosis and diversion groups,[11,12] they have consistently recommended primary repair or resection with anastomosis as the preferred method. Our retrospective study unveiled similar outcomes for patients with significant colonic and rectal injuries. However, the notable difference lies in the fact that we included patients from all trauma mechanisms rather than limiting the study population to penetrating injuries. Among our patients, 52.0% sustained significant colonic injuries from penetrating trauma, 46.2% experienced significant rectal injuries for the same reason, while the remainder were due to blunt trauma, ensuring an evenly distributed patient population. It is worth noting that in our center, we observed a higher proportion of blunt colorectal injuries compared to the reported rate of 4% for colon injuries caused by blunt trauma.[13] This might reflect the nature of the low incidence of penetrating injuries in Asian counties.

In the largest prospective multicenter study involving 297 patients with penetrating colonic injuries requiring resection,[12] anastomosis leakage was observed in 6.6% of patients who underwent resection and anastomosis. However, our data revealed a higher rate of bowel leakage following initial operative management at 27.8% (5 out of 18 cases). This finding may be attributed to the fact that 2 delayed perforations and 1 anastomosis leakage related to delayed ischemia presented after the blunt trauma, which might implicate the nature of higher energy transfer in the blunt injury mechanism.

Management of rectal injury

The treatment modalities for rectal injuries are far more complicated than those for colonic injuries because rectal injuries are unique due to their location, which requires different treatment approaches. Rectal injuries can be classified as intraperitoneal and extraperitoneal, with the latter further divided into those above or below the levator ani muscles. The principles for managing intraperitoneal rectal injuries are similar to those applied in colonic injuries.[2,14] Extraperitoneal rectal injuries in nondestructive penetrating cases can often be successfully managed with primary repair alone.[15] However, for patients with destructive injuries or injuries located above the levator ani muscles, diverting ostomy is recommended because of the higher incidence of failure by repair only.[5,16] In our analysis, we observed a relatively high incidence of destructive injuries in those who were managed with a diverting ostomy (62.5% versus 0%). However, no significant difference in outcomes was observed between the groups. Associated injuries might explain this result.

Rectal trauma is known to be associated with injuries to the genitourinary tract, small bowel, and vascular system.[5] Blunt rectal injuries are frequently linked to high-energy trauma mechanisms because of the protective properties of the pelvic rim, and they have been associated with a reported mortality rate as high as 50%.[17] Hence, the decision-making process for rectal injury management should consider three key aspects: the severity, location, and mechanism of the injuries.

Role of diversion

The role of ostomy in the management of colorectal injuries differs from that in nontraumatic diseases. Colorectal injuries almost always occur in conjunction with other injuries having various complexities, as in our series. Assessing the interactive influence between these injuries poses a difficulty. Additionally, the initial assessment of tissue conditions may present challenges, as injuries to the colon or its supplying vessels can be obscured by hematoma or potentially overestimated due to hemodynamic instability. This is a challenge to treating surgeons about the decision-making process for creating a diverting ostomy when managing such conditions. Although many available studies propose a preference of not doing diversion, most surgeons rely on their clinical judgment for specific conditions individually.[18] Because the outcomes of our patients were comparable to those of the other series, we proposed a treatment algorithm for the management of colorectal injuries, including indications for ostomy creation, as shown in Fig. 2.

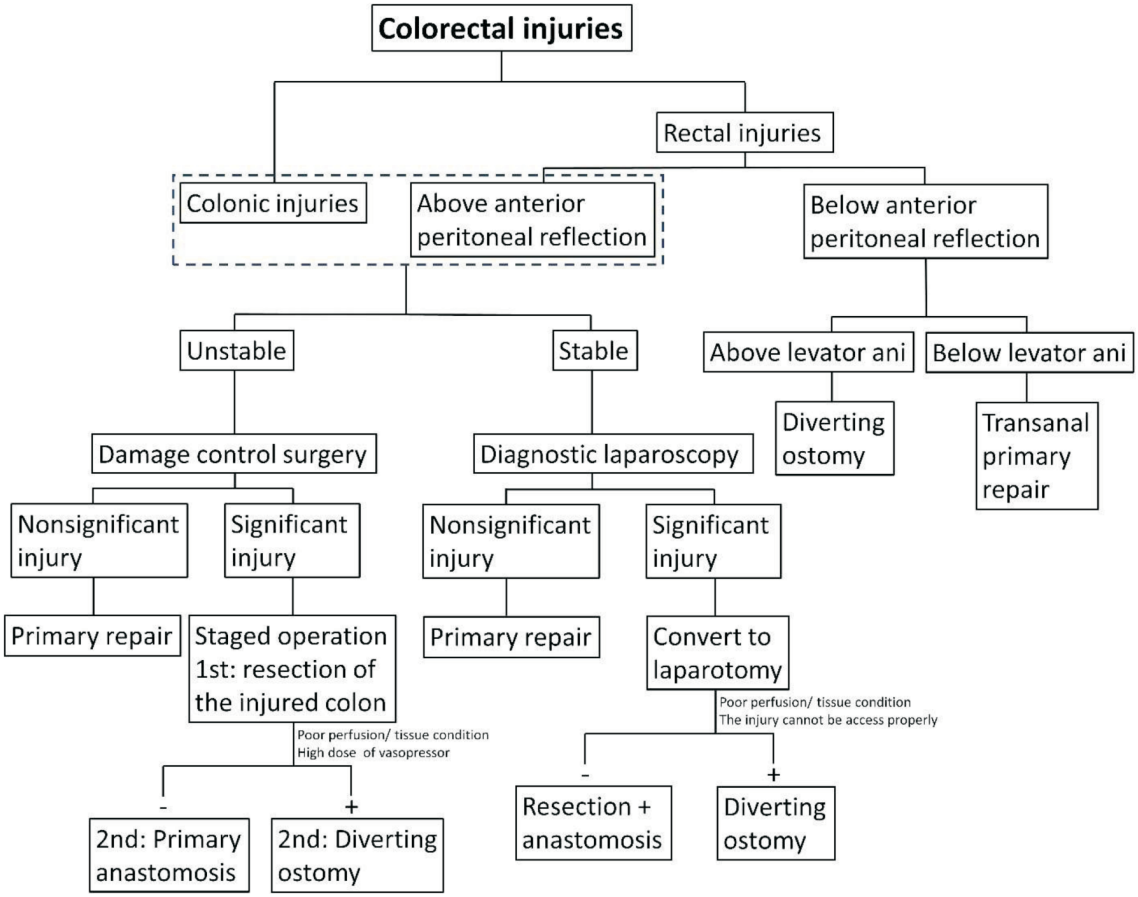

Fig. 2. An algorithm for the management of colorectal injuries based on our practical knowledge and analysis.

Limitation

Our research is subject to several limitations that warrant careful consideration. First, our retrospective design and small sample size inherently introduce bias. Second, the lack of treatment decision records could hamper our understanding of the factors guiding our treatment strategies. Finally, we did not evaluate the patients' long-term quality of life after discharge. Nonetheless, within the specific context of our setting, our study maintains its significance, despite these limitations. To achieve a more comprehensive understanding, future research should prioritize larger sample sizes and prospective study designs.

Conclusion

The creation of an ostomy or not remains a dilemma for the management of colorectal injuries. Primary repair or colectomy without ostomy are feasible and safe modalities for most patients with significant colonic injuries. On the other hand, the use of a diverting ostomy is not linked to an extended hospital stay or a higher complication rate for complex injuries. Therefore, it remains a viable option for managing complex colorectal injuries based on surgeons' clinical judgment.

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原　著

腸造口手術在結腸直腸損傷治療的角色：單一醫學中心的 17 年經驗

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目的　本研究的目的在於釐清腸造口在結腸直腸損傷中的角色，並試圖找出手術後腸道吻合處漏液之相關風險因子。此外，我們根據本院的經驗及本研究結果，提供結腸直腸損傷的治療建議。

方法　我們回顧性研究了 2006 年 1 月至 2022 年 12 月接受手術治療的結腸直腸損傷患者的臨床數據。這些患者被分為兩組，一組有接受造口手術，另一組則沒有，並進行兩組患者間之背景資訊、臨床狀況和治療成果的分析。

結果　在本研究中，我們調查了 65 名因結腸直腸損傷而接受手術治療的患者。儘管需要進行造口手術似乎與某些因素相關，但在患者的背景資訊、術前狀況和臨床特徵方面並未觀察到統計學上顯著的差異。此外，患者的治療成果亦未在兩組間展現出顯著差異。

結論　大多數顯著結腸直腸損傷的患者可以安全地進行縫合修補或結腸切除並吻合，而無需造口手術。然而，在複雜的損傷情況下，造口手術不會導致住院時間延長或產生更多併發症，外科醫師仍然可將其視為有效且安全的治療選擇。

關鍵詞　創傷、結腸直腸損傷、腸造口。