

The influence of the risk factor on the abdominal complications in colon injury management

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SUMMARY: The influence of the risk factor on the abdominal complications in colon injury management.

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Introduction. The management of colon injuries has distinctly evolved over the last three decades. However, trauma surgeons often find themselves in a dilemma, whether to perform a diversion or to perform a primary repair. The purpose of this study is to evaluate risk factors in colon injury management and their influence on abdominal complications.

Patients and methods. This is a prospective study conducted at a national level I trauma center in Tirana, Albania from January 2009 to December 2012. The data with respect to demographics, physiological risk factors, intraoperative findings, and surgical procedures were collected. Colonic injury-related morbidity and mortality were analyzed. Multivariate logistic regression analysis was performed by assessing the influence of risk factors on abdominal complications.

Results. Of the 157 patients treated with colon injury, was performed a primary repair in 107 (68.15%) of the patients and a diversion in the remaining 50 (31.85%). The mean PATI was 18.6, while 37 (23.6%) of patients had PATI greater than 25. The complications and their frequencies according to the surgical technique used (primary repair vs diversion respectively) includes: wound infections (9.3% vs 50%), anastomotic leak (1.8% vs 8.7%), and intra-abdominal abscess (1.8% vs 6.5%). The multivariate analysis identified two independent risk factors for abdominal complications: transfusions of 4 units of blood within the first 24 hours (OR = 1.2 95% CI (1.03 – 1.57) $p = 0.02$), and diversion (OR = 9.6, 95% CI 4.4 - 21.3, $p < 0.001$).

Conclusion. Blood transfusions of more than 4 units within the first 24 hours and diversion during the management of destructive colon injuries are both independent risk factors for abdominal complications. The socioeconomic impact and the need for a subsequent operation in colostomy patients are strong reasons to consider primary repair in the management of colon injuries.

KEY WORDS: Colon injury - Primary repair - Diversion - Risk factor.

Introduction

The management of colon injuries has distinctly evolved over the last three decades. However, trauma surgeons often find themselves in a dilemma whether to perform a diversion or to perform a primary repair. The reason for this dilemma is due to colon-related morbidity which sometimes can be life threatening.

Nevertheless, it is already a widely accepted notion that a primary repair is the standard procedure for a non destructive colon injury. While for a destructive colon

injury in patients with hemodynamic instability, severe fecal contamination, or co-morbid diseases (for example: uncontrolled diabetes, chronic renal failure, congestive heart failure, HIV, cirrhosis, malignancy, malnutrition, and chronic use of steroids), there is no standard surgical procedure established and the debate often leads to controversy; especially the injury is associated with intra-abdominal or extra abdominal injuries. Several authors report different independent and significant risk factors to be taken into account when deciding the type of surgical technique to be used in management of colon injuries (1-5). Their goal was to help future surgeons to identify which patients could be safely managed with primary repair, without increasing the rate of anastomotic leak and its associated morbidity.

In fact, multiple factors influence the decision-making process. The purpose of this study is to evaluate risk factors in colon injury management and their influence on abdominal complications.

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Patients and methods

This is a prospective, observational study, conducted at a national level I trauma center in Tirana, Albania from January 2009 to December 2012. We recorded data from all of the patients we had treated with colonic injuries. The data includes: age, gender, mechanism of injury, shock at admission, time from injury to operation, fecal contamination, Colon Injury Scale (CIS), site of colon injury, associated injuries, Penetrating Abdominal Trauma Index (PATI), units of transfused blood within the first 24 hours, and surgical procedure.

To assessment the level of colon injury, colon injury scale (CIS) of the American Association for the Surgery of Trauma (AAST) was used. Based on this, grade I and II classified as non destructive injuries, while III, IV, and V injuries grade were classified as destructive injuries. To assessment the influence of number organs injured at complications appear, PATI-index was used. The degree of fecal contamination was categorized as mild: when stool contamination was present on local or one quadrant, moderate: when stool contamination was present on 2 to 3 quadrants, and severe: when stool contamination was present on all four quadrants. To define anastomotic leak both the clinical signs, symptoms (signs of localized or generalized peritonitis, fecal discharge from the wound and/or drain) and radiologic investigations are used. For intra abdominal abscess are taken into account as well, clinical signs and symptoms (abdominal pain, purulent discharge from the drain, wound or anus, fever), and radiology investigations (plain films of the abdomen for identifying free air beneath the diaphragm, ultrasound, computerized tomography). To defined wound infection, we are based in these criteria: occur within 30 days of the surgical operation, infection involves subcutaneous tissue of incision and deep tissues, such as facial and muscle layers and purulent discharge from wound or drain placed in wound which required the wound opening up. Based on the surgical management strategy, the patients were divided into two groups: those undergoing primary repair and those undergoing diversion. Primary repair is defined: 1) debridement with simple suture 2) and resection with anastomosis while Diversion is defined as: 1) resection of injury segment with exteriorisation of the proximal segment and distal portion closure or exteriorisation two segments, 2) debridement and simple suture, resection and anastomosis with protective stoma. Complication such as anastomotic leak and intra-abdominal abscess are treated with percutaneous drainage, relaparotomy and/or stoma.

The decision to proceed with primary repair or diversion was left to the discretion of the operating surgeon. At the time of this study, there was no specific protocol for the management of traumatic colon injuries.

As such, all treatment decisions were made on a case-by-case basis by the operating surgeon. We assessed the complications with a special emphasis on anastomotic leak rate and intra-abdominal abscess. Patients who died within 72 hours of admission were excluded from study. We compared variables using a Chi-squared (χ^2) goodness-of-fit test, or Fisher exact tests as appropriate. Colon-related morbidity and mortality were analyzed. Multivariate logistic regression analysis was performed to assess the influence of risk factors on abdominal complications. Statistical analysis was performed using SPSS software version 15.0. P values less than 0.05 were reported as statistically significant.

Results

Demographic data and characteristics of patients

One hundred fifty-seven patients with colon injuries were included in the study. The mean age was 36.57 ± 14.97 and ranged from 6 to 86 years. There were 144 (91.7%) males. The majority of the injuries were caused by firearms (59/157 or 37.5%), followed by the stab wounds (52/157 or 33%), motor vehicle crashes (35/157 or 22.2%), falling from heights (4/157 or 2.5%), self inflicted wounds (3/157 or 1.9%), electric arc (2/157 or 1.2%), and iatrogenic (2/157 or 1.2%). Hypotension at admission (SBP, 90 mmHg) was present in 22.9 % of patients.

The mean time between injury and operation was 5.2 hours, which ranged from 0.5h to 168h. Of those studied, 82.16% of patients underwent surgical treatment within 6 hours, 7.64% between 6 to 12 hours, 3.82% within 24 hours, and 6.36% after 24 hours. We found minimal fecal contamination in 56.04% of the patients, moderate contamination in 28.66%, and severe contamination in 15.28%.

Based on CIS score, 38.7% of the patients had destructive colon injuries. The right colon was found injured in 52% of the cases, the left colon in 39% of the cases, and both sides of the colon in 9% of the cases. Associated intra-abdominal injuries were found in: the small bowel (39.8% of cases), followed by the liver (26%), the spleen (20.4%), the stomach (10%), the diaphragm (10%), the kidney (6.1%), the pancreas (2%) and the inferior vena cava (1%).

In our study the mean PATI was 18.6, while 23.6% of patients had PATI greater than 25. While the mean blood transfusion requirement within the first 24 hours was 1.5 units of blood, and 19.1% of patients required more than 4 units. We applied damage control surgery in 3.8% of patients.

We performed primary repair on most patients (68.15%) including 101 simple sutures, 4 ileocolostomies, and 2 colocolostomies. While on 31.85% of ca-

ses is applied diversion with 3 ileostomies and 47 colostomies, $p < 0.001$.

Morbidity and mortality

The overall incidence of abdominal complications was 27.5%. The most common abdominal complication was wound infection (19.8%), followed by anastomotic leak (4.3%), and intra abdominal abscess (3.3%). The complications and their frequencies according to the surgical technique used (primary repair vs diversion respectively) includes: wound infections (9.3% vs 50%), anastomotic leak (1.8% vs 8.7%), and intra-abdominal abscess (1.8% vs 6.5%) (Table 1).

In our study, 23.5% of patients developed extra abdominal complications. These complications were: 6.3% pneumonia, 3.1% deep vein thrombosis, 4.5% melena, 5% acute renal insufficiency, and 4.5% multiple organ dysfunction syndrome.

The incidence of abdominal complications in the primary repair group 19.7%, and in the diversion group was 32%. The overall mortality rate was 10%. Four deaths occurred in the primary repair group (3.7%) and three in diversion group (6.3%) the p -value = 0.7. The cause of death in each case was multiple organ dysfunction syndrome.

TABLE 1 - THE DISTRIBUTION OF COMPLICATIONS ACCORDING TO SURGICAL TECHNIQUE.

Complication	Primary repair n (%)	Colostomy n (%)	p-value
wound infection	10 (9.34%)	23(50%)	<0.001
intra-abdominal abscess	2 (1.86%)	3(6.52%)	0.3
anastomotic leak	2 (1.86%)	0.00%	0.2

Risk factors

From all of the risk factors that we have analyzed, multivariate analysis identified two independent risk factors for abdominal complications: transfusion of 4 units of blood within the first 24 hours (OR = 1.2 95% CI (1.03 - 1.57) $p = 0.02$), and diversion (OR = 9.6, 95% CI 4.4 - 21.3, $p < 0.001$). We have found a significant correlation between complications and units of blood transfused (correlation coefficient Kendall's Tau = 0:28, $p < 0.001$) (Table 2).

An increase in units of blood transfused increases the number of complications. Overall, the patients subjected to a colostomy were associated with 9.6 times higher likelihood of developing complications compared to patients subjected to a primary repair (OR = 9.6, 95% CI 4.4 - 21.3, $p < 0.001$).

The age, gender, mechanism of trauma, hypotension at admission, time from injury to operation, fecal contamination, CIS, site of colon injury, associated injuries, and PATI were not identified to be significant independent risk factors.

Primary repair vs diversion

A multivariate analysis was used to assess the factors that are described as significant risk factors for abdominal complications in patients with colon injuries.

We observed that the relative risk for developing complications in patients with a PATI < 25 is 5.6 times higher likelihood in patients subjected to a colostomy compared to patients subjected to a primary repair RR = 5.2 95% CI (2.7 - 9.8) $p < 0.001$, while in patients with a PATI > 25 this risk is 1.8 times higher RR = 1.8 95% CI (1.02 - 3.3) $p = 0.04$. Additionally, multivariate logistic regression analysis, adjusting for surgical technique and PATI, found that colostomy [OR = 9.1 95%

TABLE 2 - CORRELATION BETWEEN THE NUMBER OF UNITS OF BLOOD TRANSFUSED AND COMPLICATIONS, DEPENDING ON THE SURGICAL TECHNIQUE.

Surgical technique			Number of units of blood transfused									Total
			0	1	2	3	4	5	6	10	11	
Primary repair	Complications	no	63	5	9	4	10		2			93
		yes	7	2	7	0	0		2			18
	Total		70	7	16	4	10		4			111
Colostomy	Complications	no	5	1	5	2	1	0		0	0	14
		yes	9	3	4	1	8	5		1	1	32
	Total		14	4	9	3	9	5		1	1	46
Total	Complications	no	68	6	14	6	11	0	2	0	0	107
		yes	16	5	11	1	8	5	2	1	1	50
	Total		84	11	25	7	19	5	4	1	1	157

TABLE 3 - CORRELATION BETWEEN THE PATI AND COMPLICATIONS DEPENDING ON THE SURGICAL TECHNIQUE.

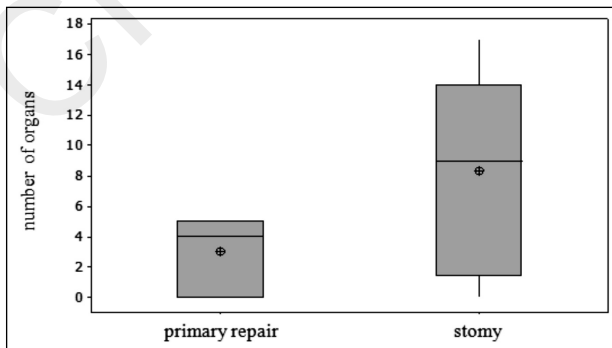
Surgical technique			PATI		Total
			< 25	> 25	
Primary repair	complications	no	84	9	93
		yes	11	7	18
	total		95	16	111
Colostomy	complications	no	10	4	14
		yes	15	17	32
	total		25	21	46
Total	complications	no	94	13	107
		yes	26	24	50
	total		120	37	157

CI (3.9 -21.1) $p < 0.001$] and PATI > 25 [OR = 4.3 95% CI (1.7 - 10.8) $p = 0.001$] has significant risk factors for developing complications (Table 3).

Using multivariate logistic regression analysis, adjusting for surgical technique and fecal contamination, we have not identified any significant difference between patients that are treated with colostomy (coefficient Kendall's Tau = 0.10, $p = 0.3$) and those with primary repair.

In patients treated with a primary repair we observed a weak correlation, with no significance, between the number of organs injured and the number of complications (coefficient Kendall's Tau = 0.11, $p = 0.07$). Increasing the number of organs injured does not increase the number of complications. While patients treated with a colostomy demonstrated a statistically significant but moderate correlation between the number of organs injured and the number of complications (coefficient Kendall's Tau = 0.30 $p = 0.002$). Increasing number the number of organs injured increases number of complications (Table 4).

TABLE 4 - CORRELATION BETWEEN THE NUMBER OF ORGANS INJURED AND COMPLICATIONS DEPENDING ON THE SURGICAL TECHNIQUE.



Discussion

Despite advancements in managing colon injuries over the last three decades, the strategic management of destructive colon injuries in the presence of risk factors that affect morbidity continues to be controversial. Many studies are performed to determine the risk factors that affect morbidity and mortality during treatment of colon injuries.

Stone and Fabian (6) in 1979, in their prospective randomized study reported that in the absence of risk factors (hypotension, delayed operation, multiple associated injuries, and destructive colon injuries requiring resection) a primary repair was associated with fewer complications than a colostomy. Ivatury et al. (7) in 1993 recommended colostomy for left colon injuries requiring resection or for delayed treatment. They identified PATI and the presence of colostomy as significant independent risk factors for abscess formation. Demetriades et al. (1) in their prospective multicenter study, reported that the surgical method does not affect the incidence of abdominal complications while severe fecal contamination, transfusions of 4 or more units of blood within the first 24 hours, and single-agent antibiotic prophylaxis are independent risk factors for abdominal complications.

We have found a significant correlation between complications and the units of blood transfused (correlation coefficient Kendall's Tau = 0.28, $p < 0.001$). An increase in the units of blood transfused will increase the number of complications. Blood transfusion is found to be a risk factor for anastomotic leak and in elective surgery (8). We also observed that the patients who underwent a colostomy were associated with 9.6 times higher likelihood of developing complications compared to patients who underwent a primary repair (OR = 9.6, 95% CI 4.4 - 21.3, $p < 0.001$). While in our multivariate logistic regression analysis, adjusting for surgical technique and fecal contamination, we did not identify any significant difference between patients that are treated with colostomy (coefficient Kendall's Tau = 0.10, $p = 0.3$) and those with primary repair.

Girgin S et al. (3) found that diversion and transfusion of 4 or more units in the first 24 hours as independent risk factors affecting colon-related morbidity. Bulger EM et al. (5) retrospectively reviewed 186 patients with penetrating colon injuries and reached the conclusion that the development of infectious complications is related to the injury severity and haemodynamic status of the patient, not the type of operation performed. Kamwendo et al. (2) in their randomized clinical trial, of 240 patients, showed that delay from injury to operation in penetrating colon injury

is not a contraindication to primary repair. Ricciardi R et al. (9) found no correlation between management strategy and morbidity or mortality after blunt colon trauma. They determined associated injuries as independent risk factors of morbidity, as well as increased age.

In our study the patients that are treated with a primary repair, we observed a weak correlation, no significance, between the number of organs injured and complications (coefficient Kendall's Tau = 0:11, $p = 0:07$). Increasing the number of organs injured does not increase the number of complications. While patients that are treated with a colostomy demonstrated a statistically significant but moderate correlation between the number of organs injured and complications (coefficient Kendall's Tau = 0.30 $p = 0.002$). Increasing the number of organs injured increases number of complications. Many authors have observed that a PATI > 25 to be associated with increased risk of developing an anastomotic leak, and therefore they suggest diversion as a choice procedure (10-12).

We also observed that the relative risk for development of complications in patients with PATI < 25 is 5.6 times higher likelihood in patients subjected to a colostomy compared to patients subjected to a primary repair RR = 5.2 95% CI (2.7 - 9.8) $p < 0.001$, while in patients with PATI > 25 this risk was 1.8 times higher RR = 1.8 95% CI (1.02 - 3.3) $p = 0.04$. Additionally, multivariate logistic regression analysis, adjusting for surgical technique and PATI, found that colostomy [OR = 9.1 95% CI (3.9 - 21.1) $p < 0.001$] and PATI > 25 [OR = 4.3 95% CI (1.7 - 10.8) $p = 0.001$] are significant risk factors for developing complications. Fealk M et al. (13) recommended that the PATI score should be included in the decision making for the management of traumatic colon injuries.

Zhang YX et al. (14) in their retrospective study reported the degree of peritoneal fecal contamination as the only independent predictor of complications. The location of the colon injury as an important risk factors for anastomotic leak is controversial. Some studies show the evidence for greater risk for anastomotic leak of the left colon than the other side of the colon. They came to their conclusion by observing a greater concentration of mucosal bacteria, the absence of posterior peritoneum, and with relatively poor blood supply of left colon (15, 16). While another study did not observe any relationship between location of injury and anastomotic leak (4, 17).

In patients with destructive colon injuries and associated injuries who tend to fall or are in acidosis, hypothermia, and coagulopathy should undergo damage control (DC) surgery in an attempt to reduce morbidity and mortality. This procedure consists in the

rapid control of hemorrhage and of fecal contamination, the transferring patients to the intensive care unit to correct the "triad of death" to come back in theatre room for the second relaparotomy within 12 to 72 hours. For the second relaparotomy Ordoñez CA et al. (18) recommends delayed anastomosis as long as severe acidosis, bowel wall edema, and/or persistent intra-abdominal infections are not present. While, Peter E et al. (19) observes that vasopressor use after initial damage control laparotomy increases risk for anastomotic disruption in the management of destructive colon injuries. Therefore, they recommend diversion in patients who require vasopressor support after the initial DC procedure. In our study we have used this procedure in only 3.83% of cases. Familiarity with the different methods to the approach manage colonic injuries will allow surgeons to minimize unnecessary complications and mortality (20). Haut ER et al. (21) observed that a similar management approach of colon injuries was appropriate for the pediatric population.

Many times in our practice we are required to use massive amounts of crystalloids, colloids, and blood products in hemodynamically unstable patients to maintain perfusion to critical organs. Schnüriger B et al. (22) in their retrospective study concluded that a threshold of 10.5 L of crystalloid fluid infused over the first 72 hours is associated with a 5-fold increased risk for colocolonic suture line failure.

Infection continues to be a major problem for traumatized patients, particularly in colon traumatic injuries. Smith BP et al. (23) concluded that antibiotic prophylaxis guidelines clearly reduce the risk of SSI in patients undergoing trauma laparotomy. Sharp JP et al. (24) observed that operative decisions for dealing with colon injuries based on a defined algorithm improve outcomes.

Conclusion

Blood transfusions of more than 4 units within the first 24 hours and diversion during the management of destructive colon injuries are both independent risk factors for abdominal complications. The socioeconomic impact and the need for a subsequent operation in colostomy patients are strong reasons to consider primary repair in the management of colon injuries.

Conflict of interest

The authors declare that they have no conflict of interest.

References

1. Demetriades D, Murray JA, Chan L, et al. Penetrating colon injuries requiring resection: diversion or primary anastomosis? An AAST prospective multicenter study. *J Trauma*. 2001;50:765-75.
2. Kamwendo NY, Modiba MC, Matlala NS, et al. Randomized clinical trial to determine if delay from time of penetrating colonic injury precludes primary repair. *Br J Surg*. 2002;89:993-8.
3. Girgin S, Gedik E, Uysal E, et al. Independent risk factors of morbidity in penetrating colon injuries. *Ulus Travma Acil Cerrahi Derg*. 2009;15:232-8.
4. Sharpe JP, Magnotti LJ, Weinberg JA, et al. Impact of location on outcome after penetrating colon injuries. *J Trauma Acute Care Surg*. 2012;73:1428-32.
5. Bulger EM, McMahon K, Jurkovich GJ. The morbidity of penetrating colon injury. *Injury*. 2003;34:41-6.
6. Stone HH, Fabian TC. Management of perforating colon trauma: randomization between primary closure and exteriorization. *Ann Surg*. 1979;190:430-6.
7. Ivatury RR, Gaudino J, Nallathambi MN, et al. Definitive treatment of colon injuries: a prospective study. *Am Surg*. 1993; 59: 43-9.
8. Stumpf M, Junge K, Wendlandt M, et al. Risk factors for anastomotic leakage after colorectal surgery. *Zentralbl Chir*. 2009;134:242-8.
9. Ricciardi R1, Paterson CA, Islam S, et al. Independent predictors of morbidity and mortality in blunt colon trauma. *Am Surg*. 2004;70:75-9.
10. Cornwell ET, Velmahos GC, Berne JV, et al. The fate of colonic suture lines in high-risk trauma patients: a prospective analysis. *J Am Coll Surg*. 1998;187:58-63.
11. Murray JA, Demetriades D, Colson M, et al. Colonic resection in trauma: colostomy versus anastomosis. *J Trauma*. 1999;46:250-4.
12. Brasel KJ, Borgstrom DC, Weigelt JA. Management of penetrating colon trauma: a cost utility analysis. *Surgery*. 1999;125:471-9.
13. Fealk M, Osipov R, Foster K et al. The conundrum of traumatic colon injury. *Am J Surg*. 2004;188:663-70.
14. Zhang YU, Chen L, Tao SF, et al. Diagnosis and management of colonic injuries following blunt trauma. *World J Gastroenterol*. 2007;13:633-6.
15. Veyrie N, Ata T, Muscari F, et al. Anastomotic leakage after elective right versus left colectomy for cancer: prevalence and independent risk factors. *J Am Coll Surg*. 2007;205:785-93.
16. Bokey EL, Chapuis PH, Fung C, et al. Postoperative morbidity and mortality following resection of the colon and rectum for cancer. *Dis Colon Rectum*. 1995;38:480-6.
17. Alves A, Panis Y, Trancart D, et al. Factors associated with clinically significant anastomotic leakage after large bowel resection: multivariate analysis of 707 patients. *World J Surg*. 2002;26:499-502.
18. Ordoñez CA, Pino LF, Badiel M, et al. Safety of performing a delayed anastomosis during damage control laparotomy in patients with destructive colon injuries. *J Trauma*. 2011;71:1512-7.
19. Fischer PE, Nunn AM, Wormer BA, et al. Vasopressor use after initial damage control laparotomy increases risk for anastomotic disruption in the management of destructive colon injuries. *Am J Surg*. 2013;206:900-3.
20. Causey MW, Rivadeneira DE, Steele SR. Historical and current trends in colon trauma. *Clin Colon Rectal Surg*. 2012;25:189-99.
21. Haut ER, Nance ML, Keller MS, et al. Management of penetrating colon and rectal injuries in the pediatric patient. *Dis Colon Rectum*. 2004;47:1526-32.
22. Schnüriger B, Inaba K, Wu T, et al. Crystalloids after primary colon resection and anastomosis at initial trauma laparotomy: excessive volumes are associated with anastomotic leakage. *J Trauma*. 2011;70:603-10.
23. Smith BP, Fox N, Fakhro A, et al. "SCIP" antibiotic prophylaxis guidelines in trauma: The consequences of noncompliance. *J Trauma Acute Care Surg*. 2012;73:452-6.
24. Sharpe JP, Magnotti LJ, Weinberg JA, et al. Applicability of an established management algorithm for destructive colon injuries after abbreviated laparotomy: a 17-year experience. *J Am Coll Surg*. 2014;218:636-41.