



CRITERIA FOR PRIMARY OR TWO-STAGE DIVERSION PROCEDURES IN COLON INJURIES: EXPERIENCE FROM A TERTIARY CARE CENTER IN MONTENEGRO

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SUMMARY – Modern literature supports primary repair in a wide array of colon injury presentations. The aim of the study was to evaluate the validity of criteria for primary repair of colon injuries. The analysis involved 96 patients with colon injuries. Group 1 (62 patients) underwent the Stone and Fabian (S/F) criteria for primary repair, whereas group 2 (34 patients) underwent the following exclusion criteria for primary repair: significant peritonitis, edema/ischemia of a large area/multiple colonic segments, latent period >8 h, and intraoperative cardiorespiratory instability. The following variables were analyzed: demographic data, mechanism of injury, latent period, distribution of injuries, macroscopic intraoperative finding, and several trauma indices. The mean latent period was shorter in group 2 (1.3±1.1 h) *versus* group 1 (4.9±3.7 h). Primary repair was more frequent in group 2. There was no difference in the success rate of the primary procedures between the two groups according to Flint grade or S/F criteria. Primary repair is safe and recommended in the first 8 h after injury in hemodynamically and respiratory stable patients without intra-abdominal sepsis.

Key words: *Colon; Colostomy; Primary repair; Surgery; Trauma*

Introduction

Colon injuries are a major public health issue with a morbidity and mortality of 35% and 5%, respectively¹. Treatment modality, i.e., primary repair or diversion, depends on the site of injury, degree of tissue destruction, associated injuries, latent period, degree of contamination, colon blood supply, as well as the degree of shock².

Flint *et al.* suggested a classification of the degree of colon injury, as follows: first degree (isolated colon injury with minimal contamination, treated with early

surgery); second degree (penetrating wound to the colon, lacerations, moderate contamination); and third degree (severe tissue loss with devascularization and massive contamination)³. The American Association for the Surgery of Trauma (AAST) suggested a new version of Colon Injury Scale (CIS) in 1990, as follows: first

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degree injuries – contusion/laceration without perforation; second and third degree – laceration with tissue loss (<50% and >50% of circumference, respectively); fourth degree – transection; and fifth degree – transection with segmental tissue loss and/or injury associated with loss of blood supply⁴. Flint grade I and II, as well as CIS I-III are considered non-destructive lesions, and primary repair is appropriate in these patients. Destructive colon injuries (associated with severe loss of colon wall integrity, circumferential and/or vascular injury) require segmental resection due to tissue loss and/or devascularization (Flint grade III, CIS IV and V)⁵.

Contemporary literature is liberal toward primary repair despite the fact that most general surgeons who rarely treat colon injuries very often perform diversion procedures⁶. The aim of this study was to evaluate the validity of certain criteria for primary repair, based on the degree of injury and general condition of the patient.

Patients and Methods

The analysis involved 96 patients with colon injuries who were surgically treated. Group 1 consisted of 62 patients treated in the 1990-2000 period with the application of the Stone and Fabian (S/F) exclusion criteria for primary repair, i.e., preoperative shock (arterial blood pressure <80/60 mm Hg, hematoperitoneum >1000 mL); more than 2 abdominal organs injured; significant fecal contamination; latent period >8 hours; destructive lesion requiring resection; and significant loss of abdominal wall tissue⁷. The presence of two or more criteria represented an indication for diversion procedure. Group 2 consisted of 34 patients treated in the 2000-2020 period, with the following exclusion criteria for primary repair (suggested by the authors): significant fibrinous-purulent or fecal peritonitis; edema/ischemia of a large area or multiple segments of the colon; latent period >8 hours; and intraoperative cardiovascular and respiratory instability (at least 2 of the following 4 criteria: oxygen saturation <98%, systolic arterial blood pressure <90 mm Hg, heart rate >120 beats/min; central venous pressure <3 or >7 mm Hg). If at least one criterion was positive, a diversion procedure was performed.

In both groups, primary repair was performed through primary suture or resection and primary ana-

stomosis. Postoperatively, two antibiotics were used (ceftriaxone with metronidazole or amikacin). The need of a revision procedure (requiring two-stage surgery) or mortality due to postoperative anastomotic/suture complications were considered as primary repair failure.

The following variables were evaluated: demographic data (sex and age); mechanism of injury; latent period; distribution of injuries according to body regions and colon segments; macroscopic intraoperative finding (non-destructive lesion: injury to one or two walls of the colon, or destructive lesion: laceration/transection or a segmental defect; and trauma indices (Injury Severity Score (ISS)⁸, Penetrating Abdominal Trauma Index (PATI)⁹, Flint grade, as well as S/F contraindication criteria).

The ISS is based on the Abbreviated Injury Scale (AIS), which ranges from 1 (minor injury) to 6 (maximal injury). The ISS recognizes injuries to six body regions: head or neck, face, thorax, abdomen, extremities or pelvic girdle, as well as external injuries. The ISS is calculated as a sum of squares for the highest values of AIS in each of the three most severely injured body regions⁸. PATI is designed as a method of evaluating the risk of complications following penetrating abdominal trauma. It is calculated by multiplying a risk factor of each organ injured (1-5) by an estimation of the injury severity (1-5)⁹.

The study sample consisted solely of patients whose clinical data contained all the necessary information, which means that a significant number of patients could not be analyzed due to incomplete documentation. Therefore, a post hoc analysis of the study sample was conducted, yielding a power of 0.78 ($p=0.031$) when comparing the complication rate between groups 1 and 2.

The standard protocol for descriptive statistics was used, including Student's t-test, Mann-Whitney test, ANOVA, χ^2 -test, and Fisher exact test. The level of statistical significance was set at $p<0.05$. The analyses were performed using the SPSS 24.0 statistical software (IBM SPSS Statistics for Windows, Version 24.0; IBM Corp., Armonk, NY, USA).

This study was approved by the local Ethics Committee (ref. no. 1453/1) and was performed in accordance with the 1975 Declaration of Helsinki. All study participants (or in case of death, their legally

authorized representatives) gave written informed consent for their anonymized information to be published in this article.

Results

Demographic data

Group 1 consisted of 57 (92%) injured men and 5 (8%) women, mean age 34.8 ± 13.43 years. According to age groups, there were 3 (4.8%) patients in the 10-19 age group, 21 (33.9%) patients in the 20-29 age group, 20 (32.2%) patients in the 30-39 age group, 5 (8%) patients in the 40-49 age group, 8 (12.9%) patients in the 50-59 age group, and 5 (8%) patients in the >60 age group.

Group 2 consisted of 29 (85.3%) injured men and 5 (14.7%) women, mean age 41.9 ± 12.1 years. According to age groups, there were 6 (17.6%) patients in the 20-29 age group, 13 (38.2%) patients in the 30-39 age group, 8 (23.5%) patients in the 40-49 age group, 3 (8.8%) patients in the 50-59 age group, and 4 (11.8%) patients in the >60 age group.

The groups did not differ significantly according to sex (χ^2 -test), while group 1 patients were significantly younger (t-test, $p=0.031$).

Mechanism of injury

The patients in both groups were usually injured by firearms (Fig. 1). Long gun injuries were significantly more common in group 1, while knife injuries were more common in group 2 (χ^2 -test, $p=0.02$). The frequency of other mechanisms of injury did not differ significantly between the two groups.

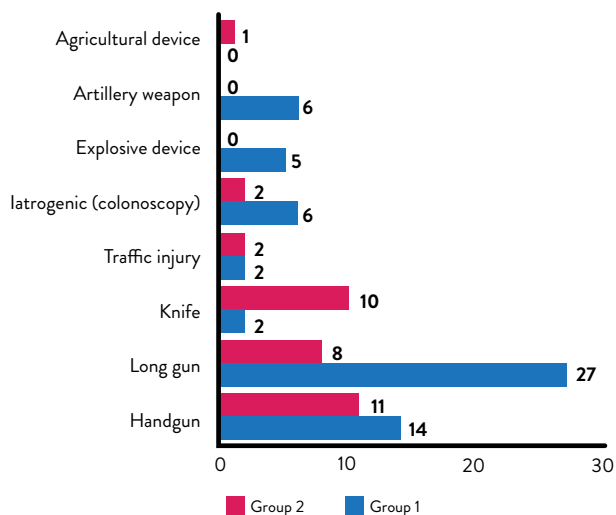


Fig. 1. The mechanism of injury in groups 1 and 2.

Latent period and trauma indices

The majority of patients were treated in the first 8 hours from injury infliction. The mean latent period was 4.9 ± 3.7 h in group 1 and 1.3 ± 1.1 h in group 2, the latter being significantly shorter (t-test, $p=0.041$). Distribution of patients in groups 1 and 2, respectively, according to the latent period was as follows:

- <1 h: 1 (1.6%) and 11 (32.3%) patients in groups 1 and 2;
- 1-2 h: 3 (4.8%) and 13 (38.2%) patients;
- 2-4 h: 11 (17.7%) and 5 (14.7%) patients;
- 4-8 h: 25 (40.3%) and 4 (11.8%) patients;
- 8-16 h: 6 (9.7%) patients;
- 16-24 h: 2 (3.2%) patients;
- 24-72 h: 2 (3.2%) patients;
- 72-96 h: 1 (1.6%) patient; and

Table 1. Trauma indices in group 1 and group 2 patients

Trauma index	Group 1		Group 2	
	Mean \pm standard deviation	Coefficient of variation (%)	Mean \pm standard deviation	Coefficient of variation (%)
ISS	27.01 \pm 8.92	33.0	23.9 \pm 8.6	35.8
PATI	24.54 \pm 11.02	44.8	26.8 \pm 2.9	62.8
Flint	2.32 \pm 0.66	28.6	1.9 \pm 0.7	36.3
S/F	2.52 \pm 1.14	45.6	2.1 \pm 1.4	65.7

ISS = Injury Severity Score; PATI = Penetrating Abdominal Trauma Index; S/F = Stone/Fabian criteria

- >96 h: 11 (17.7%) patients and 1 (2.9%) patient.

Group 2 did not contain any patients with the latent period lasting from 8 h to 96 h.

Table 1 shows trauma indices in both groups. Flint grade was the only index significantly different between groups 1 and 2 (t-test, $p=0.001$).

Distribution of injuries

Isolated abdominal injuries were most common in both groups ($n=39$ and $n=20$ in groups 1 and 2, respectively), followed by thoracoabdominal injuries ($n=13$ and $n=7$ in groups 1 and 2, respectively). Group 1 also showed simultaneous abdominal and spine injury ($n=2$), magistral blood vessel injury ($n=2$), pelvic bone fractures ($n=2$), and extremity injury ($n=1$). Two group 1 patients had extensive thoracoabdominal and extremity trauma, while one patient had cranial, abdominal and extremity trauma. Group 2 showed injury to the abdomen and magistral blood vessel ($n=2$), pelvic bone injuries ($n=2$), and cranial injuries ($n=2$), whereas one patient had cranial, abdominal and extremity trauma. There was no significant difference between the two groups according to distribution of injuries (Fisher exact test).

Group 1 most frequently presented injuries in the mobile parts of colon, i.e., sigmoid (26.01%) and transverse colon (22.5%), followed by ascending colon (16.1%), cecum and descending colon (9.67% each), splenic flexure (6.45%), and intraperitoneal rectum (4.8%). Extraperitoneal rectum was injured only in 1 (1.6%) patient. Polysegmental injuries were present in

2 patients, involving sigmoid and transverse/ascending colon.

Group 2 exhibited a similar pattern of injuries, i.e., transverse colon (20.62%), ascending colon (17.64%), sigmoid colon (14.7%), splenic flexure and cecum (11.76% each), descending colon and intraperitoneal rectum (5.88% each). Two patients had a combination of sigmoid and transverse colon injuries. One patient had sigmoid and ascending colon injury, and another patient had an injury to the ascending and transverse colon.

Twenty (32.2%) group 1 patients had a lesion of a single colon wall, while 15 (24%) patients had lesions in both colon walls. Twenty-seven (43.7%) group 1 patients had destructive lesions, i.e., 24 (38.9%) patients showed lacerations/transections and 3 (4.8%) patients showed segmental colon defect. In group 2, 16 (47.05%) patients presented a singular colon wall lesion and 12 (35.29%) patients both colon wall injuries. Ten (29.4%) patients had destructive injuries, including lacerations/transections in 7 (20.58%) patients and segmental defect in 3 (8.8%) patients. Non-destructive lesions were more frequent than destructive ones in both groups (χ^2 -test, $p=0.001$). However, the two groups did not differ according to segmental distribution of injuries or injury severity.

Table 2 shows results of trauma indices in relation to the association of colon injuries with other abdominal organ injuries. The majority of group 1 patients ($n=37$, 59.7%) had PATI <25 and less than 3 S/F criteria, while 19 group 2 (55.9%) patients had such characteristics. The only statistically significant

Table 2. Trauma indices according to association of colon and other abdominal organ injuries

No. of organs	n (%)		PATI (mean)		S/F (mean)		Flint grade (mean)	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Colon	13 (20.9)	11 (32.4)	14.3	12.1	1.6	1.2	2.0	1.5
Colon + 1	24 (38.9)	8 (23.5)	22.5	18.0	2.3	1.3	2.2	1.6
Colon + 2	18 (29)	5 (14.7)	38.3	32.2	3.5	3.3	2.2	2.5
Colon + 3	5 (8)	7 (20.5)	33.6	38.2	3.4	3.8	2.6	3.6
Colon + 4/+ >4	1 (1.6)	3 (8.8)	72.0	61.3	4.0	4.6	3.0	2.6
Rectum + urethra	1 (1.6)	0 (0)	26.0	0 (0)	3.0	0 (0)	2.5	0 (0)
Mean value of trauma index			24.5	26.8	2.5	2.19	2.3	1.9

PATI = Penetrating Abdominal Trauma Index; S/F = Stone/Fabian criteria

difference between the groups was recorded for PATI in patients with injuries of the colon and two additional organs (ANOVA and Tukey post hoc test, $p=0.032$).

Stone/Fabian criteria

The majority of patients in both groups had preoperative shock (77.4% in group 1 and 58.8% in group 2), followed by hemoperitoneum (45.1% in group 1 and 32.35% in group 2). Injuries to more than two abdominal organs were found in 35.5% and 44.1% of patients in groups 1 and 2, respectively. Destructive colon lesions requiring resection were seen in 27.4% and 23.5%, latent period longer than 8 hours in 35.5% and 2.94%, and peritonitis/massive contamination in 14.5% and 8.82% in groups 1 and 2, respectively, while a single group 1 patient had a significant abdominal wall defect. There was no difference in the frequency of S/F criteria between the two groups (χ^2 -test).

Choice of treatment and success rate

Table 3 shows results of treatment in both groups. There was a significant difference in complication rate between primary and two-stage procedures in group 1 (Fisher exact test, $p=0.028$), with complications more frequently recorded after primary procedures. The mortality between the two therapeutic methods in group 1 did not differ significantly.

In group 2, primary procedures were more frequent than two-stage surgery (χ^2 -test, $p=0.039$), without significant difference between the two treatment modes in relation to mortality. There were no complications requiring revision surgery in this group.

Flint grade I showed a 100% success rate of primary procedures in both groups; grade II had a 77% success rate in group 1 and 88.2% in group 2, while

grade III had a 45.5% success rate in group 1 and 40% in group 2. Both groups showed a significantly weaker success rate of primary surgery in grade III in comparison with grades I and II (χ^2 -test, $p=0.027$). There was no difference in the success rate of primary procedures between the two groups according to Flint grade or S/F criteria.

In group 1, the mean length of hospital stay after primary procedures was 15.6 ± 4.6 (8-28) days, while two-stage procedures were followed by a mean length of stay of 20.2 ± 10.2 (9-47) days, yielding a significantly shorter length of hospital stay after primary surgery ($p=0.032$). The results were similar in group 2, i.e., 11.2 ± 3.7 (7-21) days *versus* 13.4 ± 5.5 (10-30) days ($p=0.029$). In total, the length of hospital stay was significantly shorter in group 2 (11.1 ± 3.8 days) in comparison with group 1 (17.6 ± 9.9 days) (t-test, $p=0.001$).

Discussion

The results of this study indicate that primary repair is safe and useful in patients who are in good cardiovascular and respiratory condition, without severe peritonitis, colon edema or ischemia, treated surgically less than eight hours after injury. Groups 1 and 2 presented a similar degree of local injury, and their general condition was similar (confirmed with similar trauma indices). Nearly 60% of all patients had PATI <25 and less than 3 S/F criteria. Primary repair was more common and more successful in group 2 than in group 1, also supported by the shorter hospital stay in group 2.

The first randomized study on non-destructive colon injury treatment was performed by Stone and Fabian in 1979, showing a lower rate of intra-abdominal

Table 3. Frequency and success of primary and two-stage procedures in the two groups

Type of surgery	Group 1			Group 2		
	Primary repair, n (%)	Two-stage, n (%)	Total, n (%)	Primary repair, n (%)	Two-stage, n (%)	Total, n (%)
	36 (58)	26 (42)	62 (100)	31 (91.2)	3 (8.8)	34 (100)
Success rate	23 (63.9)	21 (80.8)	44 (70.9)	26 (83.9)	2 (66.6)	28 (82.3)
Complication rate	12 (33.3)	2 (7.7)	14 (22.5)	-	-	-
No. of deaths	1 (2.8)	3 (11.5)	4 (6.4)	5 (16.1)	1 (33.3)	6 (17.6)

infection (15% *vs.* 29%), as well as the wound infection rate (48% *vs.* 57%) after primary repair⁷. Chappuis *et al.* randomized 56 patients without any contraindication criteria for primary repair. The mean PATI was 26 (primary repair) *versus* 23.9 (colostomy). The rate of general septic complications was similar in the two groups¹⁰. Jacobson *et al.* analyzed 58 patients with the mean PATI of 26.7 treated with primary repair, reporting an intra-abdominal abscess incidence of 12.1%¹¹. In 2003, Maxwell and Fabian published a literature review encompassing 2,516 surgeries for non-destructive colon lesions. The total number of complications after primary repair was 14% (31% after colostomy), while the rate of intra-abdominal sepsis was 5% *vs.* 12%. The mortality related to the type of surgery was 0.11% *vs.* 0.14%¹². Nelson and Singer state that primary repair is associated with a significantly lower rate of postoperative complications⁶, supported by the fact that standard laparotomy with primary repair avoids the colostomy-related complications^{6,13}. Kamwendo *et al.* performed a study on 240 patients with a latent period of 3–56 h. The latent period did not influence the outcome of primary repair. The authors suggest that any latent period *per se* should not be taken into account as a contraindication for primary procedure¹⁴. A study on 259 patients from the Bosnia and Herzegovina conflict (1992–1995) is an example of therapeutic decision based on the subjective estimation of the surgeon, considering the number of injured soldiers as a limiting factor in the duration of surgical procedure. The rate of colon-related complications was similar in the two groups, 27% *versus* 30%². Although the authors conclude in favor of primary repair, the similar rates of complications illustrate the need of a structured system of indications for primary repair. Demetriades suggests that colostomy should be planned exclusively in the presence of severe colon edema or ischemia, with the degree of intra-abdominal contamination not influencing the anastomotic failure rate¹⁵.

The AAST performed a multicenter study on 297 patients with destructive colon lesions surviving at least 72 hours after the injury. In their study, the only risk factors for intra-abdominal septic complications (independent of the type of treatment) were severe stercoraceous contamination, blood transfusion >4 units, and single antibiotic prophylaxis¹⁶. In a study on

157 patients, Torba *et al.* report two factors associated with intra-abdominal complications, i.e., blood transfusion greater than 4 units in the first 24 hours and diversion procedure¹⁷, similar to Girgin *et al.*¹⁸.

A study by Mahmood *et al.* on 160 patients with intestinal injuries, 46.3% of them treated with primary repair, showed that postoperative complications were significantly associated with blood transfusion >4 units and high serum lactate levels. The authors state that the general condition of the patient is crucial in healing of the repaired bowel¹⁹.

An algorithm was produced from a study by Stewart *et al.*²⁰, indicating that primary repair should be performed in all non-destructive lesions, as well as in destructive lesions in the absence of significant comorbidities and with less than 6 blood transfusions. In 2012, the algorithm was re-evaluated based on a ten-year experience (2002–2012), showing the rates of suture line failure and colon-related mortality to be 5% and 1%, respectively²¹. The algorithm was once again confirmed to be useful in decreasing morbidity and mortality in patients requiring delayed anastomosis²².

A literature review from 2014 showed that blast injuries in hemodynamically stable patients could be safely treated with primary repair²³. Kashuk *et al.* concluded that hemodynamically unstable patients should undergo primary repair after damage control laparotomy (DCL)²⁴. Oosthuizen *et al.* agree with this conclusion²⁵, as well as Vertrees *et al.*²⁶, suggesting that the severely injured patient presenting with the lethal triad should undergo delayed colon repair after complete resuscitation. Shazi *et al.* suggested that destructive colon lesions should undergo DCL in the presence of hypothermia, acidosis, hypotension, and complex injuries²⁷. Ordonez *et al.* recommend diversion procedures with DCL in patients with visceral edema, intraperitoneal infection, and persistent acidosis²⁸.

In 1998, the Eastern Association for the Surgery of Trauma stated that patients with intraperitoneal lesions associated with a loss of >50% of bowel wall or segmental devascularization should undergo resection and primary anastomosis if the patient was hemodynamically stable, without peritonitis, significant associated injury or major comorbidities²⁹. Bulger *et al.* found that primary repair and colostomy did not

differ significantly in the complication rate if analyzed separately from the trauma severity and hypotension³⁰. A retrospective study by Fouda *et al.* revealed the following contraindication criteria for primary repair: hemodynamic instability, severe fecal contamination, significant associated injuries, and latent period >12 h, with a lower rate of complications after primary repair (21.6%) *versus* colostomy (43.8%)¹. Their contraindication criteria are similar to the criteria used herein, with the final results showing a similarly lesser rate of complications after primary procedures in patients selected based on their general condition and not solely on the extent of local colon injury. The study presented herein is an addition to the body of evidence which emphasizes the importance of physical condition of the patient who suffered abdominal injury (also illustrated in the aforementioned study by Mahmood *et al.*¹⁹). Several aforementioned studies also suggested that significant comorbidities (existing before trauma) had a major impact on recovery after surgery²⁰⁻²². Owing to this, the results of our study are in general accordance with the modern philosophy of abdominal trauma management. The clinical applicability of our study encompasses a wide spectrum of colon injury causes, as well as a large number of surgeons treating injured patients worldwide.

In conclusion, primary repair after colon injury is safe in hemodynamically and respiratory stable patients without intra-abdominal sepsis, when performed in the first 8 h after injury. Additional analyses of personal surgical experience, as well as the systemic inflammatory response syndrome and sepsis scores on admission and during the postoperative course³¹ would probably yield useful results in the understanding of the process of choosing between primary repair and two-stage surgery. The majority of patients exhibited non-destructive injuries, and there were not many critically injured patients in group 2. A repeated study with more severely injured patients and destructive colon lesions should provide a more appropriate evaluation of the suggested primary repair criteria. Future studies should also aim to evaluate diagnostic tools used in the early detection of postoperative complications after colon repair, e.g., the levels of serum and peritoneal fluid inflammatory parameters³².

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Sažetak

KRITERIJI ZA PRIMARNU ILI DVOSTUPANJSKU PROCEDURU U LIJEČENJU
OZLJEDA KOLONA: ISKUSTVA TERCIJARNOG CENTRA U CRNOJ GORI*R. Lazović, B. Vukčević, O. Šarenac, J. Lazović i N. Vukčević*

Suvremena literatura podupire primarnu reparaciju kod širokog opsega ozljede kolona. Cilj istraživanja je bio procjena validnosti kriterija za primarnu reparaciju ozljede kolona. Analizirano je 96 bolesnika s ozljedom kolona. Skupina 1 (62 bolesnika) je podvrgnuta kriterijima Stonea i Fabiana (S/F) za primarnu reparaciju. Skupina 2 (34 bolesnika) je podvrgnuta sljedećim kontraindikacijskim kriterijima za primarnu reparaciju: značajni peritonitis, edem/ishemija većeg dijela ili višestrukih segmenata kolona, latentno razdoblje >8 h i intraoperacijska kardiorespiracijska nestabilnost. Sljedeće varijable su analizirane: demografski podaci, mehanizam ozljede, latentno razdoblje, distribucija ozljeda, makroskopski intraoperacijski nalaz, kao i nekoliko indeksa traume. Srednje latentno razdoblje bilo je kraće u skupini 2 ($1,3 \pm 1,1$ h) u usporedbi sa skupinom 1 ($4,9 \pm 3,7$ h). Primarna reparacija je bila češća u skupini 2. Nije bilo razlike u uspješnosti primarnog zahvata između dviju skupina u usporedbi s Flintovim gradusom i kriterijima S/F. Primarna reparacija je sigurna i preporučljiva u prvih 8 sati nakon ozljede u hemodinamski i respiracijski stabilnih bolesnika bez intra-abdominalne sepe.

Ključne riječi: *Kolon; Kolostoma; Kirurgija; Primarna reparacija; Trauma*