

# High velocity missile-related colorectal injuries: In-theatre application of injury scores and their effects on ostomy rates

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## ABSTRACT

**BACKGROUND:** Treatment of colorectal injuries (CRIs) remains a significant cause of morbidity and mortality. The aim of the present study was to analyze treatment trends of Turkish surgeons and effects of the American Association for the Surgery of Trauma (AAST), Injury Severity (ISS), and Penetrating Abdominal Trauma Index (PATI) scoring systems on decision-making processes and clinical outcomes.

**METHODS:** Data regarding high velocity missile (HVM)-related CRIs were retrospectively gathered. Four patient groups were included: Group 1 (stoma), Group 2 (no stoma in primary surgery), Group 2a (conversion to stoma in secondary surgery), and Group 2b (remaining Group 2 patients).

**RESULTS:** Groups 1, 2, 2a, and 2b included 39 (66%), 20 (34%), 6 (30%), and 14 (70%) casualties, respectively. Ostomies were performed in casualties with significantly higher AAST scores ( $p < 0.001$ ). However, PATI and ISS scores were not decisive factors in the performance of ostomy ( $p = 0.61$ ;  $p = 0.28$ , respectively). Ostomy rates of civilian and military surgeons were 62% and 68%, respectively ( $p = 0.47$ ). Receiver operating characteristic (ROC) analysis showed that AAST score was a more accurate guide for performing ostomy, with sensitivity and specificity rates of 80% and 92.9%, respectively.

**CONCLUSION:** Clinical significance of diversion in HVM-related CRIs remains. Stomas were associated with lower complication rates and significantly higher AAST colon/rectum injury scores.

**Keywords:** Colorectal injuries; high velocity missile; military; ostomy.

## INTRODUCTION

The colon is the second most commonly involved organ in penetrating abdominal injuries.<sup>[1,2]</sup> Rectal injuries are frequently associated with pelvis fractures caused by non-penetrating injuries.<sup>[3,4]</sup>

Management of colorectal injuries (CRIs) has been dramatically influenced by experience gained during military conflicts, civilian experience, and technical advances over the last cen-

ture.<sup>[5-7]</sup> Due to high mortality rates in World War II, the past, dogmatic “exteriorization or proximal stoma” approach to colorectal injury has finally shifted toward the assured stance that “primary repair or resection-anastomosis can be safely performed in selected cases.”<sup>[8-10]</sup> However, the majority of studies that favor primary repair or resection-anastomosis are based on penetrating low velocity missile (LVM) injuries.<sup>[9,10]</sup> High velocity missiles (HVMs) cause injuries that are significantly more severe. Moreover, assessment and treatment of HVM-related injuries are frequently complicated by association with other injuries, transfusion requirements, and extended time to surgical treatment.<sup>[6-8]</sup>

Choice of CRI management primarily depends upon severity of injury. The American Association for the Surgery of Trauma (AAST) injury scoring scale is frequently used to classify severity of colorectal injuries.<sup>[11-13]</sup> The Penetrating Abdominal Trauma Index (PATI) can also be used to assess penetrating injuries to the abdomen.<sup>[2]</sup> The Injury Severity Score (ISS) is the anatomical scoring system most frequently used to assess severity of whole-body trauma.<sup>[14]</sup>

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The aim of the present study was to analyze surgical treatment tendencies of Turkish surgeons regarding ostomy performance in HVM-related CRIs. Additional aims were to analyze relevance of AAST, ISS, and PATI scores in decision-making processes, and to present clinical outcomes gathered from available data.

## MATERIALS AND METHODS

Following approval from the Gülhane Military Medical Academy Ethics Committee, retrospective data regarding all casualties treated over the past 4 years were obtained. Patients who had sustained injuries to the colon, rectum, or anus caused by HVMs were identified. Data regarding casualty demographics, injury characteristics, associated injuries, management, and subsequent outcomes were collected. Preferred surgical intervention was at the discretion of the attending military or civilian surgeon. Detailed data obtained during admission, including presence of hypotension or metabolic acidosis, was significantly lacking. All casualties had been evacuated to the nearest Role 2 or civilian hospital via military helicopter and were admitted to hospital within 1 hour of injury. ISS, AAST colon/rectum injury scores, and PATI scores were calculated for each casualty.

Casualties were grouped according to presence of stoma. The stoma group (Group 1) included patients with any type of proximal stoma performed during initial surgery. Group 2 included primary repair casualties without stoma. Primary repair was defined as debridement and primary closure or resection with primary anastomosis. Following initial surgery, casualties that required reoperation were also identified. Reoperations secondary to colorectal injury were analyzed separately, and were performed due to presence of either radiographic or surgical confirmation of leak, or other complications including postoperative hemorrhage, entry wound necrotizing fasciitis, postoperative abdominal pain and distention, and stoma retraction. Group 2 patients that underwent reoperation and either required or did not require stoma were classified as Group 2a and Group 2b, respectively.

Data were analyzed using SPSS® software (version 15.0; SPSS Inc., Chicago, IL, USA) Independent samples t-test or Mann-Whitney U test was used to compare continuous variables, as appropriate. Chi-square test was used to compare categorical variables. Linear association was analyzed with Spearman's Rho correlation test. Receiver operating characteristic (ROC) analysis was used to determine optimal cutoff value for best sensitivity and specificity rates. Odds ratios with 95% confidence interval were calculated from contingency tables. Statistical significance was set at  $p < 0.05$ .

## RESULTS

Included were 59 male casualties that had sustained HVM-related colorectal injuries. Wounds from improvised explo-

sive devices (IEDs) and gunshots accounted for 44% and 56% of casualties, respectively. Secondary fragments from IEDs cause multiple, patchy abdominal wall injuries, placing significant burden on surgical triage and complicating expedited diagnostic workup of casualties. Routinely, fragment-related intra-abdominal injuries are diagnosed by ultrasound examination of suspicious abdominal wall wounds, as well as by exploration under local anesthesia to identify full-thickness fascial defects. All casualties that underwent surgical exploration had intra-abdominal injuries that required surgical treatment. All casualties were evacuated to Role 4 hospital following initial surgery, and all had variable hospital stays in military and civilian hospitals. All treatment of complications and reoperations were performed in Role 4.

Mean age was 23.4 (SD±5.2). There were 39 (66.1%) casualties in Group 1 and 20 (33.9%) in Group 2. In Group 2, 6 (30%) casualties underwent reoperation with colostomy (Group 2a), and the remaining 14 (70%; Group 2b) had uneventful recoveries (Table 1).

CRI-related complications required surgical and nonsurgical interventions in 27 (45%) and 3 (5.1%) casualties, respectively (Table 2). In Group 1, 18 (46.2%) of the 39 patients underwent reoperation, and 5 (27.8%) had CRI-related complications. Nine (45%) of the 20 patients in Group 2 underwent reoperation, due to CRI-related complication in 7 (77.8%). In Group 2, the CRI-related reoperation rate was significantly higher (odds ratio, 3.5; 95% CI, 1.04-11.88;  $p=0.03$ ; Table 3). In Group 1, types of stoma performed were ileostomy, colostomy, and ileostomy-colostomy in 10 patients (25.6%), 28 patients (71.8%), and 1 (5%) patient, respectively. Ostomy types were transverse end, sigmoid loop, and cecostomy in 13 (46.4%), 14 (50%), and 1 (3.6%) casualty, respectively. In Group 2, 13 of the 20 (65%) casualties were treated with primary repair and 7 (35%) underwent resection-anastomosis. Rates of ostomies performed by civilian and military surgeons were 62% and 38%, respectively. No statistically significant difference in ostomy rates between civilian and military surgeons was found ( $p=0.47$ ).

AAST scores of Groups 1 and 2 were compared, and it was determined that surgeons chose to perform stomas (Group 1) in casualties with significantly higher AAST scores ( $p < 0.001$ ). When data of Groups 1 and 2 were analyzed individually, no association for either ISS or PATI score was found, ( $p=0.36$ ,  $p=0.23$ , respectively). Thus, it was hypothesized that if AAST score was correct in indicating casualties that required stomas, no statistically significant difference between Groups 1 and 2a should be present. Analysis confirmed this ( $p=0.40$ ; Tables 4, 5).

ROC curve analysis was performed to determine accuracy of AAST scores regarding selection of colostomy as treatment method, and a cutoff score of 3 to compare Groups 1 and 2 was determined. In Group 1, 18% and 82% of casualties had

AAST scores of  $\leq 2$  and  $\geq 3$ , respectively. In Group 2, however, 75% and 25% of casualties had AAST scores of  $\leq 2$  and  $\geq 3$ , respectively. Given the cutoff points, the sensitivity and specificity of AAST scores in the choice of colostomy as treatment meth-

od were 82.1% and 75%, respectively. (AUC=0.83,  $p < 0.001$ ).

Interestingly, AAST score was also decisive between the ostomy and non-ostomy groups ( $p < 0.001$ ). Casualties were

**Table 1.** Distribution of colorectal injuries (CRI)

Groups (n)	Right colon		Transvers colon		Left colon		Sigmoid colon		Anus and rectum	
	n	%	n	%	n	%	n	%	n	%
Group 1 (39)	9	23	5	13	8	20.5	6	15.3	11	28.2
Group 2 (20)	1	5	7	35	5	25	6	30	1	5
Group 2a (6)	1	16.6	2	33.6	1	16.6	1	16.6	1	16.6
Group 2b (14)	0	0	5	35.7	4	28.6	5	35.7	0	0

**Table 2.** Causes and distribution of reoperations and non-operative management

	Complications	n	%	Total
Re-operation	Anastomosis leakage	9	15.2	27
	Intraabdominal abscess	3	5.1	
	Necrotizing fasciitis	3	5.1	
	Signs of peritoneal irritation	8	13.5	
	Hemorrhage	3	5.1	
	Ostomy retraction	1	1.6	
Non-operative management	Surgical site abscess	3	5.1	3

**Table 3.** Distribution of re-operations in Group 1 and Group 2

	n	%	Re-operations due to CRI-related complications		Other indications for re-operations	
			n	%	n	%
Reoperated casualties in Group 1	18/39	46	5/18	27	13/18	73
Reoperated casualties in Group 2	9/20	45	7/9	77	2/9	23
Total	27/59	45	12/27	45	15/27	55

**Table 4.** Distribution of AAST colon/rectum injury scores (1–5) among study groups

	n	Scor 1		Scor 2		Scor 3		Scor 4		Scor 5	
		n	%	n	%	n	%	n	%	n	%
Group 1	39	0	0	7	17.9	22	56.4	7	17.9	3	7.7
Group 2	20	12	60	3	15	3	15	2	10	0	0
Group 2a	6	1	16.6	1	16.6	2	33.3	2	33.3	0	0
Group 2b	14	11	78.6	2	14.3	1	7.1	0	0	0	0
Colorectal injury	59	12	20.3	10	16.9	25	42.3	9	15.2	3	5.08

AAST: American Association for the Surgery of Trauma.

**Table 5.** Mean severity scores of colorectal injury groups

	n	PATI (0–200)	ISS (0–75)
Colorectal injury	59	21.78	16.72
Group 1	39	22.93	17.30
Group 2	20	19.84	15.60
Group 2a	6	21	18.50
Group 2b	14	19.42	14.75

PATI: Penetrating Abdominal Trauma Index; ISS: Injury Severity Score.

**Table 6.** Statistical analyses between groups for severity scores

Groups Compared	AAST-AIS 90 (p)	PATI (p)	ISS (p)
Group 1 & Group 2	0.001*	0.23	0.36
Group 1 & Group 2a	0.40	0.49	0.71
Group 2a & Group 2b	0.01*	0.61	0.28
Group 1 & Group 2b	0.001*	0.21	0.07

\*Statistically significant (p<0.05). AAST: American Association for the Surgery of Trauma; AIS: Abbreviated Injury Scale; PATI: Penetrating Abdominal Trauma Index; ISS: Injury Severity Score.

further analyzed as ostomy (Group 1 + Group 2a) and non-ostomy (Group 2b) groups using ROC curve analysis. A cutoff AAST score of 3 was determined for analysis. In the ostomy group, 20% and 80% of casualties had scores of  $\leq 2$  and  $\geq 3$ , respectively. In the non-ostomy group, however, 93% and 7% of casualties had AAST scores of  $\leq 2$  and  $\geq 3$ , respectively. Given the cutoff points, the sensitivity and specificity of AAST scores in the selection of colostomy were 80% and 92.9%, respectively (AUC=0.94; p<0.001). Accordingly, 4 of 6 casualties had AAST scores of  $\geq 3$  in Group 2a. The authors speculate that the second surgical intervention could have been prevented if colostomy had been performed during initial surgery.

PATI and ISS scores were not statistically significant in Group 1, compared to Group 2b (p=0.21, p=0.07), or in Group 2a, compared to Group 2b (p=0.61, p=0.28; Table 6).

Ten (17%) patients underwent damage control procedures, nine (90%) of whom underwent a colostomy. These patients underwent a mean of 2.4 (range, 1–4) operations following the initial damage control. No mortalities occurred during CRI treatment in the general surgery clinic.

## DISCUSSION

Throughout history, various surgical approaches to colorectal injuries have been practiced. During World War II, the Surgeon General of the United States mandated proximal stoma or bowel exteriorization, which led to significant decrease in rates of mortality and morbidity.<sup>[15,16]</sup> In the 1970s, the para-

digm shifted toward use of primary repair in the treatment of uncomplicated colorectal injuries, in accordance with advances in evacuation, resuscitation, and antibiotherapy of casualties.

In 1979, Stone et al.<sup>[9]</sup> published the first widely accepted research to oppose mandatory performance of stomas. The authors demonstrated that rates of infectious complications were 48% in primary repair and 57% in colostomized patients. However, mortality rates were 1.5% and 1.4%, and the difference was obviously not statistically significant. Moreover, the study showed that primary repair was associated with shorter hospital stays, and was cost-effective.

In 1989, Nelken and Lewis compared 3 different scoring systems (ISS, PATI, and the Flint colon injury score) in CRI patients who had undergone either colostomy or primary repair. The authors concluded that PATI was the system most sensitive in predicting success and complications in primary repair patients.<sup>[17]</sup> In order to decrease the magnitude of confounding factor effects on outcomes, vascular injuries were excluded from the present study. Instead of PATI, surgeons regarded AAST score as a more convenient system when choosing between primary repair and ostomy. Moreover, no statistically significant differences in PATI scores were found between the ostomy and repair groups, and CRI-related or unrelated complications.

In the 1990s, primary repair rates reached 60–93% in civilian settings. As a general rule when primary repair of colon injuries is performed, patients are required to have stable vital

signs, short prehospital periods, no additional organ injuries, and no extensive peritoneal contamination.<sup>[15,18,19]</sup> Otherwise, a stoma is generally required.<sup>[20]</sup>

According to the Eastern Association for the Surgery of Trauma's 1998 guidelines, if PATI score is >25, hemodynamic instability and significant comorbidities occur. Surgeons are advised to perform colostomy for destructive colon injuries.<sup>[21]</sup> In 2003, it was demonstrated in a retrospective study that primary repair or resection-anastomosis were the most viable treatment options in normotensive patients with PATI scores <15 and minimal peritoneal contamination.<sup>[22]</sup> PATI calculations are based on operative findings and used to predict postoperative outcome.<sup>[23]</sup> Findings of the present study suggest that despite its versatility in evaluating intra-abdominal organ injuries, PATI analysis during surgical intervention is impractical. In the present study, mean PATI was 23 and 20 in ostomized and non-ostomized patients, respectively.

ISS is the anatomical scoring system most commonly used to evaluate casualties with multiple injuries.<sup>[24]</sup> However, it has been shown to be excellent only at retrospective comparison of overall injury data.<sup>[25]</sup> In the present study, mean ISS was 17.3 and 15.6 in ostomized and non-ostomized patients, respectively.

In the present study, both ISS and PATI scores were found to be inferior at determining required surgical treatment of CRI, compared to the AAST score.

Glasgow et al.<sup>[26]</sup> investigated 977 CRI cases and found that diversion rate in rectal injuries was approximately twice that in colon injuries. Similarly, rates in the present study were 90% and 36% in rectum and colon injuries, respectively.

Non-operative management of penetrating abdominal injuries has been proposed in selected cases.<sup>[27,28]</sup> Unlike civilian mechanisms of injury, however, terrorist attacks tend to cause multiple HVM-related injuries.<sup>[29]</sup> Thus, laparotomy was advocated, provided that full-thickness abdominal wall penetration had been diagnosed.<sup>[30]</sup> In the present study, 47% of casualties underwent reoperation due to CRIs and other associated injuries.

Damage control surgery has recently been extended to involve CRI.<sup>[31]</sup> Fecal diversion is traditionally performed during damage control surgery in CRI patients. The rate of damage control surgery was 17% in the present study, and a stoma was performed in 90% of these cases.

HVM-related injuries are frequently extensive, grossly contaminated, and complicated by long evacuation times. Civilian LVM injuries are not grossly contaminated and involve short prehospital periods.<sup>[32]</sup> Thus, LVM-related CRIs are amenable to primary repair.<sup>[33,34]</sup> HVM-related intestinal perforations are larger, with irregular margins. Moreover, temporary cavity-related

microvascular injury may cause ischemia and perforations. Primary repair of these injuries has higher complication rates.<sup>[35]</sup>

Limitations of the present study stem from its retrospective nature. Critical data was missing, including vital signs and blood gas analysis results obtained during hospital admittance of patients with vascular injury associated with CRIs, extent of abdominal contamination during laparotomy, and rectal and abdominal drain placement, etc. This data could have provided more insight. In addition, limited long-term follow-up data was available. Following CRI treatment, patients are invariably transferred to other clinics for specific treatment of associated (i.e. orthopedic) injuries. This is one reason the study failed to include duration of hospital stays. However, the present study included one of the largest cohorts of HVM-related CRIs in Turkey, and also focused on trends in management and outcomes.

## Conclusion

Numerous studies have demonstrated the safety of primary repair or resection-anastomosis in CRI. However, clinical significance of diversion in HVM-related CRIs remains ill defined. It was determined in the present study that stomas were associated with lower complication rates and were more frequently correlated with significantly higher AAST scores. No significant difference in stoma rates between civilian and military surgeons was found.

AAST scores seem to be a more accurate guide for selecting a treatment method of ostomy or primary repair, with a sensitivity and specificity rate of 80% and 92.9%, respectively. Accordingly, an AAST score  $\leq 2$  may indicate repair and one of  $\geq 3$  may indicate the need for ostomy.

Conflict of interest: None declared.

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## ORJİNAL ÇALIŞMA - ÖZET

### Yüksek kinetik enerjili parça tesirine bağlı kolorektal yaralanmalar: Cerrahi esnasında skorlama sistemlerinin uygulanması ve ostomi oranları üzerine etkisi

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**AMAÇ:** Kolorektal yaralanmalar halen önemli bir mortalite ve morbidite nedenidir. Çalışmanın amacı Türk cerrahların tedavi kararı konusunda American Association for the Surgery of Trauma (AAST) kolon/rektum yaralanma skoru, Injury Severity Score (ISS) ve Penetrating Abdominal Trauma Index (PATI) skorlarını kullanmaya eğilimlerini ve mevcut klinik sonuçlarını analiz etmektir.

**GEREÇ VE YÖNTEM:** Dört yıllık bir periyot içerisinde yüksek kinetik enerjili silahların neden olduğu kolorektal yaralanmalı hastaların verileri geriye dönük olarak toplandı. İlk ameliyatta ostomi açılanlar grup 1, açılmayanlar grup 2, sonradan ostomi açılanlar grup 2a ve hiç ostomi açılmayanlar grup 2b olarak belirlendi.

**BULGULAR:** Otuz dokuz (%66) hastaya ilk ameliyatta ostomi açılmış, 20 (%34) hastaya açılmamıştı. İlk ameliyatta ostomi açılmayan altı (%30) hastaya daha sonra ostomi açılırken, 14 (%70) hastaya hiç ostomi açılmamıştı. Belirgin şekilde AAST skorları yüksek olan hastalara ostomi açıldığı görüldü ( $p<0.001$ ). Fakat PATI ve ISS skorları ostomi açma konusunda belirleyici olmamıştı ( $p=0.61$ ,  $p=0.28$ ). Sivil ve askeri cerrahların ostomi oranları sırasıyla %62 ve %68 olarak bulundu ( $p=0.47$ ). Receiver operating characteristic (ROC) analizine göre AAST skorunun ostomi açma konusunda daha belirleyici olduğu görüldü.

**TARTIŞMA:** Yüksek kinetik enerjili silahlarla meydana gelen ateşli silah yaralanmalarında diversiyon halen önemini korumaktadır. Diversiyon uygulaması ve sonrasında gözlenen daha düşük komplikasyon oranları AAST skoru yüksekliği ile ilişkili bulundu.

**Anahtar sözcükler:** Askeri; kolorektal yaralanmalar; ostomi; yüksek hızlı mermiler.

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