

# Epidemiology of modern battlefield colorectal trauma: A review of 977 coalition casualties

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<b>BACKGROUND:</b>	Traumatic injuries to the lower gastrointestinal tract occur in up to 15% of all injured combatants, with significant morbidity (up to 75%) and mortality. The incidence, etiology, associated injuries, and overall mortality related to modern battlefield colorectal trauma are poorly characterized.
<b>METHODS:</b>	Using data from the Joint Theater Trauma Registry and other Department of Defense electronic health records, the ongoing Joint Surgical Transcolonic Injury or Ostomy Multi-theater Assessment project quantifies epidemiologic trends in colon injury, risk factors for prolonged or perhaps unnecessary fecal diversion, and quality of life in US military personnel requiring colostomies. In the current study, all coalition troops with colon or rectal injuries as classified by DRG International Classification of Diseases—9th Rev. diagnosis and Abbreviated Injury Scale (AIS) codes in the Joint Theater Trauma Registry were included.
<b>RESULTS:</b>	During 8 years, 977 coalition military personnel with colorectal injury were identified, with a mean (SD) Injury Severity Score (ISS) of 22.2 (13.2). Gunshot wounds remain the primary mechanism of injury (57.6%). Compared with personnel with colon injuries, those with rectal trauma sustained greater injury to face and extremities but fewer severe thoracic and abdominal injuries ( $p < 0.005$ ). Overall fecal diversion rates were significantly higher in Iraq than in Afghanistan (38.7% vs. 31.6%, respectively; $p = 0.03$ ), predominantly owing to greater use of diversion for colon trauma. There was little difference in diversion rates between theaters for rectal injuries (59.6% vs. 50%, $p < 0.15$ ). The overall mortality rate was 8.2%. Notably, the mortality rate for patients with no fecal diversion (10.8%) was significantly greater than those with fecal diversion (3.7%, $p < 0.0001$ ).
<b>CONCLUSION:</b>	Military personnel sustaining colon or rectal trauma continue to have elevated mortality rates, even after reaching surgical treatment facilities. Furthermore, associated serious injuries are commonly encountered. Fecal diversion in these patients may lead to reduced mortality, although prospective selection criteria for diversion do not currently exist. Future research into risk factors for colostomy creation, timing of diversion in relation to damage-control laparotomy, and quality of life in veterans with stomas will produce useful insights and help guide therapy. ( <i>J Trauma Acute Care Surg.</i> 2012;73: S503–S508. Copyright © 2012 by Lippincott Williams & Wilkins)
<b>LEVEL OF EVIDENCE:</b>	Epidemiologic study, level III.
<b>KEY WORDS:</b>	Colon and rectal trauma; fecal diversion; mortality; epidemiology; military.

The surgical management of multisystem trauma patients such as those seen in Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) remains highly challenging. Penetrating injuries to the lower gastrointestinal tract can be particularly difficult. Based largely on anecdotal evidence gleaned from previous conflicts, the conventional wisdom for the treatment of many battlefield colorectal injuries has remained fecal diversion with colostomy.<sup>1,2</sup> While armed conflict in the 21st century has witnessed remarkable and

rapid evolutions in tactics and weaponry, surgical dogma may be more resistant to change.<sup>3</sup> In addition, the widespread use of improvised explosive devices (IEDs) during OIF/OEF introduced a new pattern of wounding that combines aspects of both blunt and penetrating injuries.<sup>4</sup> The clinical course of these devastating injuries has not been documented, and potential exists to improve care through investigation of their natural history.

Whereas colon trauma was once considered an essentially fatal event, contemporary civilian mortality rates are declining, while the use of either primary repair or resection/anastomosis continues to increase.<sup>3</sup> For the most severely injured patients, damage-control surgery, with its emphasis on controlling fecal spillage, stopping hemorrhage, and aggressive and timely patient resuscitation, has been applied successfully in both the combat and civilian arenas.<sup>5,6</sup> However, aside from single-institution studies, the epidemiology, management, and outcomes of military-related colorectal injury have been poorly characterized.<sup>7–10</sup> How the relatively newer techniques of battlefield damage-control surgery relate to the well-established practice of fecal diversion is unknown. Going

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forward, the impact on quality of life and activities of daily living that a permanent stoma imposes on injured military personnel must be fully investigated. As a preliminary step toward answering these questions, the current study reports on the epidemiology of colorectal trauma resulting from OIF/OEF, with a basic investigation of related injuries patterns, the use of fecal diversion for specific injuries, and overall mortality.

## PATIENTS AND METHODS

The Joint Theater Trauma System was developed as a systematic and integrated approach to better organize and coordinate battlefield care.<sup>11</sup> Under the auspices of the Joint Theater Trauma System, the Joint Theater Trauma Registry (JTTR) is maintained by the US Army Institute for Surgical Research as a repository for near-real-time data collection on coalition casualties. Data are entered by trained research nurses at both forward deployed locations and the major referral medical centers. The JTTR captures benchmark data on mechanism, diagnosis, and therapeutics with the purpose of improving combat casualty care.<sup>12</sup>

The Joint Surgical Transcolonic Injury or Ostomy Multi-theater Assessment (J-STOMA) project is an ongoing initiative to examine outcomes from OIF/OEF specific to colorectal injury. Using both retrospective and prospective techniques, J-STOMA will focus predominantly on (1) epidemiology of wartime injuries to the colon, rectum, and anus; (2) contemporary surgical management of the same; (3) modern indications for fecal diversion and risk factors for nontimely ostomy reversal; (4) quality of life in injured US Service members who require fecal diversion (temporary or permanent); and (5) incidence and outcomes of massive pelvic perineal wounding patterns that are frequently observed following IED blast. The J-STOMA database was initially populated using data from the JTTR to maximally identify all combatants with colorectal, anal, or massive perineal trauma (as outlined later). However, other federal electronic health records will supplement these data, including the Patient Administration Systems and Biostatistics Activity, the Armed Forces Health Longitudinal Health Application, and the Theater Medical Data Store databases. J-STOMA was approved by the institutional review board for the US Army Medical Research and Materiel Command and is conducted within the US Army Institute for Surgical Research.

For the current report, the J-STOMA database was queried for all colon and/or rectal injuries using DRG International Classification of Diseases—9th Rev. diagnosis codes (863.4x, 863.5x) and military Abbreviated Injury Scale (AIS) codes with a severity modifier of 2 or greater. Anal and complex pelvic perineal injuries were excluded and will be reported separately. Dates of interest were from January 2003 to March 2011. The study population consists of all coalition military personnel, including US service members, North Atlantic Treaty Organization (NATO) military personnel, and host-nation (non-NATO) military forces. The latter group includes troops such as the Iraqi and Afghan National Armies, police, and security forces. Civilian casualties and prisoners of war were excluded. In addition, casualties killed in action or dead on arrival to a medical treatment facility are not included.

When possible, specific anatomic location of the colon injury was gleaned from DRG International Classification of Diseases—9th Rev. codes; however, these data were incomplete. For the purposes of this review, patients with multiple colorectal wounds were categorized according to the most distal injured region. These data are reported in conjunction with comprehensive reviews of the literature in the Discussion section from subject matter experts.

Normally distributed data were analyzed using Fisher's exact and unpaired *t* tests as appropriate and are reported as mean (SD). Nonparametric data are reported using the median and range. A  $p < 0.05$  is considered statistically significant.

## RESULTS

### Demographics of Colorectal Wounds

A total of 977 military personnel with battle-related trauma to the colon or rectum were identified during the study period. The mean (SD) age of injured personnel was 26.1 (6.7) years. US military personnel constituted 529 of the 977 (54.1%) wounded troops overall. As shown in Table 1, Americans were significantly overrepresented in OIF relative to OEF (58.8% vs. 44.8%, respectively;  $p < 0.0001$ ).

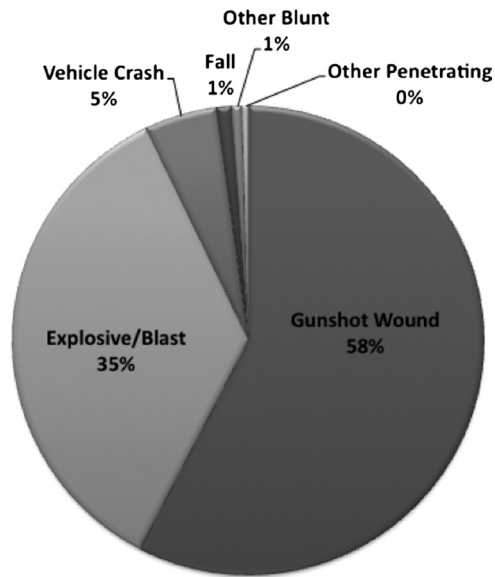
### Mechanism of Wounding

The modern patterns of injury in OIF and OEF have been well documented.<sup>4,13</sup> Despite the trend toward the blast-related mechanisms causing most battlefield trauma during the last decade, in the current series of combat-related colorectal injuries, most occurred from penetrating trauma. Gunshot wounds were the most prevalent mechanism of injury for the entire cohort, occurring in 429 (57.6%) of the 745 injured personnel with an established mechanism of injury. In the subset of non-NATO military forces, the incidence of injury caused by gunshot wounds causing colorectal injury was significantly higher at 66.2% of personnel (vs. 49.3% for NATO and American forces,  $p < 0.0001$ ). Conversely, NATO and US forces with colorectal injury were more likely to experience explosion and blast injuries compared with their non-NATO military counterparts (39.9% vs. 30.5%;  $p = 0.007$ ). The predominant mechanisms of injury in military personnel with colorectal trauma were gunshot wounds (57.6%) and explosives (35.3%). Of note, the mechanism of wounding did not significantly differ between OIF and OEF ( $p = 0.13$ ).

**TABLE 1.** Incidence of Colorectal Trauma Sustained During OIF (n = 651) and OEF (n = 326)

Personnel	Total Cohort	OIF	OEF
US Military, n (%)	529 (54.1)	383 (58.8)	146 (44.8)
Army	389	288	101
Navy	12	9	3
Air Force	7	4	3
Marines	121	82	39
NATO personnel, n (%)	61 (6.2)	7 (1.1)	54 (16.6)
Non-NATO personnel, n (%)	387 (39.6)	261 (40.1)	126 (38.7)

Non-NATO personnel consist of host-nation security forces, police, and national armies.

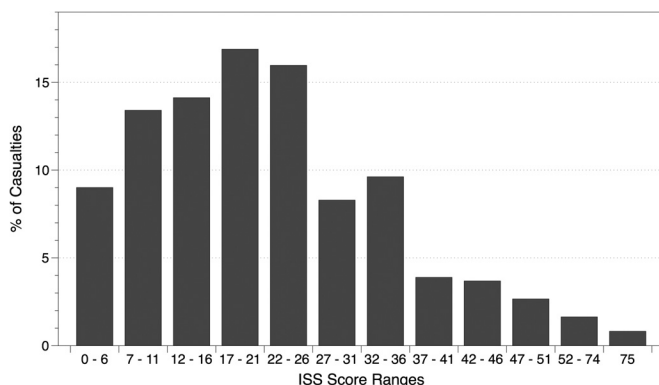


**Figure 1.** Mechanism of injury in 745 combatants with colon and/or rectal injuries.

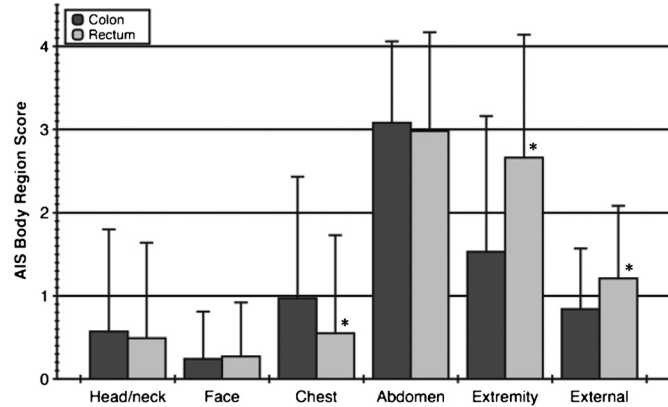
Notably, a certain subset of troops injured by explosives such as IEDs will incur both penetrating and blunt mechanisms of injury, making classification of their wounding more difficult. Even injuries that are almost unheard of in the civilian sector, such as indirect damage to a hollow viscus organ (e.g., the colon) following the transfer of high energy from a projectile, are described in wartime.<sup>14</sup> For this reason, it may be more practical to broadly categorize wounding by modality rather than penetrating versus blunt, as shown in Figure 1.

### Injury Severity and Associated Injuries

The Injury Severity Score (ISS) summarizes the severity of injury across six body regions using the anatomically focused 2005 AIS scores as its basis. For the entire cohort of combatants sustaining colon or rectal trauma (n = 977), the mean (SD) ISS score was 22.2 (13.2). Figure 2 depicts the



**Figure 2.** Distribution of ISSs among 977 military personnel sustaining colorectal injury during OIF/OEF.



**Figure 3.** AIS scores by body region for military personnel with colon (n = 494) or rectal (n = 251) injuries. Data are expressed as mean (SD). Asterisk indicates  $p < 0.0001$  versus colon injuries.

distribution of ISS scores. For reference, patients with ISS scores greater than 16 are generally considered seriously injured; a total of 620 military personnel (63.5% of the study group) met this criterion. Injury severity did not significantly differ between the OIF and OEF theaters (ISS 21.8 [12.9] vs. 22.9 [13.7], respectively;  $p = 0.25$ ). Patients with colon injuries had statistically significantly lower mean ISS scores than those with rectal injuries (21.3 [13.2] vs. 24.2 [13.3];  $p = 0.005$ ).

The mean AIS scores by each individual body region are depicted in Figure 3, and the percentages of patients sustaining AIS score of greater than 2 (serious injury) are reported in Table 2. Relative to personnel with rectal trauma, patients with colon injuries were significantly more likely to sustain concurrent serious injury to the chest (22.1% vs. 10% for rectal trauma;  $p < 0.0001$ ). Conversely, those with rectal trauma experienced greater frequency of serious injuries to the extremities (69.3% vs. 39.3% for colon trauma;  $p < 0.0001$ ) and face (6% vs. 0% for colon trauma;  $p < 0.0001$ ). Substantially more personnel sustained severe abdominal injury in the group with colon injury relative to those with isolated rectal injuries (68.2% vs. 57%, respectively;  $p = 0.003$ ). Mean AIS scores showed similar trends for colon versus rectal trauma military personnel, with higher mean scores for chest injury in personnel with colon-only trauma and greater extremity and external injury in those with rectal trauma (Fig. 3).

**TABLE 2.** Incidence of Serious (Maximum AIS Score > 2) Wounds to Each Body Region, With Respect to Either Colon (n = 494) or Rectal (n = 251) Injury

Location of Injury	Colon Injury, %	Rectal Injury, %	p
Head and neck	9.9	9.2	0.79
Face	0	6	< 0.0001
Chest	22.1	10	< 0.0001
Abdomen	68.2	57	0.003
Extremity	39.3	69.3	< 0.0001
External	5.5	8	0.20

External (Body Region 6) includes skin and soft tissue injuries.

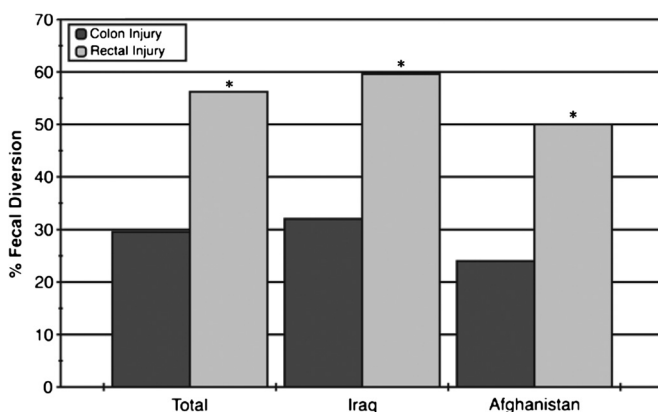
## Fecal Diversion

Fecal diversion using either colostomy or ileostomy was performed in 355 of the 977 injured combatants, for an overall diversion rate of 36.3%. Precise details about the method of fecal diversion, the timing, and the intent of the surgeon (temporary vs. permanent, indication, etc.) are not available from the JTTR data but will be forthcoming in future J-STOMA studies. The fecal diversion rate did not differ statistically among American, NATO, and non-NATO coalition forces (see Figure, Supplemental Digital Content 1, <http://links.lww.com/TA/A210>). However, the overall fecal diversion rate for colorectal trauma was significantly higher during OIF than OEF (38.7% vs. 31.6%, respectively;  $p = 0.03$ ).

As expected, fecal diversion was used more commonly for rectal than for colon trauma (Fig. 4). Notably, the overall diversion rate for rectal injuries was 56.2%, indicating that almost half of all rectal injuries were managed without diversion. Again, the severity grading for rectal injuries were not reliably reported, thus preventing detailed analysis of selection criteria for nondiversion. The rates of diversion for rectal trauma were approximately twice that for colon injury across both areas of operations. There was no statistical difference in rectal trauma diversion rates between OIF and OEF (59.6% vs. 50%;  $p = 0.15$ ).

## Mortality

Of the 977 military personnel who survived to a surgical treatment facility, there were 80 deaths for an overall mortality rate of 8.2%. The mortality rates for US (7.6%), NATO (6.6%), and non-NATO (9.3%) forces did not differ significantly. Likewise, among the 745 personnel with identifiable specific colon or rectal injury, the mortality rates did not differ based on injury location (colon, 7.1%; rectum, 8.0%). There were 13 late deaths that occurred at Level IV or V treatment facilities. As expected, the ISS of those who died was significantly higher than for the survivors (33.5 [17.6] vs. 21.2 [12.2], respectively;  $p < 0.0001$ ).



**Figure 4.** Fecal diversion rates by area of operations based on whether most distal injury was to the colon ( $n = 494$  total) or rectum ( $n = 251$  total). Asterisk indicates  $p < 0.05$  versus colon injuries.

Of the 355 patients who were treated with colostomy or ileostomy, 13 died, for a mortality rate of 3.7% among those undergoing fecal diversion. This was significantly lower than the mortality rate for the nondiverted population (67 deaths [10.8%] in 622 patients,  $p < 0.0001$ ). However, ISS scores for patients who underwent fecal diversion (23.9 [12.3]) were slightly higher than those who did not undergo diversion (21.2 [13.5];  $p = 0.002$ ).

## DISCUSSION

Modern battlefield injuries are unique in many regards. Compared with civilian patients, military trauma more often involves high-velocity weaponry, blast injuries, fragmentation wounds, and burns.<sup>15</sup> Combined with supply limitations, remote locations, and the more frequent need to transport injured soldiers on prolonged evacuation routes without constant physician attention, the military surgeon has many additional considerations when deciding on the optimal management for casualties with colorectal trauma. When dealing with injuries to the colon and rectum, fecal diversion may seem a “safer” option than primary repair or anastomosis. These factors should be considered when reviewing outcomes from combat series.<sup>8</sup> The J-STOMA initiative and others like it seek to capitalize on the wealth of information with the ultimate goal of improving the surgical care of injured US soldiers, sailors, airmen, and Marines.

Contrary to some other published reports on wounding patterns OIF/OEF,<sup>4</sup> the current study found that penetrating injury from gunshot wounds is the primary etiology for colorectal trauma. Gunshot injury was even more prevalent among non-NATO military personnel (66.2% vs. 49.3% for NATO and US forces, respectively). Although conjecture, this may be secondary to the near-universal use of individual body armor by NATO and US service members, providing some measure of protection from penetrating torso injury. When colorectal trauma did occur in US military personnel, it was more likely the result of a blast or explosion than for non-NATO personnel. Nonetheless, among all subsets, gunshot wounds remain to be the predominant mechanism of wounding the colon and rectum. Additional efforts at improving personal protective gear will likely yield further reductions in colorectal trauma.

Several observations are warranted regarding patterns of injuries associated with colorectal wounding. Serious injury to the chest, defined as AIS severity modifier greater than 2, occurred more frequently in association with colon injury than rectal trauma. Conversely, patients receiving rectal wounds also were more likely to experience serious facial and extremity injuries. These wounding patterns fit with the more common mechanisms of injury, namely, blast from a ground-level IED causing rectal injury as compared with penetrating torso (chest and abdomen) trauma leading to colon injury. There was minimal variation in the wounding patterns observed for OIF and OEF in this series of colorectal trauma patients. The mean ISS of 22 is consistent with previous reports on wartime colorectal trauma patients.<sup>8,10</sup>

The decision to perform primary repair, resection and anastomosis, or diversion remains one of the most controversial in trauma. Several algorithms are in place to assist civilian

surgeons;<sup>3</sup> however, many variables that are commonly encountered are difficult to quantify (e.g., degree of primary and associated injuries, appearance of the bowel, comfort level, and experience of the surgeon). While use of primary repair techniques continue to increase in both the civilian and the combat arenas, many surgeons have resisted the adoption of newer management recommendations, despite data from more recent reports suggesting successful outcomes that are independent of the management strategy used.<sup>16,17</sup> The current study found an overall diversion rate of 36.3% for colorectal trauma, with higher rates observed during the earlier OIF conflict. There was no difference in fecal diversion rates among the various combatants, reflecting the equanimity with which non-NATO forces are treated within coalition medical treatment facilities. Rectal wounds were treated with diversion at almost twice the rate of colon injuries. We have previously reported that diversion for wartime left-sided colonic injuries remains more commonly practiced than when dealing with trauma to the right colon.<sup>9</sup>

The large difference in all-cause mortality between those undergoing fecal diversion as a component of their treatment compared with nondiverted patients was surprising (3.7% vs. 10.8%, respectively;  $p < 0.0001$ ), especially considering that the diverted group statistically had slightly higher ISS scores. The reason for this disparity is unclear. It may be that some patients in the nondiverted population underwent damage-control surgery and colorectal resection but did not survive long enough for subsequent ostomy creation or that reflex fecal diversion for patients perceived to have more severe associated injuries is a safer course of action. While primary repair is generally accepted as safe for most civilian colorectal trauma, anastomotic leak rates of up to 30% have been reported in previous modern military series, and diversion is independently associated with lower leak rates.<sup>8,9</sup> Conversely, others have reported no difference in outcomes based on initial management strategy (diversion vs. nondiversion vs. damage control).<sup>7</sup> Nonetheless, in-depth analysis of the cause of death in the nondiverted group is warranted to determine whether certain predictors can help guide surgeons' treatment decisions.

Because of the nature of the data contained within the JTTR, it is difficult to discern specific factors that might influence the combat surgeon to perform a colostomy as opposed to primary repair. Ongoing efforts using the J-STOMA database may help elucidate factors that contribute to the decision for fecal diversion. Planned analyses include multivariate modeling of patient- and surgeon-specific factors as well as examination of outcomes following fecal diversion. In addition, the influence of damage-control surgical practices and the routine use of repeated laparotomy (15–42% in several small series) also remain to be elucidated in future studies.<sup>7,9,10</sup> Moreover, startlingly scant data exist regarding soldiers' quality of life in coping with either temporary or permanent stomas. As reported previously, at least 355 military personnel have undergone fecal diversion for colorectal injury; in-depth determination of quality of life may yield areas of focus for future combat surgeons as well as facilitate the veterans' smooth transition to civilian life.

The information management systems developed during the military conflicts of the last 10 years provide the

opportunity not only to characterize current surgical management of colorectal war injuries but also to shape future clinical practice guidelines and optimize care of our injured US Service members and coalition partners. In summary, this survey of JTTR-derived data show that gunshot projectiles continue to be the primary cause of colorectal injury on the battlefield and that such trauma typically coexists with (and may serve as a marker for) serious concurrent injury. More than one third of military personnel with colorectal trauma undergoes fecal diversion. Furthermore, all-cause mortality in these seriously wounded soldiers remains more than 8%, with nondiverted patients experiencing significantly higher mortality than those treated by colostomy creation. By building on the lessons learned from such prospectively acquired data, military surgeons of the future will be better equipped to provide surgical care to the troops who inevitably will sustain wartime colorectal trauma.

#### AUTHORSHIP

S.C.G. and T.E.R. designed this study. S.C.G., S.R.S., and J.E.D. conducted the literature search. S.C.G. collected the data. All authors participated in data analysis and interpretation. S.C.G., S.R.S., and J.E.D. wrote the manuscript, which T.E.R. critically revised.

#### DISCLOSURE

The authors declare no conflicts of interest.

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