Nontherapeutic laparotomy in American combat casualties: A 10-year review

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BACKGROUND: The civilian literature has expanded the indications for selective nonoperative management (SNOM) for abdominal trauma to minimize morbidity from nontherapeutic laparotomies (NTLs); however, this treatment modality remains controversial and rare in austere settings. This study aimed to quantify the percentage of NTL and incidence of failed SNOM performed in theater and to define each of their respective intra-abdominal–related morbidities.

METHODS: A retrospective evaluation of all patients who underwent a laparotomy from 2002 to 2011 during Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) was performed for patients who survived a minimum of 24 hours. With the use of DRG International Classification of Diseases—9th Rev. procedure codes, a therapeutic laparotomy was defined by the presence of a defined intraperitoneal or retroperitoneal procedure; an NTL was defined by the absence of a defined intraperitoneal or retroperitoneal procedure. Second, patients transferred from North American Treaty Organization Role II to Role III medical treatment facilities to be operated on were deemed failed SNOM. Finally, intra-abdominal complications and mortality were identified for patients undergoing therapeutic laparotomy, NTL, and failed SNOM.

RESULTS: Blunt, burn, and penetrating injuries accounted for 38.5% (n = 490), 1.1% (n = 14), and 60.4% (n = 769) of all laparotomies in the OEF and OIF, respectively. Thirty-two percent of all laparotomies performed during the OEF and OIF campaigns were NTL; specifically, the NTL rates in OEF and OIF were 38.2% and 28.6%, respectively. In addition, 31.6% and 32.2% of all penetrating and blunt injury mechanisms resulted in an NTL, respectively. The percentage of all patients identified as failing SNOM was 7.5% (n = 95). The early intra-abdominal complication rate for failed SNOM and for all patients undergoing NTL was 2.1% and 1.7%, respectively.

CONCLUSION: The OIF and OEF combined NTL rate was 32.1%, with an associated 1.7% intra-abdominal early complication rate. The infrequent application of SNOM in a deployed military environment is likely secondary to unpredictable fragmentation trajectories and related blast injury patterns, limited medical resources including computed tomography, and a complex aeromedical evacuation system preventing serial observation. (*J Trauma Acute Care Surg*. 2014;77: S171–S175. Copyright © 2014 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Epidemiologic study, level IV.

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Mandatory military decree in 1915 stated that all penetrating abdominal wounds required laparotomy.[1] Forty-five years later, Dr. Gerald Shaftan, a civilian, is credited for introducing selective nonoperative management (SNOM) for penetrating abdominal trauma.[2] SNOM, which now encompasses both penetrating and blunt injury mechanisms, aims to minimize the morbidity associated with nontherapeutic laparotomy (NTL) while lowering health care costs through shorter hospital stays and by reducing the unnecessary use of operating room and related perioperative resources.[3] Patients undergoing SNOM are managed with admission and serial examinations and frequently discharged within 24 hours. According to Demetriades et al.,[4] 60% to 90% of blunt abdominal trauma (BAT), 30% of anterior and 67% of back abdominal gunshot wounds, as well as 50% of anterior and 85% of back stab wounds can be managed using SNOM. Professional organizations such as the Eastern Association for the Surgery of Trauma now recommend that those patients with abdominal trauma who remain hemodynamically stable during initial workup be considered for SNOM.[5] While SNOM for abdominal trauma has been studied and become widely accepted in civilian practice, the consequences of its application in a theater of war are unknown. In these circumstances, the surgeon must take into account available resources, throughput or tempo, the timing of medical evacuations for casualties, and the risk of a missed injury before deciding to use SNOM.

The purpose of this article was to quantify the US military's NTL rate, incidence of failed SNOM, associated NTL, and failed SNOM-related intra-abdominal complications during the 10 years of war in Afghanistan and Iraq. We hypothesize that the combined rate of NTL in US military casualties in Operation Enduring Freedom (OEF), Afghanistan, and Operation Iraqi Freedom (OIF),

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Iraq, is higher than that reported in civilian trauma patients because of the decreased use of SNOM in the deployed setting for the reasons stated earlier. Because of the greater distances and time required for patient transport between facilities in Afghanistan as compared with Iraq as well as a more robust medical evacuation system in Iraq, we hypothesize that the NTL rate in OEF will be higher than in Iraq (OIF). Lastly, as a result of fewer resources and the potential for the number of casualties overwhelming smaller Role II facilities, we hypothesize that the NTL rate at a North American Treaty Organization (NATO) Role II medical treatment facility (MTF) will be higher than at a NATO Role III MTF.

PATIENTS AND METHODS

This is a retrospective analysis of US military personnel wounded in OEF and OIF from March 2002 to September 2011. This information was obtained from the Joint Theater Trauma Registry and Patient Administration Systems and Biostatistics Activity (PASBA). PASBA is the Army Medical Department's executing agency for the Military Health System Data Quality Management Control Program that aims to enhance clinical outcomes.[6] The Joint Theater Trauma Registry is a computer application used by deployed tri-service nurse coordinators to collect battlefield injury demographics, care, and outcomes.[7] These two sources were queried for all American military personnel who underwent a laparotomy in OEF and OIF at a NATO Role II or III MTF who survived 24 hours. NATO Role II MTFs include basic primary care with limited surgical capabilities and two operating rooms, inclusive of a 20-person team including three general surgeons and one orthopedic surgeon.[8] NATO Role III MTFs are the highest level of trauma care in theater with capabilities approaching a Level I civilian trauma center including capacity for a 248-bed hospital with six operating rooms. Data analysis yielded the subject's laboratory data, vital signs, and overall blood product use. Total blood product use was used as an internal verification of appropriately separating patients undergoing therapeutic laparotomy (TL) versus NTLs. DRG International Classification of Diseases—9th Rev. (ICD-9) procedure and complication codes were used to quantitatively and geographically identify TL versus NTL in addition to the number and type of intra-abdominal complications. A TL was defined as a laparotomy performed concomitantly with an ICD-9 procedure code confirming that an intraperitoneal or retroperitoneal intervention was performed on a specific anatomic structure (e.g., ICD-9 code 41.5 for total splenectomy). For instance, a laparotomy incision to perform a pericardial window or to decompress a documented abdominal compartment syndrome was considered TL. In contrast, an NTL was defined as a patient who underwent a laparotomy and had no ICD-9 procedure code for a specific intraperitoneal or retroperitoneal anatomic structure. Thirty-four patients with an ambiguous ICD-9 code in the absence of additional intraperitoneal or retroperitoneal procedures were excluded from data analysis. For example, ICD-9 codes 38.88, "Other surgical occlusion of vessels, lower limb arteries," and 38.89, "Other surgical occlusion of vessels, lower limb veins" were removed secondary to the inability to guarantee that proximal vascular control was obtained at the common or external iliac arteries through laparotomy incisions instead of obtaining at the common or superficial femoral arteries.

Failed SNOM was defined as patients managed nonoperatively at a NATO Role II MTF that subsequently underwent laparotomy at a NATO Role III MTF. We identified patients with documented NATO Role II ICD-9 codes without an ICD-9 procedure code for an intraperitoneal or retroperitoneal operative procedure or exploratory laparotomy at a Role II MTF who subsequently underwent laparotomy at a NATO Role III MTF confirmed by identifying operative intraperitoneal or retroperitoneal or exploratory laparotomy ICD-9 procedure codes at a Role III MTF. Strictly intra-abdominal complications and overall theater discharge status were identified for these patients.

The data were collated on a Microsoft Excel (Microsoft, Redmond, WA) spreadsheet, and SAS software (Cary, NC) was used to perform all statistical analysis. Categorical data were analyzed using a χ^2 test, Mantel-Haenzsel test, or Fisher's exact data analysis juxtaposing all TL versus NTL demographic information to evaluate for significance. All continuous data are presented as medians with interquartile ranges (IQRs), and *t* test or Wilcoxon test were used for statistical comparisons. A *p* value of less than 0.05 was considered significant.

RESULTS

From March 2002 to September 2011, 1,273 US military personnel underwent laparotomies in OIF and OEF that met inclusion criteria for analysis, and 32.1% (n = 408) were judged to be an NTL. The baseline demographics are listed in Table 1. The NTL rates in blunt, penetrating, and burn trauma were 32.2% (n = 158), 31.6% (n = 243), and 50% (n = 7), respectively.

TABLE 1. Baseline Demographics of the NTL Versus the TL Group

	NTL (n = 408)	TL (n = 865)	*p*
Sex, male	98.3%	98.2%	0.867
Geographic location			0.0004
OEF	42.9%	32.7%	
OIF	57.1%	67.3%	
NATO role			0.094
Role II	18.9%	23.1%	
Role III	81.1%	76.9%	
Injury pattern			0.341
Blunt	38.7%	38.4%	
Burn	1.7%	0.8%	
Penetrating	59.6%	60.8%	
Dominant injury causes			0.784
Explosive device	67.2%	63.6%	
Bullet/gunshot wound/firearm	22.1%	27.3%	
Motor vehicle collision	4.2%	4.5%	
Discharge status, alive	99.0%	98.6%	0.543
Age	24 (21.0–28.5)	24 (21.0–28.0)	0.49
ISS	19 (10.0–27.0)	25 (17.0–34.0)	<0.0001
AIS score (abdomen)	2.0 (2.0–3.0)	3.0 (3.0–4.0)	<0.0001
ED Glasgow Coma Scale score (total)	15.0 (3.0–15.0)	14.0 (3.0–15.0)	0.48

Values reported in median (IQR 1–IQR 3).

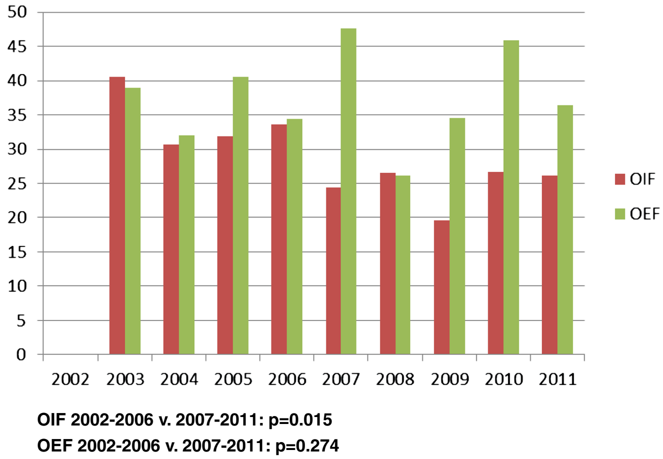

Figure 1. Percentage of NTLs by year: OEF versus OIF.

Specifically, the NTL rate in explosive device and bullet/gunshot wound/firearm was 33.3% (n = 274) and 27.6% (n = 90), respectively (0.0676). The yearly NTL percentage breakdown comparison of OEF and OIF is documented in Figure 1; the OIF TL rate from 2002 to 2006 compared with 2007 to 2011 increased from 67% to 75% (p = 0.01), while OEF TL rate decreased from 64% to 59% (p = 0.27). Patients' initial laboratory and vital signs are found in Table 2; a higher maximal heart rate and base deficit were identified in the TL group compared with the NTL group. Total blood product resuscitation is found in Table 3; patients undergoing TL had higher overall blood product use compared with patients undergoing NTL. Table 4 reports all documented intra-abdominal ICD-9 complication codes for both groups, with an overall intra-abdominal complication rate identified in the NTL group of 1.7%.

Failed SNOM occurred in 95 patients with 70.5% (n = 68) resulting in TL; 69.5% (n = 66) were associated with an explosive device. Documented injuries to the gastrointestinal tract (i.e., colon, small intestine, and stomach) and spleen were identified in 49.2% (n = 33) and 41.8% (n = 28) of patients undergoing TL, respectively. Failed SNOM resulted in a 2.1% (n = 2) intra-abdominal complication rate; two patients experienced abdominal compartment syndrome at the NATO Role III MTF. The overall mortality for failed SNOM was 1.1% (n = 1).

TABLE 2. Vital Signs and Laboratory Data for the NTL Versus the TL Group

Vitals/Laboratory Data	NTL	TL	*p*
ED SBP (range)	122 (105 to 138)	114 (99 to 130)	<0.0001
Maximum ED heart rate (range)	103.5 (86 to 122)	109.5 (90 to 127.5)	0.02
ED INR	1.2 (1.0 to 1.4)	1.2 (1.0 to 1.4)	0.19
ED HCT	36.3 (31.0 to 41.3)	35.1 (30.7 to 40.8)	0.56
ED blood gas pH	7.35 (7.29 to 7.40)	7.32 (7.25 to 7.38)	0.70
Minimum ED base deficit	−2.0 (−5.0 to 0.0)	−3.0 (−6.0 to 0.0)	0.02

Values reported in median (IQR 1–IQR 3).
ED, emergency department; HCT, hematocrit; INR, international normalized ratio; SBP, systolic blood pressure.

TABLE 3. Blood Product Resuscitation for the NTL Versus the TL Group

Blood Products (Total Resuscitation)	NTL	TL	*p*
PRBC (total)	2.0 (0–9.0)	5.0 (1.0–13.0)	<0.0001
Platelets (total)	0 (0–1.0)	0 (0–2.0)	0.0002
Cryoprecipitate (total)	0 (0–0)	0 (0–2.0)	0.0001
Plasma (total)	2.0 (0–8.0)	4.0 (0–10.0)	<0.0001

Values reported in median (IQR 1–IQR 3).
PRBC, packed red blood cell.

DISCUSSION

This study documents the largest series of laparotomies during contemporary warfare, demonstrating an NTL rate of 32.1% with an associated short-term intra-abdominal morbidity of 1.7%. The NTL rate in blunt and penetrating trauma was essentially the same at 32% for each mechanism. Divided by region of conflict, the NTL rate in OEF and OIF were 38.2% and 28.6%, respectively (p < 0.01). By treatment location, the NTL rate at Role II and III MTFs was 27.1% versus 32.4% for Role III MTFs (p = 0.09). Failed SNOM occurred in 95 patients with an associated 2.1% short-term intra-abdominal morbidity.

In 1995, Renz and Feliciano[9] demonstrated that in a civilian population, 27.1% of all trauma laparotomies were nontherapeutic and therefore unnecessary compared with a 2012 publication by Schnüriger et al.[10] demonstrating an NTL rate of 3.9% in 1,871 patients. Although the civilian literature illustrates increasing adoption of successful SNOM resulting in lower rates of NTL, the military NTL remains much higher at 32.2%, perhaps because of a lower threshold for laparotomy by military surgeons treating soldiers with blunt abdominal injury from explosive devices, an injury mechanism uncommon in civilian practice. Previous military studies by Morrison et al.[11] and Beekley et al.[12] assessing NTL rates in Iraq and Afghanistan found an NTL rate of 20.8% in Iraq and 14% in Afghanistan, which is lower than our NTL rate of 32.1%. Both authors included data only from NATO Role III MTFs; however, our study found no significant difference in the rate of NTL between NATO Role II and Role III MTFs (27% vs. 32%, p = 0.09).

TABLE 4. ICD-9 Complication Codes for NTLs

Complication: ICD-9 Code	NTL	TL	*p*
Abdominal compartment syndrome (code 22)	0 (0%)	47 (5.4%)	**<0.0001**
Dehiscence/evisceration (25)	0 (0%)	1 (0.1%)	1
Evisceration (code 30)	0 (0%)	1 (0.1%)	1
Ileus (code 40)	4 (1.0%)	5 (0.6%)	0.479
Intra-abdominal abscess (code 41)	1 (0.2%)	0 (0%)	0.321
Postoperative hemorrhage (code 53)	2 (0.5%)	10 (1.2%)	0.357
Wound infection (code 66)	0 (0%)	6 (0.7%)	0.185

Percentage, normalized percentages.

Our data show that the NTL rate in Afghanistan (OEF) was significantly greater than in Iraq (OIF) at 38.2% versus 28.6% ($p = 0.01$). Notably, the overall TL rate in OIF increased to 75% in 2007 to 2011 from 67% in 2002 to 2006. This difference in NTL may be attributed to the experience gained in OIF over time. Second, peak NTL years of 2007 (47.6%) and 2010 (45.9%) in OEF may be reflective of increased fighting intensity in Afghanistan, during which a surgeon's threshold to operate may be lower because of large numbers of casualties requiring a faster pace of evacuation that makes close observation more difficult. Third, the increased use of improvised explosive devices (IEDs) within OEF, which results in a more unpredictable fragmentation injury pattern and blast effect, may have increased the NTL rate. Lastly, the rugged terrain and inclement weather in Afghanistan affecting patient holding and prolonged evacuation times may have contributed to a lower threshold to perform a laparotomy.

SNOM remains a controversial practice while in an austere environment. We identified 95 military personnel who potentially underwent SNOM at a NATO Role II MTF and were then subsequently operated on at a NATO Role III MTF, with 44% experiencing BAT. The application of SNOM for BAT within OIF and OEF may reflect the US military's changing approach to BAT compared with previous military conflicts. The original Joint Theater Trauma System Clinical Practice Guideline in 2004 for BAT permitted SNOM of hemodynamically stable patients with a negative Focused Abdominal Sonography for Trauma (FAST) result.[13] However, in 2008, the Clinical Practice Guideline acknowledged that BAT with a positive FAST result could be managed via SNOM in some circumstances.[14] Although a portion of these 95 casualties may represent missed intraperitoneal or retroperitoneal injuries at a NATO Role II MTF, we surmise that the majority underwent SNOM for blunt and penetrating abdominal injuries through a conscious decision by the provider at the NATO Role II MTF. Although this study does not answer the total number of patients undergoing SNOM in OIF and OEF, it demonstrates that failure of SNOM resulted in comparable overall morbidity and mortality between NTL and TL groups. Future investigation into a broadened application of SNOM in an austere environment is warranted.

Overall, the increased rate of NTL in a theater of war compared with the civilian environment is likely multifactorial: the absence of a computed tomography (CT) scanner at NATO Role II facilities, fragmentation injuries from IEDs, limited medical resources, complex aeromedical evacuation system, tempo of concurrent operations, and unknown consequences of SNOM in the austere combat environment where multiple transitions of care occur frequently. First, the absence of a CT scanner at NATO Role II facilities diminishes the surgeon's ability to evaluate IED and gunshot intraperitoneal or retroperitoneal trajectories vital to SNOM decision making. For example, Eastern Association for the Surgery of Trauma recommends abdominopelvic CT as Level II evidence in patients initially managed nonoperatively. Second, limited medical resources, high tempo of some military operations, and unpredictable medical evacuation may make serial abdominal examinations difficult and prompt earlier laparotomy. Third, a missed intra-abdominal injury may be devastating during the intercontinental aeromedical evacuation process from a Role III to the Role IV facility in Germany. Therefore, deployed military surgeons must be confident in their nonoperative management strategy, and any uncertainty may lower their threshold to operate. Lastly, the majority of surgeons deploying to OIF and OEF are not specialized in trauma critical care and may lack the necessary experience with SNOM to feel confident applying it. All of these factors may play a role in the deployed surgeon's decision whether to use SNOM.

We identified a short-term intra-abdominal complication rate of 1.7%, with ileus (n = 4) being the most common complication. There were no documented wound dehiscence or evisceration events during the study period. Our complication rate takes into account only the immediate perioperative period; it does not capture complications occurring at the NATO Role IV facility in Landstuhl, Germany, and at NATO Role V medical centers within the United States. Furthermore, we only include intra-abdominal complications directly related to the NTL and not extra-abdominal complications since it cannot be proven that these are a direct consequence of the NTL in patients with multitrauma. In a military cohort of NTL, Morrison et al. noted an overall early complication rate of 25%. In comparison, Renz et al. and Schnüriger et al. within their civilian studies had overall intra- and extra-abdominal complication rates of 41% and 14.5%, within their NTL subjects. Therefore, the 1.7% intra-abdominal complication rate in our study is likely underestimating the total number and types of complications in patients undergoing NTL.

This retrospective study is limited by the extraction of documented ICD-9 codes from OIF and OEF databases. For example, the complication code 53, postoperative hemorrhage, may not have been from an intra-abdominal location, as many of the patients experiencing explosive injuries may have required further surgery because of bleeding postoperatively from an extremity site, rather than their intra-abdominal incision. In addition, some of the procedures performed that defined a case as a TL may not have actually had a clinical impact, such as hepatorraphy; however, an underlying assumption of this article was that all intraperitoneal and retroperitoneal procedures were necessary to a patient's care. However, we are confident that we separated the NTL from the TL population as the Injury Severity Score (ISS), abdominal Abbreviated Injury Scale (AIS) score, base deficit, and overall blood product requirements were significantly lower in the NTL group, supporting our hypothesis that these are two different populations. Second, as stated earlier, we postulate that SNOM was intentionally used in these conflicts and that the majority of those requiring operations were a failure of SNOM and not missed injuries. Future documentation by deployed surgeons may call for SNOM category to allow for this evaluation. Third, these data represent greater than 10 years of warfare in two geographically distinct theaters of operation, and clinical practice regarding injury patterns changed during this time. Lastly, this study only includes short-term complications during the initial hospital stay at NATO Role II and III facilities and does not include their definitive care management upon evacuation to Landstuhl, Germany, or within the United States; in addition, no long-term complications of laparotomy are included within this study.

In conclusion, our analysis demonstrates an NTL rate of 32% in the deployed military setting of OIF and OEF from 2002 through 2011 with an associated short-term intra-abdominal complication rate of 1.7%. The increased NTL rate in our study compared with the results reported in the civilian literature is likely caused by a decreased use of SNOM by surgeons in a deployed setting for the reasons we have discussed. While the low short-term intra-abdominal complication rate in our NTL group may reassure a deployed surgeon who chooses laparotomy over SNOM, the effect that NTL has on extra-abdominal complications as well as the development of delayed or late intra-abdominal complications is unknown and should be considered.

AUTHORSHIP

T.A.M. contributed to the data analysis, interpretation, and production of the article. T.E.B. contributed to the data interpretation and writing. T.H. contributed to the data analysis. J.K.A. contributed to the data analysis. L.B. contributed to the study concept, data interpretation, and writing. C.W. contributed to the study concept, data interpretation, and critical editing.

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DISCLOSURE

The authors declare no conflicts of interest.

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