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Defining and predicting surgeon utilization at forward surgical teams in Afghanistan

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ABSTRACT

Background: The forward surgical team (FST) is the US Army's smallest surgical element. These teams have supported current conflicts since 2001. The purpose of this study was to determine if surgeon utilization varied at two different FSTs and to determine factors that may predict the need for a surgeon.

Method: Data from two FSTs were reviewed. A t-test was used to compare the military injury severity scores (mISS) and the revised trauma scores (RTS). χ^2 analysis was used to compare types and mechanisms of injury and to compare life- or limb-saving surgeries (LLSS) and life-saving interventions among the FSTs. Logistic regression was used to determine if mISS, RTS, physiologic parameters, or laboratory values predicted the need for LLSS or life-saving intervention.

Results: The 541st FST treated a larger volume of patients than the 772nd FST ($n = 761$ versus $n = 311$). The 772nd FST performed a significantly higher percentage of LLSS; however, absolute number of LLSS was 31 at both FSTs. The mISS among operative patients were similar, but RTS were significantly different (772nd FST = 7.28 versus 541st FST = 7.58, $P = 0.008$). The 772nd FST saw a higher percentage of motor vehicle collision and rocket-propelled grenade injuries and thoracic and neurologic injuries, and the 541st FST saw a higher percentage of blast and gunshot wound injuries and abdominal injuries. Lactate level was the most significant predictor of the need for LLSS.

Conclusion: Although percentage of surgical interventions varied between the two FSTs, the absolute number of needed surgical interventions was the same and was small. Lactate level predicted the need for surgical intervention in our population.

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1. Introduction

The history of military and civilian trauma systems is intertwined [1,2]. Civilian trauma systems have been shown to decrease mortality of injured persons [3–5]. Based on civilian data and experience, a formal military trauma system with clear objectives and requirements was established in 2005 [6]. A military trauma system must constantly be evaluated to ensure that it is supporting combat operations. Thus, it is useful to determine if any factors determine which trauma assets to use and where to place them in support of all combat operations in the theater.

The forward surgical team (FST) is the US Army's smallest surgical element. These teams have been deployed in Afghanistan since 2001 and in Iraq since 2003. Much has been previously published regarding data from individual FST deployments and from other US military surgical teams since 2001 [7–17]. In addition to these reports, outcomes of injured soldiers treated at the FST have been shown to be equivalent to outcomes of those treated at the much larger and more resource-rich combat support hospital [18].

The authors' current deployment experience suggests that FSTs and their surgeons are used to varying degrees based on location and ongoing conflict in the specific area. In addition, current triage criteria cannot accurately predict whether an immediate surgery is needed. To date, the literature does not describe this variable FST utilization from a surgical resource perspective or factors that may determine the need for a surgical versus a nonsurgical trauma capability. We hypothesize that the current utilization of FSTs varies widely in overall trauma and in surgical utilization. Thus, the primary aim of our study was to define and then quantitatively compare surgical utilization between two FSTs deployed to Afghanistan during two different time periods in order to demonstrate their variable utilization on the battlefield. The secondary aim was to determine if injury severity, physiologic parameters, or laboratory values obtained at the FST correlated with the need for surgical intervention in order to define areas for possible future prospective studies to elucidate improved triage criteria.

2. Methods

An Institutional Review Board–approved retrospective review of all admission performance improvement data for the 772nd FST and the 541st FST was conducted. These data were prospectively collected during the individual FST deployments. Demographic data including patient status, sex, and age were recorded. Physiologic variables including temperature, heart rate, systolic blood pressure, respiratory rate, and Glasgow Coma Scale (GCS) at the time of initial patient presentation were recorded. Mechanism of injury, types of injury, surgical procedures performed, and ultimate disposition were recorded. Laboratory data, including lactate, hematocrit, pH, and base deficit, were collected and recorded.

Determining FST utilization and its surgeon utilization on an ever-changing battlefield in other than qualitative terms is

difficult. To date, the literature does not quantitatively describe this resource utilization. We thus defined the following terms in order to quantify the surgical or nonsurgical utilization of an FST. A “life- or limb-saving surgery” (LLSS) is defined as a procedure done by a surgeon in an operating room that needs to be done *immediately* in order to save the patient's life or the patient's limb. For example, a LLSS would be an exploratory laparotomy for hemorrhage control for a hypotensive patient. A “life-saving intervention” (LSI) was initially described by Holcomb [19]. Here LSI is used in contrast to LLSS. It is defined as a life-saving procedure done outside of an operating room and not requiring a surgeon. An example of LSI would be the placement of a chest tube for a tension pneumothorax.

The need for LLSS or LSI was prospectively determined at the 772nd FST and retrospectively determined for the 541st FST data. (The commander of the 541st FST is an author on this paper and was present for this unit's entire deployment. Thus, he was able to make accurate determinations regarding LLSS and LSI.) Number and percentage of LLSS and LSI were calculated for the two FSTs and were compared using χ^2 analysis.

Types of injuries and mechanism of injuries were also calculated and compared between FSTs using χ^2 analysis. Mean military injury severity score (mISS) and revised trauma score (RTS) were calculated for each FST and compared using the t-test. Logistic regression using the Enter method was used to determine if the injury scores, physiologic data, or laboratory data predicted need for LLSS or LSI.

3. Results

The 541st FST treated 761 patients over the course of its deployment in 2007–2008, and 327 patients (43.0%) required at least one operation. The 772nd FST treated 311 patients, with 98 patients (31.5%) requiring an operation over its deployment in 2008–2009. A t-test showed no statistically significant differences in the survival probability rates (M) between the two locations (772nd FST: M = 0.949, SD = 0.173; 541st FST: M = 0.950, SD = 0.178; P = 0.89). Thus, both FST locations were equally effective at preventing loss of life, with survival rates of approximately 95%.

The 541st FST performed 31 LLSS (4.1%) and 88 LSI (11.6%). The 772nd FST also performed 31 LLSS but had a statistically higher percentage (10.0%), since they saw a smaller number of overall patients (P < 0.05). The 772nd FST performed less than half the number of LSI (40 versus 88), but %LSI was similar (772nd FST = 12.9% and 541st FST = 11.6%, P = ns) (Table 1).

There was a significant difference in number of patients returned to duty or placed on temporary “quarters” (temporary rest at same location followed by return to duty) between the 772nd FST and the 541st FST (56 [18.0%] versus 300 [42.2%], P < 0.05, respectively). There was also a significant difference in the number of Afghan civilians treated at the 772nd versus the 541st FST (61 [19.6%] versus 284 [37.3%], P < 0.05, respectively).

Table 1 – Comparison of life- or limb-saving surgeries and life-saving interventions between the 772nd FST and the 541st FST.

Forward surgical team	Number of trauma patients	LLSS		LSI	
		Number	Percent	Number	Percent
772nd	311	31	10.00*	40	12.90
541st	761	31	4.10*	88	11.60

* Statistically significant difference ($P < 0.05$).

By mechanism of injury, the 772nd FST treated significantly more motor vehicle collisions (13.2% versus 7.9%) and rocket-propelled grenade injuries (14.1% versus 5.6%), but the 541st FST treated significantly more blast injuries (43.6% versus 31.8%) and gunshot wounds (28.3% versus 22.2%) (Table 2). By type of injury, the 772nd FST treated significantly more thoracic injuries (13.4% versus 7.5%) and more neurologic injuries (20.7% versus 8.8%), but the 541st treated significantly more abdominal injuries (14.5% versus 8.6%) (Table 3). Additionally, the “other” category of injuries for the 772nd FST made up a large percentage of overall injuries and included superficial soft tissue injuries, inhalation injuries, ocular injuries, and those with no apparent injury on examination at the FST but requiring computed tomography scanning at the theater hospital to complete their evaluation.

The difference in mean mISS between the two FSTs approached but did not reach statistical significance for all patients treated (772nd FST mISS = 7.48 and 541st FST mISS = 6.01; $P = 0.07$). When only operative patients were included, mISS were similar (772nd FST mISS = 10.70 and 541st FST mISS = 12.04; $P = 0.35$). Also, when excluding patients who were returned to duty within 72 h, were placed on quarters, or were observed only, mean mISS were also similar between FSTs (772nd FST mISS = 8.65 and 541st FST mISS = 8.04; $P = 0.60$).

The RTS for the two FSTs showed significantly more severe injuries for the 772nd FST versus the 541st FST for all patients treated (772nd FST RTS = 7.27 and 541st FST RTS = 7.47; $P = 0.04$) and when only operative patients were included (772nd FST RTS = 7.28 and 541st FST RTS = 7.58; $P = 0.008$). However, there was no difference in RTS when using the “returned to duty” exclusion criteria as noted above (772nd FST RTS = 7.37 and 541st FST RTS = 7.26; $P = 0.38$).

The RTS and the mISS results were further analyzed using logistic regression to determine if they predicted the need for either a LLSS or a LSI in either FST individually or with data from both FSTs combined. The mISS was a slightly better predictor than RTS of the need for a LSI and LLSS at

each FST and when data from both FSTs are combined (Tables 4 and 5).

Heart rate (HR), hematocrit, pH, lactate, and base deficit were also compared using logistic regression to determine if any of these predicted the need for either LLSS or LSI. For this analysis, data from the 541st FST were not available, so results are based solely on data from the 772nd FST. The HR and lactate values were found to be predictive for both LSI and LLSS. The odds ratio for heart rate as a predictor of LSI was 1.018 (CI = 1.005–1.032, $P = 0.008$) and for predicting LLSS was 1.018 (CI = 1.004–1.033, $P = 0.014$). The odds ratio for lactate as a predictor for LSI was 1.190 (CI = 1.056–1.340, $P = 0.044$) and for predicting LLSS was 1.456 (CI = 1.250–1.694, $P < .001$). Overall, both HR and lactate predicted LSI and LLSS with statistical significance (Tables 6 and 7).

4. Discussion

All US Army FSTs have the same mission and the same basic personnel, equipment, and training. However, when deployed, even within the same theater of operations such as Afghanistan, their utilization will vary based on ongoing conflicts in the local area, number of troops and civilians involved, and the intensity of the conflicts. This leads to a wide disparity in the ultimate utilization of each FST. Such is the case with the two FSTs discussed in this paper. In the same way, severity of injury and need for immediate surgical intervention may vary. By defining utilization and then comparing the utilization of two such FSTs within the same theater, we sought to quantitatively highlight this difference to provide future guidance for military commanders and medical planners.

Thus, our primary aim was to define and then quantitatively compare surgical utilization between two FSTs deployed to Afghanistan during two different time periods in order to demonstrate their variable utilization on the battlefield. The percentage of LLSS did vary between the 772nd FST and the 541st FST (10.0% versus 4.1%, respectively). Although the 772nd FST performed significantly more LLSS by percentage, the 541st FST evaluated more than twice the total number of trauma patients (311 patients versus 761 patients, respectively). Thus, the absolute number of LLSS performed was the same (31 LLSS each), but the percentage of the total number of patients evaluated varied significantly. The absolute data did not show a variable surgical utilization between these two FSTs. Each team was used for its surgical capability 31 times over a 15-mo period of deployment. This represents two necessary

Table 2 – Comparison of mechanism of injury between the 772nd FST and the 541st FST.

Forward surgical team (number of trauma patients)	Aviation crash	Blast	Burn	Fall	Gunshot wound	Motor vehicle collision	Rocket-propelled grenade	Stab	Other
772nd (311)	2.30 (7)	31.80* (99)	1.60 (5)	5.50 (17)	22.20* (69)	13.20* (41)	14.10* (44)	0.60 (2)	8.70 (27)
541st (761)	1.20 (9)	43.60* (332)	2.40 (18)	3.70 (28)	28.30* (215)	7.90* (60)	5.550* (42)	1.40 (11)	6.00 (46)

Data are given as percentage, followed by number of patients in parentheses.

* Statistically significant difference ($P < 0.05$).

Table 3 – Comparison of type of injury between the 772nd FST and the 541st FST.

Forward surgical team (number of trauma patients)	Abdominal	Extremity	Vascular	Urology	Thoracic	Head and neck	Neurologic	Burn	Other
772nd (311)	8.60* (27)	58.90 (185)	2.50 (8)	2.50 (8)	13.40* (42)	19.70 (62)	20.70* (65)	16.60 (16)	41.80* (76)
541st (761)	14.50* (110)	64.00 (487)	2.10 (16)	2.50 (19)	7.50* (57)	20.80 (158)	8.80* (67)	5.40 (41)	8.80* (67)

Data are given as percentage, followed by number of patients in parentheses.

* Statistically significant difference ($P < 0.05$).

surgical interventions per mo at each FST during their deployment. Assuming each FST had two general surgeons, this is roughly one surgery per surgeon per mo deemed life- or limb-saving.

This conclusion may be examined from two different perspectives. As military surgeons, we believe in a zero tolerance for the loss of a life or a limb in combat. These 31 surgeries were determined to be LLSS. The injured person was determined to be unable to wait to get to the next level of care for surgical intervention for fear of loss of life or limb. The decision to qualify a surgery as a LLSS was a judgment decision by a single surgeon (at the 541st FST) or by a consensus of surgeons (at the 772nd FST). Despite the data, we still do not know if a percentage of these 31 patients would have made it to the next level of care in time to undergo the required life- or limb-saving surgery, but the risk of attempting that was judged as too high. Perhaps some of these patients could have been flown directly to the theater hospital, which has the most robust trauma center capabilities in the theater of operations. The difference may have been as little as a few more min of flight time to 30 more min of flight time on a helicopter. The actual effect of this additional time on each individual injury and potential outcome is unknown.

Unfortunately, resource constraints are a commander's reality in war. Furthermore, the hazardous combat environment brings risk of injury or death to surgeons and other medical personnel. The risk of loss of medical personnel and equipment in war must be balanced against the necessity for two LLSS per mo per FST (generalizing our FST data for this example) in the setting of limited surgical resources (personnel and equipment) to ensure the success of the overall military mission. Maintaining some balance between a zero tolerance for loss of life and limb and the risk of combat

loss of a surgeon and surgical team in war is most definitely an extremely difficult and weighty task for military commanders. Our data expose the question of surgical utilization for further discussion, but unfortunately cannot provide definitive guidance.

For comparison, several civilian and military studies discuss timelines in relation to surgical care and mortality. The British military reviewed their data from the current war and determined that optimal care for their soldiers requires initial treatment and evacuation within 1 h, initial surgical resuscitation at a hospital within 2 h, and definitive surgical intervention within 4 h, a 1:2:4 trauma rule. These standards appear to be less strict from a time to initial care and necessary surgery perspective than that of the US military [20]. The Israelis, in contrast, discuss reaching a medical center as quickly as possible, but they have the advantage of fighting within close proximity of their civilian trauma facilities [21]. Demetriades et al. showed that mortality curves are based not only on time from injury but on injury type and severity as well [22]. The Israelis also looked at their time-to-death data in low-intensity warfare and found that 77% of deaths occur in the prehospital phase and 88% of deaths occur within 30 min of injury [23].

Larger military studies are necessary to determine whether we can modify our current timeline to needed surgery and improve surgical utilization of FSTs. FSTs are performing a large proportion of trauma resuscitations and LSI, highlighting the US Army's potential need for a nonsurgical trauma team on the battlefield. However, from our data, percentage of surgical utilization varied but absolute utilization did not vary between these two FSTs.

Our secondary aim was to determine if injury severity, physiologic parameters, or laboratory values determined the

Table 4 – Comparison of mISS and RTS as a predictor for LSI.

Forward surgical team	mISS or RTS	Odds ratio	P value	95% confidence interval
Both FSTs combined	mISS	1.085	<0.001*	1.067–1.104
	RTS	0.832	<0.001*	0.753–0.918
772nd FST only	mISS	1.099	<0.001*	1.060–1.140
	RTS	0.636	<0.001*	0.532–0.761
541st FST only	mISS	1.081	<0.001*	1.060–1.103
	RTS	1.000	0.999	0.845–1.184

* Statistically significant difference ($P < 0.05$).

Table 5 – Comparison of mISS and RTS as a predictor for LLSS.

Forward surgical team	mISS or RTS	Odds ratio	P value	95% Confidence Interval
Both FSTs combined	mISS	1.041	<0.001*	1.026–1.056
	RTS	0.855	0.017*	0.751–0.973
772nd FST only	mISS	1.056	<0.001*	1.029–1.085
	RTS	0.774	0.004*	0.651–0.920
541st FST only	mISS	1.032	0.002*	1.012–1.053
	RTS	1.012	0.933	0.762–1.344

* Statistically significant difference ($P < 0.05$).

Table 6 – Comparison of physiologic factors as predictors for LSI.

Physiologic factor	Odds ratio	P value	95% confidence interval
Heart rate	1.018	0.008*	1.005–1.032
Hematocrit	.992	0.468	0.972–1.013
pH	.998	0.972	0.881–1.130
Lactate	1.190	0.044*	1.056–1.340
Base deficit	1.033	0.119	0.992–1.077

* Statistically significant difference ($P < 0.05$).

need for surgical intervention. Our data showed that mISS was a better predictor for the need for LLSS and LSI than the RTS. However, although statistically better, the small absolute odds ratio difference for mISS in predicting the need for LSI or LLSS makes its clinical applicability unlikely.

Heart rate and lactate were found to be predictive for both LSI and LLSS. Although statistically significant, the absolute difference of the odds ratio is small. The strongest statistically significant predictor of LLSS was the lactate, with an odds ratio of 1.456 (CI = 1.250–1.694, $P < 0.001$). This difference could be clinically relevant, and lactate as a predictor for the need for LLSS should be studied in larger populations.

Several studies in the literature also discuss predictors of intervention, surgery, and mortality. Steele *et al.* reviewed the American College of Surgeons' "Major Resuscitation" criteria and found they had a variable ability to predict the need for an emergency operative procedure: gunshot wound to the neck or torso (likelihood ratio [LR] = 7.5), confirmed hypotension (LR = 5.3), interhospital transfers requiring blood transfusions (LR = 4.6), respiratory compromise (LR = 2.9), and GCS score < 8 (LR = 2.1) [24]. In a review of the military injury population in 2004, Eastridge *et al.* demonstrated an association of hypothermia with the need for an operation and an association of blood pressure, GCS, and ISS with mortality [25]. Holcomb *et al.* studied prehospital physiologic parameters in search of a predictor for the need for a prehospital life-saving intervention. He found that radial pulse character and GCS motor and verbal scores alone predicted the need for a prehospital LSI 88% of the time [19].

Two authors have studied lactate levels specifically. Vandromme *et al.* studied 2413 trauma patients over a 9-y period at a level I center and found that emergency department blood lactate level was a better predictor than either prehospital or

emergency department systolic blood pressure for the prediction of the need for greater than or equal to 6 units of packed red blood cells transfused within the first 24 h post-injury and of mortality [26]. In a recent 2011 study, Guyette *et al.* measured prehospital lactate levels in 1168 patients transported to a level I trauma center over an 18-mo period. His data showed that prehospital lactate level was significantly associated with mortality (OR = 1.23) and with surgery (OR = 1.13) [27].

Data from this study showing that lactate has a predictive value for the need for LLSS, with an OR = 1.456, compare favorably with the above studies. A larger study of the military population is needed to better determine the predictability of lactate. FSTs and other surgical teams receive patients early after injury. Perhaps lactate levels from patients at the FSTs and other surgical teams would facilitate the study of the utility of a lactate level early after injury.

This paper has several limitations. First, the sample size from both FSTs is small. Collecting these data prospectively at the FST level in theater may yield better data for evaluation of surgical utilization. A large study with aggregate FST data from the theater would be beneficial to further explore whether lactate can truly predict the need for an LLSS. If this is the case based on FST data, it would be useful to perform lactate levels with a portable monitor in the field to study whether it can add significance to current triage criteria.

Second, this study uses the honest judgment of surgeons to determine whether a surgery needed to be done at the receiving FST. There is likely an intrinsic surgeon bias in this decision, as most surgeons believe that what they are doing is necessary at that time. This could certainly have influenced the results by overestimating LLSS. This would bias this study's data to the conservative side of no difference in surgical utilization when there could have been an actual difference. A more formalized, prospective approach to determining LLSS immediately after the surgical events would be beneficial to improving data collection. Also, all surgeons at the FST should contribute to a group determination of LLSS to improve consistency of the results. That being said, overestimating the number of LLSS needed at a given location tilts the balance between saving life and limb and resource utilization in favor of the soldier, and this bias is preferred.

This study is the first to quantify surgical versus nonsurgical utilization of the FST from a resource utilization perspective with the hope of highlighting its importance, providing quantitative data for commanders and medical planners and for future research efforts. Our FST comparison found that although volume, presenting mechanisms, and percentage of surgical intervention varied between the two teams, the absolute number of needed surgical interventions was the same and was small for both teams during their deployment. Statistically and clinically, our data showed that the lactate level can predict the need for surgical intervention in our population. Further prospective data collection at the individual FST level is needed to better elucidate surgical utilization. Furthermore, aggregate data collection at the FST level and possibly on the battlefield is needed to determine if lactate can improve upon current military medical evacuation triage criteria.

Table 7 – Comparison of physiologic factors as predictors for LLSS.

Physiologic factor	Odds ratio	P value	95% confidence interval
Heart rate	1.018	0.014*	1.004–1.033
Hematocrit	.988	0.277	0.966–1.010
pH	1.128	0.206	0.936–1.360
Lactate	1.456	< 0.001 *	1.250–1.694
Base deficit	1.011	0.501	0.979–1.045

* Statistically significant difference ($P < 0.05$).

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