Prehospital Administration of Antibiotic Prophylaxis for Open Combat Wounds in Afghanistan: 2013–2014

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ABSTRACT

Background: Military operations place injured Servicemembers at high risk for open wounds. Austere environments and initial wound contamination increase the risk for infection. Wound infections continue to cause significant morbidity among injured Servicemembers. Limited evidence suggests that early antibiotic therapy for open wounds reduces infection rates. **Methods:** We obtained data from the Prehospital Trauma Registry (PHTR) from January 2013 through September 2014. This database includes data from Tactical Combat Casualty Care (TCCC) cards, Department of Defense 1380 forms, and after-action reports to provide near–real-time feedback to units on prehospital medical care. We evaluated whether patients with open wounds received antibiotics in accordance with TCCC guidelines. Low adherence was defined at less than 80%. **Results:** In this data set, overall, prefixed facility providers administered antibiotics to 54.0% of patients with an open combat wound. Of the antibiotics given, 11.1% were within TCCC guidelines. The relatively low administration and adherence rates persisted across subgroup analyses. **Conclusion:** Overall, relatively few patients with open combat wounds receive antibiotic administration as recommended by TCCC guidelines. In the group that received antibiotics, few received the specific antibiotics recommended by TCCC guidelines. The development of strategies to improve adherence to these TCCC recommendations is a research priority.

KEYWORDS: *prehospital; antibiotics; wound; prophylaxis; combat; emergency; tactical; casualty*

Introduction

Battlefield wounds from blast and high-velocity projectiles are often complex and heavily contaminated with soil, weapon fragments, or debris from other casualties, placing them at high risk for infections.[1] Wound infections continue to cause significant morbidity in injured Servicemembers and is the leading cause for fracture nonunion and limb amputation.[2]

The wound patterns and mechanisms currently seen in Operation Iraqi Freedom and Operation Enduring Freedom differ from those in prior conflicts, most notably because of the dramatic increase in blast injuries, most commonly from improvised explosive devices (IEDs). These operations have had the highest proportion of blast injuries seen in any large-scale conflict. The current injury patterns for combat wounds include head and neck (34%), thorax (6%), abdomen (11%), and extremity (54%).[3] The majority of combat wounds primarily result in injury to the extremities.[3] Blast mechanisms often result in severe orthopedic injuries and open wounds.

Studies of open tibial shaft fractures sustained during Operation Iraqi Freedom and Operation Enduring Freedom found infection rates of 23% to 27%, with approximately 22% ultimately requiring amputation. In several studies, *Staphylococcus aureus* was the most common organism contributing to recurrent infection.[2,4] However, studies also have reported isolation of multidrug resistant gram-negative organisms, notably *Acinetobacter calcoaceticus-baumannii* complex, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, from the wounds of Operation Iraqi Freedom and Operation Enduring Freedom casualties.[5] Although there was no association between injury severity and degree of bone loss in these studies, there was an association between infection and bone loss.

It is common practice to give antibiotic prophylaxis to patients with open fractures. Early prophylactic antibiotic administration in contaminated orthopedic injuries is especially important; clinical and preclinical models have shown reduced infection rates and development of osteomyelitis with antibiotic administration within 3 hours compared with after 3 hours.[6,7] Limited evidence from military studies suggests that early antibiotic administration for open combat wounds reduces infection rates.[8,9]

Battlefield first responder (BFR) is the first phase of out-of-hospital care and encompasses a brief but high-impact phase of self-aid and buddy aid. All deploying Soldiers receive training in BFR before deployment and aid bags are equipped with all the necessary equipment and medications to successfully follow Tactical Combat Casualty Care (TCCC) guidelines for the BFR stage. TCCC encompasses BFR and the entire gamut of prehospital care in the tactical setting. The current TCCC recommendations for antibiotic administration include 400mg

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of moxifloxacin orally for all patients with penetrating eye trauma or other open combat wounds who are able to take oral medications. For patients with penetrating eye trauma or open combat wounds unable to take oral medication (owing to, for example, shock, unresponsive, or abdominal injury), TCCC guidelines recommend ertapenem 1g IV or IM once daily.[10,11]

The current TCCC guidelines have made recommendations for the use of antibiotic medications for the prehospital providers at the point of injury. Prehospital provider adherence with this recommendation is unclear. The aim of this study was to evaluate adherence to TCCC guidelines for prehospital medication administration, specifically for antibiotics for open wounds and penetrating eye trauma.

Methods

Project Design

We used the Prehospital Trauma Registry (PHTR) to obtain the prehospital data. We submitted an institutional review board protocol; obtained the data in a de-identified manner; and the study was determined to be institutional review board exempt.

Data Acquisition

We obtained data from the PHTR within the Joint Trauma System (JTS) from January 2013 through September 2014. We included all records with open wounds entered in to the PHTR during that time with data available. These records were from casualties in Afghanistan during Operation Enduring Freedom.

PHTR Description

The JTS PHTR is a data collection and analytic system designed to provide near–real-time feedback to commanders. The primary purpose of this system is to improve casualty visibility, augment command decision-making processes, and direct procurement of medical assets. In addition, this system seeks to improve morbidity and mortality rates through performance improvement in the areas of primary prevention (i.e., tactics, techniques, and procedures) and secondary prevention (i.e., personal protective equipment), and tertiary prevention (i.e., casualty response system and TCCC). Central Command and their JTS capture all prehospital trauma care provided on the ground by all Services in the Afghanistan Theater. TCCC cards, Department of Defense 1380 forms, and TCCC after-action reports provide the registry data.

Results

From January 2013 through September 2014, there were 737 casualties. Of these, 24 were killed in Action, five were dead on arrival, and three were enemy prisoners of war; data from these casualties were excluded. Of the remaining 705 casualties with available records, 643 (91.2%) had battle injuries, and there were 550 with a documented open wound, including penetrating eye injury, other penetrating trauma, amputation, laceration, degloving, or gunshot wound (Table 1). Within the 550, 30 (5.5%) had a concomitant penetrating eye injury. Four of the 30 (13.3%) were noted to have bilateral eye wounds. Of the 550 casualties with documented open wounds, 93 (16.9%) were conventional forces, 100 (18.2%) were Special Operations Command forces, 323 (58.7%) were Afghan-component forces (e.g., military, policy), and 34 (6.2%) were civilian or unknown. Table 2 outlines the causes of the injury. There were 327 total instances of antibiotic administration (Table 3). Given that many of these injuries were the result of polytrauma, we were unable to perform an analysis based on the etiology of the injury or the injuries sustained.

TABLE 1 *Injuries Sustained*[a]

Injury Type	No. (%)
Amputation	61 (11.1)
Degloving	6 (1.1)
Gunshot wound	273 (49.6)
Laceration	150 (27.3)
Peppering	87 (15.8)
Puncture wound	79 (14.4)

[a]N = 550; however, summation of injuries is >550 because of polytrauma.

TABLE 2 *Injury Etiologies*

Etiology	No. (%)
Vehicle collision	15 (2.7)
Explosive	255 (46.4)
Gunshot wound	266 (48.4)
Other	14 (2.5)

Discussion

Overall, we found low percentages of patients with open combat wounds who received prehospital antibiotics. Most of the antibiotics provided were not those recommended in the TCCC guidelines (Table 4). These findings appeared to persist across all subgroup analyses.

In a previous report, we highlighted low TCCC adherence rates for pain management.[12] Based on the current data set, it appears that the same challenge exists with antibiotic administration. We suspect the reasons for this challenge are multifactorial and may include limitations in initial training and skills sustainment. Unpublished data suggest that US Army Combat

TABLE 3 *Antibiotics Administered*

Injury	Antibiotic								
	Cefazolin	Ceftriaxone	Clindamycin	Combat wound pill pack	Ertapenem	Cephlexan	Levofloxacin	Metronidazole	Piperacillin-tazobactam
Overall, no. (%) (*n* = 327)	218 (66.7)	38 (11.6)	5 (1.5)	20 (6.1)	13 (4.0)	1 (0.3)	5 (1.5)	4 (1.2)	23 (7.0)
Penetrating eye, no. (%) (*n* = 20)[b]	14 (70.0)	0 (0)	0 (0)	1 (5.0)	0 (0)	0 (0)	5 (25.0)	0 (0)	0 (0)

[a]Based on the total number of antibiotic administrations with some patients receiving more than one.
[b]The 20 doses were given to 18 patients.

TABLE 4 *Administration Rates and Adherence to TCCC Guidelines, With Subgroup Analyses*[a]

Category	Antibiotic Administered, no. (%)	Antibiotic Within TCCC Guidelines, no. (%)[b]
Overall (*N* = 550)	297 (54.0)	33 (11.1)
Unit		
CON (*n* = 93)	18 (19.4)	8 (44.4)
SOCOM (*n* = 100)	26 (26.0)	22 (84.6)
AFG (*n* = 323)	244 (75.5)	3 (1.2)
UNK (*n* = 34)	9 (26.5)	0 (0)
Injury classification		
BI (*n* = 524)	291 (55.5)	31 (10.7)
NBI (*n* = 26)	6 (23.1)	2 (33.3)
Evacuation priority[c]		
Urgent (*n* = 396)	229 (57.8)	14 (6.1)
Routine (*n* = 43)	13 (30.2)	5 (38.5)
Priority (*n* = 89)	49 (55.1)	12 (24.5)
Provider level[d]		
NMFR (*n* = 35)	0 (0)	0 (0)
Medic (*n* = 169)	35 (20.7)	24 (68.6)
Medical officer (*n* = 334)	245 (73.4)	6 (2.4)

AFG, Afghan; BI, battle injury; CON, conventional; NBI, nonbattle injury; NMFR, nonmedic first responder; SOCOM, Special Operations Command.
[a]When sufficient data were available.
[b]Percentage of no. given in column 2.
[c]n = 22 excluded owing to no documented evacuation status.
[d]n = 35 excluded owing to no documented provider at any point.

medics do not maintain their skills in garrison.[13] However, with low rates (i.e., less than 80%) even with involvement of medical officers, we suspect training deficits may extend beyond just point-of-injury providers. With the change in evacuation doctrine with less clearly delineated evacuation schemes, more prolonged field care, and more potential for delayed evacuation directly to fixed facilities, implementation of more targeted prehospital interventions at or near the point of injury and en route is required to ensure early intervention. With this nondoctrinal evacuation model being more widely used, there is an accompanying need to increase providers' proficiency in performing prehospital procedures and interventions.

Many surgeons rely upon cefazolin administration in the preoperative setting, because of its efficacy on bacteria commonly encountered in surgery and postoperative infections.[14] Cefazolin is cited as the antibiotic of choice in Emergency War Surgery and the Joint Theater Trauma System Clinical Practice Guidelines for all nonocular penetrating wounds, with primary reason cited being the relatively narrow spectrum of coverage for the common wound infection risks.[14,15] That cefazolin recommendation for prehospital administration differs from the TCCC guidelines, which recommend oral moxifloxacin, cefotetan IV or IM, or ertapenem, if the patient is unable to take medications orally. This difference is primarily related to field-stability challenges. However, the lack of uniformity may create confusion among the Combat medics supervising providers.

It is worth noting there was no documented use of cefotetan, despite its placement in the TCCC guidelines. It is unclear why this occurred. There has been a concern among the Committee on TCCC regarding the length of the guidelines. It is possible, that due to the TCCC guideline length and repetitive nature, that it becomes lost in the details. Another possibility is that because ertapenem is readily available in the Central Command area of responsibility, it is used more often. Limited access and higher costs of cefotetan may also help explain why providers instead rely on cefazolin.

Based on the data from this analysis, we recommend the following actions:

1. Pursue additional field-care training in antibiotic indications and administration among Combat medics and forward medical providers.
2. Equip medics with preloaded, Carpuject-style (Pfizer, https://www.pfizerinjectables.com), administration devices to simplify antibiotic administration in the complex, tactical setting.
3. Develop a uniform recommendation for prehospital and Role 1 wound prophylaxis across the TCCC guidelines, JTS Clinical Practice Guidelines, and Emergency War Surgery to reduce confusion.
4. Standardize all sets, kits, and outfits to match the most up-to-date TCCC guidelines. Updating the sets, kits, and outfits must be fluid and easily modifiable to meet changes as they occur.
5. Equip healthcare providers with antibiotics based on the TCCC guidelines rather than the discretion of the supervising provider (e.g., brigade surgeon).
6. Collect long-term data evaluating outcomes as a result of prehospital antibiotic administration and re-establish the PHTR.

Limitations

The primary limitation of our study lies in limited data capture. The prehospital battlefield setting poses unique challenges for clinical investigation.[16] The combat environment is chaotic and many units coordinate and participate in the management of a combat casualty. In 2012, the Department of Defense created the PHTR, which sought to fill the gap in missing data on patients before they reach a fixed facility.[15] However, given the challenges of proper documentation in combat situations, the data may be incomplete and not truly reflect what happens at the point of injury. We will publish a more extensive evaluation of documentation deficits separately.

Second, the databases are not all inclusive and thus we may have missed some patients. However, it is unlikely that the number of patients not included would have caused major changes in our findings. In addition, we have attempted to describe the data in as much detail as we can, based on the database. Unfortunately, the database has significant limitations, so it is not always clear who the source is and we are required to make some inferences.

Conclusions

Overall, relatively few patients with open combat wounds receive antibiotic administration as recommended by TCCC guidelines. In the group that received antibiotics, few received the specific antibiotics recommended by TCCC guidelines. The development of strategies to improve adherence to these TCCC recommendations is a research priority.

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Disclosures

The authors have indicated they have no financial relationships relevant to this article to disclose.

Author Contributions

SGS is the principal investigator and is responsible for the overall project through publication. ADF, KAS, CWC, RC, JDF, and JAP assisted with data interpretation, manuscript development, manuscript edits, and publication. MDA assisted with project conceptualization, data interpretation, manuscript edits, and publication.

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