MILITARY MEDICINE

THE EFFECT OF SYSTEMIC ANTIBIOTIC PROPHYLAXIS AND WOUND IRRIGATION ON PENETRATING COMBAT WOUNDS IN A RETURN-TO-DUTY POPULATION

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ABSTRACT

Background. Systemic antibiotic prophylaxis (SAP) for combat wounds is controversial. Current military practice favors its use, despite scant supporting evidence. **Objective.** To analyze outcomes of combat casualties returned to duty after initial wound care for penetrating trauma, comparing infection rates based on whether SAP was administered and whether wounds were irrigated. Setting: Forward operating base in Central Iraq, with units engaged in urban combat. **Methods.** This was a retrospective cohort study using field medical records. Wound mechanism, location, antibiotic use, and clinical course were abstracted. Subjects were excluded if injuries were isolated burns or eye trauma or if follow-up was not documented. Statistical analysis: Contingency table analysis, Fisher's exact test, and odds ratios were used. **Results.** Fifty-eight eligible cases were identified; five were excluded for incomplete follow-up (four) or confounding injuries (one). Of the remaining 53 cases, 43 included receipt of SAP (81%). Wound mechanisms and anatomic locations were comparable between groups. Infections developed within 48 hours in 7% of the SAP cases versus 40% without SAP (*no SAP*); odds ratio 0.11 (95% confidence interval [CI] 0.02 to 0.57); number needed to treat (NNT) 3 (95% CI 2 to 14). Forty-four subjects received wound irrigation (83%). Infections developed within 48 hours in two (4.5%) irrigated cases versus five (55%) without irrigation (*no irrigation*); odds ratio 0.04 (95% CI 0.006 to 0.24); NNT 2 (95% CI 1.4 to 4.7). Further 4×2 contingency table analysis yielded wound infection rates as follows: no SAP/irrigation, 17%; SAP/no irrigation, 40%; SAP/irrigation, 2.6%; no SAP/no irrigation, 75% (Fisher's exact $p < 0.0005$).**Conclusions.** We detected independent and combined associations among SAP, irrigation, and significantly decreased wound infection rates. Effects of SAP and irrigation may be synergistic. Copious irrigation with potable water or sterile isotonic solution should be performed at the earliest practical juncture after a wound occurs. SAP should be administered if irrigation cannot be performed, and may be warranted in addition to irrigation for complex or contaminated wounds or if expeditious return to duty is required. Larger epidemiologic studies are needed to validate our findings. **Key words:** antibiotic prophylaxis; penetrating trauma; military medicine; war; wound infection; wound irrigation

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INTRODUCTION

Wound care is a fundamental component of medical practice and impacts a wide range of specialties. While its use is still common in clinical practice, systemic antibiotic prophylaxis (SAP) in most uncomplicated and acute soft-tissue injuries has been demonstrated to offer no clinical benefit over aggressive irrigation and appropriate topical wound care.[1,2] Despite this observation, some special circumstances may indicate the need for SAP, such as immunocompromised patients, bite wounds, open fractures, and extensive delay prior to initial treatment.[3]

Based primarily on expert consensus recommendation, the current prevailing practice pattern among deploying U.S. Army Medical Department role-one

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health service support elements (prehospital and presurgical care) favors the use of SAP in the setting of penetrating combat wounds.[4–6] Although combat wounds typically affect a predominantly young and otherwise healthy population, it is a widely held belief in military medical circles that combat wounds are more likely to become infected than corresponding wounds occurring in the civil-sector setting. Geographic pathogenic patterns and agricultural practices notwithstanding, there is some logic to support the theory that relatively high-velocity projectiles issuing from expended munitions, or sharp objects exposed to the elements, may possess higher potential for inflicting contaminated or even septic wounds. Clinical data to support this supposition are lacking, however.

In addition to ballistic issues, wounds inflicted in the combat setting also present unique challenges due to setting and circumstances. Appropriate initial wound care by civil-sector standards is often delayed or overlooked because of tactical constraints, because of mission requirements, or in the effort to facilitate rapid extraction from hostile fire and evacuation to definitive care. Although usually considered standard practice, SAP is not always employed, either by being overlooked (as in a mass casualty incident) or, occasionally, by practitioner preference.

While the use of SAP remains debatable in civil-sector emergency medicine practice, the practice of aggressive wound irrigation with sterile aqueous solutions, and even clean municipal water supplies, has been demonstrated to effectively decrease the rate of wound infection in the emergency department (ED) setting.[7] In a manner corresponding to the use of SAP, the determination of whether this practice translates comparably to the treatment of combat wounds has remained the subject of conjecture.

The objective of this study was to analyze the respective outcomes of battle casualties returned to duty after initial wound care for penetrating soft-tissue combat trauma, comparing infection rates based on whether SAP was administered and whether wounds were irrigated, in order to ascertain whether either or both practices might impact wound care in the combat setting.

METHODS

This study employed a retrospective cohort design, consisting of a quantitative review of records from a single consolidated battalion aid station (BAS) over a one-year deployment period. Data were abstracted from handwritten deployment outpatient medical record documents, as well as electronic BAS outpatient encounter and evacuation records, and casualty status reports from higher headquarters. The BAS served two combat battalions and was located at an austere forward-operating base in a major metropolitan area in central Iraq. The tenant units were engaged in high-intensity urban combat operations for the majority of the study period.

The inclusion criteria were all battle casualties undergoing medical treatment for penetrating combat wounds at the study BAS from March 31, 2004, to February 15, 2005, and who were able to return to duty after initial treatment without requiring evacuation for a higher level of care. A *battle casualty* was defined as a subject who was either killed or wounded as the result of hostile action.[8] It should be noted that by the nature of military practice, combat casualty demographic and epidemiologic records for virtually all incidents are captured, a fact that lent itself to facilitating the forthcoming analysis.

Demographic, epidemiologic, and treatment data were abstracted. Relevant clinical data points collected included anatomic location and mechanism of the wound; field diagnosis; whether wound irrigation, debridement, and/or closure were performed; whether antibiotics were administered and type as applicable; follow-up clinical findings and modification to treatment plan; final diagnosis; and clinical outcome.

Subjects were excluded if they initially required evacuation to higher echelons of care for admission and surgical intervention, if they sustained isolated burn or eye injuries, or if they received topical antibiotics for abrasions only. They were also excluded if follow-up clinical data and final outcome were unavailable. Subjects who were evacuated simply for radiographic studies, and who required no further care prior to return, were not excluded.

The type of SAP administered was at the discretion of the treating health care practitioner. Antibiotics given included parenteral ceftriaxone and/or oral fluoroquinolones predominantly, followed by second-generation cephalosporins, or amoxicillin/clavulanate. Antibiotic course duration ranged from seven to 10 days.

Data Analysis

Relative rates of infection between groups were analyzed using standard contingency table analysis, employing Fisher's exact test for 2×2 and 4×2 tables, and calculation of odds ratios (ORs) and number needed to treat (NNT).

Data were collected and maintained in accordance with institutional privacy safeguards. This study was reviewed and approved by the institutional human subjects review board of Brooke Army Medical Center, which has oversight responsibility for clinical research conducted in combat.

RESULTS

Demographic and epidemiologic data were available for all of the battle casualties encountered. During this period, the study population remained stable and

TABLE 1. Wound Mechanism and Anatomic Location Based on Systemic Antibiotic Prophylaxis Administration Status

		n	SAP	% SAP	No SAP	% No SAP	Infected
Mechanism of injury	Mortar	19	15	79%	4	21%	1 (1 SAP)
	Roadside Bomb	20	19	95%	1	5%	1 (1 No SAP)
	RPG	10	5	50%	5	50%	5 (2 SAP, 3 No SAP)
	Gunshot	3	3	100%	0	0%	0
	Human bite	1	1	100%	0	0%	0
	Total	53	43	81%	10	19%	7
Anatomic location of injury							
	Head/neck	10	9	90%	1	10%	0
	UE	16	14	76%	2	24%	2 (1 SAP, 1 No SAP)
	LE	16	12	75%	4	25%	4 (2 SAP, 2 No SAP)
	Trunk	11	9	82%	2	18%	1 (1 No SAP)
	Total	53	44		9		7

LE = lower extremity; RPG = rocket-propelled grenade; SAP = systemic antibiotic prophylaxis; UE = upper extremity.

comprised 1.1% of the total census of U.S. troops deployed to the Iraqi theater of operations for the study period as reported by the U.S. Department of Defense.[9] No casualties were excluded from the analysis.

From a total of 322 battle casualties, 58 subjects were identified as eligible by our criteria. Four were excluded because of lack of follow-up and final outcome, and one was excluded because of the presence of multiple penetrating injuries, one of which was later identified as harboring a retained foreign object causing chronic infection, yielding a final study group of 53 subjects (91%). All were male. All were under the age of 50 years, with an interquartile range of approximately 19 to 25. None were diabetic or otherwise immunocompromised. None of the subjects' wounds underwent primary closure. As a matter of policy, all subjects received tetanus prophylaxis prior to deployment, and none received tetanus immune globulin after sustaining the wound.

Within the study group, 43 subjects received SAP (81%). Of the remaining 10 subjects, nine did not receive SAP (*no SAP*), and one had the antibiotic course interrupted after initial dosage. The latter was incorporated into the no-SAP group for our analysis. Infections developed within 48 hours in three (7%) SAP subjects versus four (40%) without SAP, yielding an OR of 0.11 (95% confidence interval [CI] 0.02 to 0.57) and an NNT of 3 (2 to 14). Wound mechanism and anatomic locations for respective subgroups receiving versus not receiving SAP are depicted in Table 1.

Within the study group, 44 subjects received wound irrigation (83%) as a part of initial wound care. Wound mechanism and anatomic locations for respective subgroups receiving versus not receiving initial wound irrigation are depicted in Table 2. Infections developed within 48 hours in two (4.5%) subjects receiving irrigation versus five (55%) without irrigation, yielding an OR of 0.04 (0.006 to 0.24) and an NNT of 2 (1.4 to 4.7). We then sought to analyze the combined effect of SAP and initial wound irrigation on development of subsequent wound infections. Subjects were recategorized via 4 × 2 contingency table, with analysis revealing the following wound infection rates: for those undergoing wound irrigation but receiving no SAP, 17% (one of six); for those receiving SAP but no wound irrigation, 40% (two of five); for those receiving both SAP and wound irrigation, 2.6% (one of 38); and for those receiving neither SAP nor wound irrigation, 75% (three of four). Further analysis yielded a Fisher's exact $p < 0.0005$.

TABLE 2. Wound Mechanism and Anatomic Location Based on Initial Wound Irrigation Status

		n	Irrigated	% Irrigated	Not Irrigated	% Not Irrigated	Infected
Mechanism of injury							
	Mortar	19	18	95%	1	5%	1 (1 Irr)
	Roadside Bomb	20	18	90%	2	10%	1 (1 Irr)
	RPG	10	4	40%	6	60%	5 (5 No Irr)
	Gunshot	3	3	100%	0	0%	0
	Human bite	1	1	100%	0	0%	0
	Total	53	44	83%	9	17%	7
Anatomic location of injury							
	Head/neck	10	8	80%	2	20%	0
	UE	16	14	87%	2	13%	2 (1 Irr, 1 No Irr)
	LE	16	13	81%	3	19%	4 (1 Irr, 3 No Irr)
	Trunk	11	9	82%	2	18%	1 (1 Irr)
	Total	53	44	83%	9	17%	7

Irr = irrigation; LE = lower extremity; RPG = rocket-propelled grenade; UE = upper extremity.

DISCUSSION

To the best of our knowledge, this study reports the first quantitative analysis of the effect of SAP and wound irrigation on the clinical outcome of soft-tissue penetrating wounds sustained as a result of combat operations. Our interpretation of this analysis lends credence to the current practice of employing SAP in this operational setting, and particularly in circumstances where copious wound irrigation is not practical because of time or resource constraints.[5,6]

More so than in civil-sector medical practice, military medical practitioners seek to return their patients to a state of operational function at the earliest possible juncture, in order to support the overarching objectives of the expeditionary operations in which they are engaged. As a result, great emphasis is placed on both primary and early secondary preventive interventions, including antimicrobial prophylaxis, where appropriate.

Overall, the incidence of actual wound infection is multifactorial. Optimal patient outcome depends on the health care practitioner analyzing several predetermined and largely uncontrollable factors—such as mechanism of injury, anatomic wound location, degree of wound contamination, and the baseline health of the patient prior to presentation—and then selecting the optimal method of wound management. SAP utilization is frequently supportable in the combat setting precisely because these predisposing factors are so often unpredictable. This observation stands in contrast to the setting of civil-sector practice, where such treatment would not be supported for routine use by the growing body of available evidence. As such, our findings would be most applicable to settings involving combat, or other mass casualty incidents and tactical medical applications where wound mechanisms would tend toward contamination, protracted time intervals prior to initial treatment, and limited time and logistic resources available for comprehensive wound care.

LIMITATIONS AND FUTURE RESEARCH

This study was conducted in the combat setting, which by its very nature places significant limitations on investigators seeking to conduct meaningful and ethically based clinical research. As a result, a preponderance of such combat research is observational in nature, or is designed to retrospectively assess the effects of new interventions or technologies approved for deployment use. This study reflects many of the limitations inherent to such a design, including the risk of recall and selection bias, incomplete follow-up data for some subjects, the inability to reliably report time intervals between wound occurrence and SAP administration or wound irrigation, and the reliance on subjective and uncontrolled criteria applied by practitioners for defining wound infection.

In addition to the aforementioned constraints, our results and their interpretation are limited by our relatively small sample size. Also, our sample excluded subjects with significant intrathoracic, abdominal, cranial, maxillofacial, or complex extremity wounds involving neurovascular or skeletal structures. As such, our conclusions may not be extrapolated to the moderately or severely injured.

Despite these limitations, we believe that our observations may provide a limited though valuable preliminary insight into the relative efficacy of SAP and initial wound irrigation in the setting of penetrating soft-tissue combat trauma. Given the limitations to clinical research posed by the combat setting, and the current prevailing policy of military institutional review boards who are responsible for oversight of such research, it seems unlikely that prospective and controlled clinical trials designed to assess this practice in a more rigorous manner would be forthcoming. As such, the results of this study, and likewise subsequent observational studies, are the best evidence we might expect to obtain in the near term.

CONCLUSIONS

We report the results of a retrospective study of the effects of SAP and wound irrigation on rates of subsequent infection in a return-to-duty population of combat casualties. We detected independent and combined associations among SAP, wound irrigation, and significantly decreased wound infection rates. Our results imply that the effects of SAP and irrigation may be synergistic. When tactical conditions permit, we recommend copious irrigation with potable water or sterile isotonic solution at the earliest possible juncture after a wound occurs. Routine use of SAP may be appropriate in combat and other operational settings where a patient's return to duty must be expedited. From the available evidence, we would also recommend that SAP be administered if wound irrigation cannot be performed during initial treatment. Larger epidemiologic studies involving the initial treatment of penetrating soft-tissue combat wounds should be undertaken to validate our findings.

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