

Epidemiology and Timing of Infectious Complications from Battlefield-Related Burn Injuries



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Background

- Burn injuries are a cause of significant morbidity and mortality, representing approximately 8.8% of all casualties medically evacuated from Iraq and Afghanistan
- Combat-related burn injuries became more common with use of improvised explosive devices (IEDs)
- Increasing burn total body surface area (TBSA) is associated with infectious complications with most frequent etiologies to include skin and soft-tissue infection (SSTI), pneumonia, bloodstream infection, and urinary tract infection
- The Trauma Infectious Disease Outcomes Study (TIDOS) is an observational study of short and long-term infectious complications associated with trauma sustained during deployment
- Descriptive understanding of the epidemiologic timing of infectious complications in our deployed soldiers with burn injuries will provide critical information for management of casualties and serve as important comparators to previously published burn data

Methods

- Eligibility criteria:**
- TIDOS population: active-duty personnel or DOD beneficiary injured during deployment (6/1/2009 – 12/31/2014) and required medical evacuation to Landstuhl Regional Medical Center (Germany) before transition to a participating U.S. military hospital
 - Sustained ≥1 burn injury and were admitted to the U.S. Army Institute of Surgical Research Burn Center at Brooke Army Medical Center
- Infections were defined using Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network definitions based on clinical, laboratory findings, and microbiological data
 - Initial infection was defined based on the date of 1st available microbiological culture
 - Multidrug-resistant organisms (MDRO) were defined as either resistance to ≥ 3 classes of antibiotics (aminoglycosides, β-lactams, carbapenems, and/or fluoroquinolones), or presence of an extended-spectrum β-lactamase (ESBL) or *Klebsiella pneumoniae* carbapenemase (KPC) producer.
 - Methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant *Enterococcus* spp. were also classified as MDR.
 - Demographic and clinical characteristics of patients with ≥1 infection were compared to patients without infections
 - Microbiology of initial infections among military personnel with burn injuries were categorized by type of infection (blood stream infection, SSTI, pneumonia, and intra-abdominal infection), time to infection, and by injury mechanism (blast vs. non-blast)
 - Statistical analysis was performed using Chi-squared and Fisher's exact test for categorical data and Mann-Whitney U for continuous data

Results

Table 1: Demographic and clinical characteristics of wounded military personnel with burn injuries, No. (%)

Characteristic	Total Patients (N=144)	Patients with ≥1 Infection (N=26)	Patients without Infections (N=118)	P-value
Age in years, median (IQR)	24 (22-29)	24 (22-29)	24 (21-29)	0.678
Male	143 (99)	26 (100)	117 (99)	0.638
Injury mechanism				
Blast	65 (45)	18 (69)	64 (54)	0.162
Non-blast	79 (55)	8 (31)	54 (46)	0.162
Source of burn				
Combat	89 (62)	21 (80)	68 (58)	0.028
Non-combat	55 (38)	5 (20)	50 (42)	0.028
Injury severity score, median, (IQR)				
TBSA %, median (IQR)	9 (4-21)	30 (17-45)	6 (4-12)	<0.001
Baux score, median (IQR)	6 (3-14)	31 (13-43)	5 (2-8)	<0.001
Inhalation injury	24 (17)	12 (46)	14 (12)	<0.001
Mechanical ventilation (MV)	56 (39)	25 (96)	31 (26)	<0.001
Median days MV, median (IQR)	7 (4-14)	15 (8-27)	0 (0-2)	<0.001
Length of hospital stay, median days (IQR)	15 (7-24)	48 (30-79)	11 (6-19)	<0.001
Median days from injury to Burn Center admission (IQR)	5 (3-6)	4 (3-6)	6 (3-5)	0.350
Median days from injury to first surgical procedure (IQR)	7 (6-10)	6 (4-8)	8 (6-10)	0.007
Median days to definitive graft (IQR)	13 (8 – 32)	35 (15-56)	10 (8-14)	<0.001
Death	4 (2.7)	4 (15)	0	<0.001

IQR – interquartile range; TBSA – total body surface area

Infections were diagnosed in 26 (18%) patients

- Pneumonia was most common (N=16, 62%), followed by SSTI (N=6, 23%), bloodstream infections (N=3, 12%), and intra-abdominal infections (N=1, 4%)
- Median time from injury to initial infecting syndrome was 4 days (IQR 3-5 days) for pneumonia, 7 days (IQR 4-12) for SSTI, 7 days (IQR 6-7) for bloodstream infections, and 17 days (IQR 17-17) for intra-abdominal infections

Table 2: Microbiology of initial infectious complication: Bloodstream Infections

Patient	Injury Mechanism	Days to Infection	Gram-positive	Gram-negative	Fungus
1	Non-blast	7	<i>Staphylococcus aureus</i>	-	-
2	Blast	5	-	<i>Enterobacter cloacae</i>	-
3	Blast	7	-	<i>Stenotrophomonas maltophilia</i>	-

Results (cont.)

Table 3: Microbiology of initial infectious complication: SSTI

Patient	Injury Mechanism	Days to Infection	Gram-positive	Gram-negative	Fungus
4	Blast	6	-	<i>Escherichia coli</i>	-
5	Blast	2	<i>Enterococcus faecium</i>	<i>Escherichia coli</i> *	<i>Aspergillus</i> spp.; <i>Geotrichum</i> spp.; <i>Alternaria</i> spp.
6	Blast	8	-	<i>Acinetobacter</i> complex*	-
7	Blast	13	-	-	<i>Mucor</i> spp.; <i>Fusarium</i> spp.
8	Blast	22	-	<i>Proteus mirabilis</i>	-
9	Blast	3	<i>Enterococcus faecium</i>	<i>Pseudomonas aeruginosa</i> ; <i>Bacteroides fragilis</i>	-

* Indicates MDR

Table 4: Microbiology of initial infectious complication: Pneumonia

Patient	Injury	Days to Infection	Inhalation Injury	Intubated	Gram-positive	Gram-negative
11	Non-blast	6	N	Y	<i>Staphylococcus aureus</i>	<i>Haemophilus influenza</i>
12	Non-blast	14	Y	Y	-	<i>Escherichia coli</i> *
13	Non-blast	7	N	Y	-	<i>Citrobacter</i> spp.
14	Non-blast	4	Y	Y	-	<i>Klebsiella pneumoniae</i>
15	Non-blast	3	N	Y	<i>Staphylococcus aureus</i> ; <i>Streptococcus</i> spp.	<i>Haemophilus influenza</i>
16	Non-blast	3	Y	Y	<i>Staphylococcus aureus</i> ; <i>Streptococcus</i> spp.	-
17	Non-blast	3	N	Y	-	<i>Escherichia coli</i> ; <i>Enterobacter cloacae</i>
18	Blast	2	Y	Y	<i>Streptococcus</i> spp.	-
19	Blast	3	Y	Y	-	<i>Klebsiella aerogenes</i>
20	Blast	3	N	Y	-	<i>Haemophilus</i> spp.
21	Blast	3	Y	Y	-	<i>Enterobacter cloacae</i>
22	Blast	4	N	Y	<i>Staphylococcus aureus</i>	-
23	Blast	5	Y	Y	-	<i>Serratia marcescens</i>
24	Blast	5	N	Y	<i>Staphylococcus aureus</i>	-
25	Blast	23	N	Y	-	<i>Serratia marcescens</i>
26	Blast	4	Y	Y	<i>Staphylococcus aureus</i>	<i>Klebsiella aerogenes</i>

* Indicates MDR

Results (cont.)

- Blast injury was the mechanism of injury in 69% of patients with infectious complications
- All patients with pneumonia were intubated and 50% had an inhalation injury at time of initial injury
- Initial infection was polymicrobial in 35% of patients
- Only one initial infecting syndrome was an intra-abdominal infection (polymicrobial, *Enterococcus* spp., *K. pneumoniae*, and *B. fragilis*)
- Gram-negative organisms were isolated in 20 (77%) of patients, in which 15% were MDR
- Gram-positive organisms were identified in 42% of patients
- Fungi as the initial isolate were seen in 2 patients (8%) with SSTIs

Conclusions

- This study provides a better understanding of both the timing and microbiology of initial infectious complications in these burned service members
- In the TIDOS population, the most frequent initial infection and briefest time from injury to infection was pneumonia and the majority of pneumonia patients had an inhalation injury and all required intubation
- Infectious complications were often polymicrobial with Gram-negative organisms most frequently isolated
- Infectious complications were associated with higher injury severity score, larger TBSA burned, higher rates of inhalation injury, and longer delays to definitive grafting
- Infection in these service members was associated with a higher mortality. A better understanding of the risk factors of burn injury will improve long-term management and outcomes

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