Infections in Combat Casualties During Operations Iraqi and Enduring Freedom

Clinton K. Murray, MD, Kenneth Wilkins, PhD, Nancy C. Molter, PhD, Heather C. Yun, MD, Michael A. Dubick, PhD, Mary Ann Spott, MPA, MBA, Donald Jenkins, MD, Brian Eastridge, MD, John B. Holcomb, MD, Lorne H. Blackbourne, MD, and Duane R. Hospenthal, MD, PhD

Background: **Infections are a common acute and chronic complication of combat-related injuries; however, no systematic attempt to assess infections associated with US combat-related injuries occurring in Iraq and Afghanistan has been conducted. The Joint Theater Trauma Registry (JTTR) has been established to collect injury specific medical data from casualties in Iraq and Afghanistan.**

Methods: **We reviewed the JTTR for the identification of infectious complications (IC) using International Classification of Diseases, 9th Revision (ICD-9) coding during two phases of the wars, before and after the end of the major ground operations in Iraq (19 March–May 31, 2003 and June 1, 2003–December 31, 2006). ICD-9 codes were combined into two categories; anatomic or clinical syndrome and pathogen. An IC was defined as the presence of ICD-9 codes that included both anatomic or clinical syndrome and a pathogen.**

Results: **There were 425 patients evaluated in phase I and 684 in phase II with approximately one third having an IC. The most common anatomic or clinical syndrome codes were skin or wound followed by lung, and the most common pathogen code was gram-negative bacteria. The site of injury had varying rates of IC: spine or back (53%), head or neck (44%), torso (43%), and extremity (35%). Injury Severity Score and certain mechanisms of injury (explosive device, bomb, and landmine) were associated with an IC on multivariate analysis ($p < 0.01$).**

Conclusion: **Infections are common after combat-related injuries. Although the JTTR can provide general information regarding infections, improved data capture and more specific clinical information is necessary to improve overall combat-related injury infection care.**

Key Words: **Combat, Infection, Iraq, Afghanistan.**

J Trauma. 2009;66:S138–S144.

The deployment of forward surgical assets, rapid evacuation to medical care, use of body armor, and well-trained corpsmen and medics have culminated in improved care and outcomes of US combat casualties. One of the priorities of combat casualty care is to continually assess ongoing management strategies to improve care. The Joint Theater Trauma Registry (JTTR) was established as a performance improvement program to provide a central repository of clinical data from all casualties injured in Operation Iraqi and Enduring Freedom (OIF or OEF) to allow assessment of injury patterns, care provided, and associated outcomes.[1]

One of the lessons learned during previous wars is that infections associated with combat-related injuries can have significant impact on morbidity and mortality. Septic shock was a leading cause of mortality in the Vietnam War with infections noted to complicate 3.9% of casualties.[2–4] During the current wars in Iraq and Afghanistan, infections are also noted to complicate the care of combat casualties. An autopsy review of US casualties of OIF or OEF during two separate time periods of the war revealed sepsis as the fourth leading cause of potentially survivable injury, behind central nervous system injury, hemorrhage, and airway disorders.[5] Among extremity injuries in US casualties, approximately 5% to 15% develop osteomyelitis.[6–9] One of the major concerns with combat-related infections is that they are associated with bacteria that are multidrug resistant, limiting potential therapy.[7–9] However, no study has been undertaken to evaluate large numbers of casualties for injury patterns and associated infectious complications (IC). This study used the JTTR to capture data from all completed records for the presence of infectious codes among personnel with combat-related injuries associated with service in OIF or OEF.

MATERIALS AND METHODS

The JTTR is a Department of Defense (DoD) performance improvement program designed to collect medical data from patients that suffer trauma within the current com-

Submitted for publication January 22, 2009.
Accepted for publication January 22, 2009.

From the Brooke Army Medical Center (C.K.M., H.C.Y., B.E., J.B.H., L.H.B., D.R.H.), Fort Sam Houston, Texas; Department of Preventive Medicine and Biometrics (C.K.M., K.W., H.C.Y., D.R.H.) Uniformed Services University of the Health Sciences, Bethesda, Maryland; Infectious Disease Clinical Research Program (K.W.), Bethesda, Maryland; and US Army Institute of Surgical Research (N.C.M., M.A.D., M.A.S., D.J., B.E., J.B.H., L.H.B.), Fort Sam Houston, Texas.

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Address for reprints: Clinton K. Murray, MD, Infectious Disease Service, San Antonio Military Medical Center, Brooke Army Medical Center, 3851 Roger Brooke Drive, Fort Sam Houston, TX 78234; email: Clinton.Murray@amedd.army.mil.

DOI: 10.1097/TA.0b013e31819d894c

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 APR 2009	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Infections in combat casualties during Operations Iraqi and Enduring Freedom	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Murray C. K., Wilkins K., Molter N. C., Yun H. C., Dubick M. A., Spott M. A., Jenkins D., Eastridge B., Holcomb J. B., Blackbourne L. H., Hospenthal D. R.,	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX 78234	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**7**	

bat theaters in Iraq and Afghanistan. The JTTR contains data that is collected and summarized in a central repository, from point of injury through the various levels of medical care in and out of the combat zone. This study was reviewed and approved by the Brooke Army Medical Center Institutional Review Board and the Unites States Army Institute of Surgical Research.

This study assessed the JTTR for the presence of infections associated with injuries sustained during combat operations in Iraq and Afghanistan. Data recovery from the JTTR for use in this study was completed on January 2, 2008. The study evaluated two phases of the wars: phase I from March 19, 2003 to May 31, 2003 defined as the time period from the onset until it was announced that major military operations had been completed; and phase II which was June 1, 2003 to December 31, 2006. Casualties from OEF were also divided into these two time periods. The number of JTTR entries that underwent complete coding was compared with the Patient Administration Systems and Biostatistics Activities (PASBA), which received all inpatient records from deployed medical units.

The data collected included summary totals of patients with data captured in the JTTR by year, theater of operation, and phase of military operations, with associated gender, military rank, branch of military service, injury severity score (ISS), medical care level at the time of diagnosis (level I, II, III, IV, and V),[10] battle injury or nonbattle injury, injury site(s), and mechanism(s) of injury. Injury patterns were grouped by anatomic distribution; specifically, recorded International Classification of Diseases, 9th Revision (ICD-9) codes involving trauma were mapped to body region using the Barell Matrix posted by the CDC (http://www.cdc.gov/nchs/data/ice/final_matrix_post_ice.pdf). ICs were captured using ICD-9 codes entered within the JTTR. In addition, they were bundled for analysis based upon major categories of anatomic or clinical syndromes, which included bacteremia, abdominal, bone or joint, skin, lung, urine, central nervous system, and other. Infectious disease ICD-9 codes were also bundled into gram-positive bacteria, gram-negative bacteria, other bacteria, and fungi. An IC was defined as a patient having codes for both an anatomic or clinical syndrome and a corresponding pathogen. Note that certain ICD-9 codes for anatomic or clinical syndrome included a pathogen, whereas those ICD-9 codes for anatomic or clinical syndrome lacking a pathogen were considered an IC if a separate ICD-9 code for that patient also specified a pathogen.

Statistical analysis included descriptive evaluation of various cohorts, point and interval estimates for standard logistic and "exact" logistic regression coefficients within multivariate analyses, whereas univariate or bivariate analyses included the unpaired Student's t test or Mann-Whitney rank-sum test for continuous variables, and χ^2 or Fisher's exact for categorical variables, where appropriate. A nominal 0.05 significance level was employed throughout these analyses.

Table 1 **Total Number of Individual Patients Records Reviewed From the JTTR and Recorded Infectious Disease ICD-9 Codes Associated With Them**

Combat Zone	Number of Patients	Number of ICD-9 Codes by Year of Trauma				
		Total	2003	2004	2005	2006
OIF/OEF	1,108	12,410	4,713	3,675	3,694	328
OIF	1,059	11,921	4,481	3,641	3,506	293
Battle injuries	653	9,085	2,551	3,154	3,133	247
Nonbattle injuries	406	2,836	1,930	487	373	46
OEF	49	489	232	34	188	35
Battle injuries	27	333	162	29	128	14
Nonbattle injuries	22	156	70	5	60	21

RESULTS

There were completed records for 562 individuals injured in 2003, 284 for 2004, 231 for 2005, and 31 for 2006, representing a 100%, 77%, 66%, and 23% completion rates based on PASBA data, respectively (Table 1). Overall, only 56% of records had been entered into JTTR as of November 2007 based on PASBA data.

Nearly, all of the records reviewed were from patients injured in Iraq (96%) (Tables 1 and 2). Overall, 61% of injuries were due to battle injuries although there were fewer battle injuries in phase I (38%) compared with phase II (76%) of the war (Table 2). Most casualties were Army personnel although a higher percentage of Marines was noted in phase I. The majority of patients were enlisted (grade of E-5 or below; mostly E-4) men. Explosion associated injuries were more common during phase II (80%) than during phase I (42%), with grenade associated explosions being the most common in phase I (24%) and improvised explosions being the most common in phase II (55%). Gunshots were more common in phase I (32%) than phase II (16%) among battle related injuries. Casualties in phase II (15) had greater mean ISS scores than during phase I (4).

During phase I only 28 of the 425 patients (6.6%) had an ICD-9 code for an infectious anatomic or clinical syndrome or pathogen in contrast to phase II, where 661 of 684 patients (96.6%) had an ICD-9 code for an infectious anatomic or clinical syndrome or pathogen. The most common infectious code by anatomic or clinical syndrome was skin and wound followed by lung (Table 3). Gram-negative bacteria were the most common pathogens reported (Table 3). Overall, an IC was present in 35% of patients in phase II. The specific ICD-9 codes for anatomic or clinical syndrome or pathogen are provided in Tables 4 and 5, respectively, along with the frequency reported for each code in the abstracted JTTR data. Based on anatomic site of injury, 55% of spine and back injuries, 44% of torso injuries, 43% of head and neck injuries, and 34% of extremity injuries developed an IC during phase II (Table 6). The first level of military medical care of an IC was recorded at was level V in 71% of the cases followed by level IV in approximately 27% of cases (Table 7).

Table 2 **Patient Demographics in the JTTR for Phase I (19 March 2003–30 May 2003) and Phase II (1 June 2003–31 December 2006)**

	Phase I Number (%)	Phase II				
		Total, Number (%)	2003	2004	2005	2006
Number of patients	425	684	137	284	231	31
Female*	21 (4.9%)	23 (3.4%)	4	13	4	2
Branch of service						
Army	319 (75.1%)	577 (84.4%)	134	248	174	20
Marine	88 (20.7%)	86 (12.6%)	1	26	49	10
Air force	7 (1.6%)	9 (1.3%)	1	5	3	0
Navy	11 (2.6%)	12 (1.8%)	1	5	5	1
Military grade/rank						
Enlisted	384 (90.3%)	637 (93.3%)	128	264	218	27
E1	9 (2.1%)	6 (0.9%)	2	0	3	1
E2	32 (7.6%)	23 (3.4%)	4	8	11	0
E3	82 (19.3%)	122 (17.8%)	20	45	47	10
E4	132 (31.1%)	241 (35.2%)	59	99	76	7
E5	83 (19.5%)	134 (19.6%)	16	64	47	7
E6	32 (7.5%)	70 (10.2%)	17	33	18	2
E7	11 (2.6%)	31 (4.5%)	10	12	9	0
E8	3 (0.7%)	10 (1.5%)	0	3	7	0
Warrant	4 (0.9%)	2 (0.3%)	1	0	0	1
W1	2 (0.5%)	0 (0.0%)	0	0	0	0
W2	2 (0.5%)	2 (0.3%)	1	0	0	1
Officer	33 (7.8%)	42 (6.1%)	7	20	12	3
O1	1 (0.2%)	7 (1.0%)	1	3	2	0
O2	9 (2.1%)	15 (2.2%)	2	8	5	0
O3	15 (3.5%)	12 (1.8%)	4	5	1	2
O4	4 (0.9%)	5 (0.7%)	0	3	1	1
O5	1 (0.2%)	1 (0.2%)	0	0	1	0
O6	3 (0.7%)	3 (0.4%)	0	1	2	0
Unknown	4 (0.9%)	2 (0.3%)	1	0	1	0
Disposition						
Died	8 (1.9%)	11 (1.6%)	1	4	4	2
Return to duty	55 (12.9%)	31 (5.0%)	10	16	5	0
Unknown	362 (85.2%)	642 (93.9%)	127	268	225	31
Total-OIF	404 (95.1%)	656 (95.9%)	133	279	218	25
Battle injury	150 (37.1% of 404)	504 (76.8% of 656)	87	224	175	17
Total-OEF	21 (4.9%)	28 (4.1%)	4	5	13	6
Battle injury	11 (52.4% of 21)	16 (57.1% of 28)	2	4	8	2
Injury severity score: mean of maximum score (range)			(n = 126)	(n = 259)	(n = 217)	(n = 27)
Military AIS (n = 630)	5.2 (1, 75)	20.3 (1, 75)	19.2	20.5	21.0	17.6
2005 (n = 630)	4.3 (1, 38)	14.6 (1, 75)	13.3	14.5	15.8	13.7

Mechanism of injury†	BI: 161/NBI: 266 (% of 161/% of 266)†	BIs: 523/NBIs: 165 (% of 523/% of 165)†								
Explosion	67/13 (41.6%/4.9%)	419/6 (80.1%/3.6%)	BI	NBI	BI	NBI	BI	NBI	BI	NBI
Gun shot	52/12 (32.3%/4.5%)	83/14 (15.9%/8.5%)	14	7	34		28	6	7	1
Shrapnel/fragment	17/0 (10.6%/0%)	3/1 (0.6%/0.6%)	2				1			1
Motor vehicle crash	3/64 (1.9%/24.1%)	2/30 (0.4%/18.2%)		6	1	11	1	11		2
Fall/jump from height	2/35 (1.2%/13.2%)	1/14 (0.2%/8.5%)	1	5		4		5		
Machinery/equipment	3/33 (1.9%/12.4%)	0/15 (0%/9.1%)		4		5		3		3
Exertion/overexertion	2/22 (1.2%/8.3%)	0/0 (0%/0%)								
Burn	4/13 (2.5%/4.9%)	4/10 (0.8%/6.1%)		3	2	4	2	2		1
Knife or other sharp object	0/3 (0%/1.1%)	0/9 (0%/5.5%)		3		1		3		2
"Other"	11/71 (6.8%/26.7%)	11/66 (2.1%/40%)	5	16	4	31	2	16	5	16

* One casualty wounded in 2005 has gender "Undetermined."

† Entries reflect number and percentage of reported mechanisms, not individual patients, who might provide more than one mechanism of injury.

BI, number of battle injuries; NBI, number of nonbattle injuries; RPG, rocket-propelled grenade.

Table 3 Infection ICD-9 Coding Based Upon Anatomical/Clinical Syndrome or Pathogen Bundled

	Phase I	Phase II by Year			
		Total	2003	2004	2005	2006
Anatomical and clinical syndrome						
Abdomen	0	13	1	9	1	2
Bacteremia	2	90	20	38	32	0
Bone and joint	1	37	7	17	13	0
Central nervous system	0	12	5	5	2	0
Lung	6	94	17	41	30	6
Skin and wound	14	190	36	86	56	12
Other	3	144	36	65	38	5
Pathogen						
Gram-positive bacteria	3	123	29	57	34	3
Gram-negative bacteria	7	299	57	127	109	6
Fungus	0	30	6	11	10	3
Other	4	185	45	72	64	4
Infectious complication	6	241	55	101	80	5

Patients may have received more than one infectious code.

Risk factors associated with IC include certain injury patterns and mechanisms of injury (Table 8). In addition, patients with higher ISS had higher risk of developing an IC. On multivariate analysis, higher ISS, injury during phase II of the study, and certain mechanisms of injury (explosive device, bomb, and landmine) remained significant.

There were a total of 19 deaths reported in this data set. During phase I, 8 persons died from various injuries: grenade, (1), gunshot (1), motor vehicle crash (1), and unknown (5). During phase II, there were 11 deaths (1 in 2003 from a motor vehicle crash; 4 in 2004 from motor vehicle crash [1], gunshot [1], explosion [1] and burn [1]); 4 in 2005 from explosion (3) and grenade (1); 2 in 2006 from gunshot (1) and explosion (1). None of the phase I deaths had any infectious anatomic or clinical syndrome or pathogens listed as a complication whereas 10 of the 11 phase II deaths were associated with an infection by ICD-9 coding. The presence of one or more IC was not estimated (via exact logistic regression) as being significantly associated with mortality, after adjusting for phase and ISS.

DISCUSSION

Military personnel who suffer combat-related injuries are at risk of developing acute and chronic ICs. This is even more concerning as many of these infections are due to multidrug-resistant bacteria. Although limited single-site studies of OIF or OEF casualties have assessed specific infections of combat-related injuries, this study uses a more global approach through evaluating the JTTR. Overall, approximately one third of the casualties assessed in this study had the presence of an IC. These infections involved primarily skin and wound sites or the lung, with a high rate of bacteremia. As in most combat studies, the primary bacteria were

Table 4 Infection ICD-9 Coding by Anatomical/Clinical Syndrome Based

Syndrome	Code	Code Description	Number
Abdomen	567.2	Suppurative peritonitis	3
	567.8	Peritonitis	2
	567.9	Peritonitis unspecified	16
	569.61	Colostomy/enterostomy infection	3
Bacteremia	038.11	*Staphylococcus aureus* septicemia	2
	038.43	*Pseudomonas* septicemia	3
	038.49	Gram-negative septicemia	2
	038.8	Septicemia	2
	038.9	Septicemia	14
	790.7	Bacteremia	77
Bone/joint	730.02	Acute osteomyelitis arm	1
	730.05	Acute osteomyelitis pelvis	3
	730.06	Acute osteomyelitis leg	5
	730.07	Acute osteomyelitis ankle	2
	730.16	Chronic osteomyelitis leg	2
	730.22	Osteomyelitis arm	2
	730.23	Osteomyelitis forearm	3
	730.25	Osteomyelitis pelvis	3
	730.26	Osteomyelitis leg	6
	730.27	Osteomyelitis ankle	1
	730.28	Osteomyelitis unspecified	2
	996.66	Infection joint prosthesis	2
	996.67	Infection orthopaedic device	12
Central nervous system	320.89	Meningitis other bacteria	1
	320.9	Bacterial meningitis	2
	322.9	Meningitis unspecified	4
Lung	465.9	Acute upper respiratory infection	3
	481	Pneumococcal pneumonia	9
	482.1	*Pseudomonas* pneumonia	2
	482.31	Group A *Streptococcus* pneumonia	1
	482.41	Pneumonia *Staphylococcus aureus*	1
	482.82	*E. coli* pneumonia	1
	482.83	Gram-negative pneumonia	10
	482.89	Bacterial pneumonia	11
	486	Pneumonia organism unspecified	35
	510.9	Empyema without fistula	10
	V46.1	Dependence on respirator	12
Skin/wound	519.01	Tracheostomy infection	1
	528.3	Cellulitis/abscess mouth	1
	566	Anal/rectal abscess	1
	682.1	Cellulitis/abscess neck	1
	682.2	Cellulitis trunk	11
	682.3	Cellulitis arm	37
	682.4	Cellulitis hand	16
	682.5	Cellulitis/abscess buttock	1
	682.6	Cellulitis leg	77
	682.7	Cellulitis foot	30
	682.9	Cellulitis/abscess unspecified	6
	686.9	Local skin infection unspecified	7
	728.86	Necrotizing fasciitis	1
	785.4	Gangrene	5
	912.1	Abrasion shoulder/arm infected	1
	916.1	Abrasion hip/leg infected	3
	916.3	Blister hip/leg infected	2
	917.3	Blister foot and toes-infected	2
	958.3	Post-trauma wound infection	35
	997.62	Infection amputation stump	9

Table 4 Infection ICD-9 Coding by Anatomical/Clinical Syndrome Based (continued)

Syndrome	Code	Code Description	Number
Other	041.89	Infection bacteria other	39
	112.1	Vulva/vaginal candidiasis	1
	381.4	Nonsuppurative otitis media	1
	451.82	Superficial phlebitis arm	2
	451.83	Deep phlebitis arm	1
	451.89	Thrombophlebitis other	6
	451.9	Thrombophlebitis not otherwise stated	3
	519.2	Mediastinitis	4
	910.5	Infection bite head	5
	916.5	Infection bite hip/leg	19
	995.91	Systemic inflammatory response syndrome without organ dysfunction	12
	995.92	Systemic inflammatory response syndrome with organ dysfunction	12
	996.62	Infection due to vascular device	18
	996.69	Infection due to device	3
	998.59	Other postoperative infection	55

gram-negative.[11] Because of rapid transport out of theater, most IC occurred at levels IV and V medical care.

As in previous conflicts, extremity injuries have been the most commonly encountered injury pattern.[12,13] During the Vietnam War, an assessment of ICs near the time of injury reported 7,106 upper extremity injuries of which 3.69% became infected and 8,838 lower extremity injuries of which 5.04% became infected.[4] Studies of US casualties assessing IC of extremity injuries have described rates of deep tissue or bone infections of 2% to 15%.[6,9] In phase II of this study, 198 of the 574 (34%) patients with extremity injuries had associated coding consistent with an IC. Although this is insightful information, the current ICD-9 codes do not specifically capture some bacteria, including *Acinetobacter*, and the more specific details on injury pattern and management strategies are not detailed. ICD-9 lacks the descriptive specificity to understand the clinical significance of these disparate rates.

It has been noted that during OIF or OEF there has been a lower proportion of thoracic wounds than in past conflicts although of those who suffer a torso injury in this study there is a relatively high rate of IC.[13] In the previously mentioned Vietnam study of wounds and infection, there were 3,490 patients with thoracic wounds with 3.84% developing an infection, and of the 2,454 patients with abdominal wounds 6.89% became infected.[4] An assessment of primarily non-US casualties treated on the US naval ship during the early stages of OIF revealed that abdominal injuries had an odds ratio of 2.7 for developing an infection.[14] A study performed in a Combat Support Hospital between September 2003 and December 2004 in Iraq revealed of the 175 (5% of the study population) primarily non-US patients with colon and rectal injuries, sepsis developed in 27 patients (16%) and had significant impact upon mortality.[15]

Table 5 Infectious ICD-9 Coding by Pathogen

Pathogen	Code	Code Description	Number
Fungus	112.1	Vulva/vaginal candidiasis	1
	112.3	Candidiasis of skin/nails	1
	112.5	Disseminated candidiasis	3
	112.89	Candidiasis site not available	6
	112.9	Candidiasis site unspecified	13
	117.3	*Aspergillus*	5
	117.9	Mycoses	14
Gram-negative	003.8	Other *Salmonella* infection	1
	038.42	*E. coli* septicemia	1
	038.49	Gram-negative septicemia	1
	041.3	*Klebsiella* infection	84
	041.4	*E. coli* infection unspecified	47
	041.6	*Proteus* infection unspecified	3
	041.7	*Pseudomonas* infection	102
	041.85	Infection gram-negative	190
	482.1	*Pseudomonas* pneumonia	3
Gram-positive	038.11	*Staphylococcus aureus* septicemia	6
	038.19	*Staphylococcus* septicemia	2
	041.01	Infection Streptococcus group A	5
	041.02	Infection Streptococcus group B	2
	041.03	Infection Streptococcus group C	1
	041.04	Enterococcus group D	39
	041.09	Infection Streptococcus other	7
	041.11	Infection *Staphylococcus aureus*	70
	041.19	Infection Staphylococcus other	27
	481	Pneumococcal pneumonia	2
Other bacteria	008.45	*Clostridium difficile* enteritis	8
	032.89	Other specified diphtheria	1
	041.82	*Bacteroides fragilis* infection	2
	041.83	*Clostridium perfringens* infection	1
	041.84	Infection anaerobe	9
	041.89	Infection bacteria other	92
	041.9	Bacterial infection not specified	29
	795.39	Other nonspecific positive culture	11
	V09.0	Infection microorganism resistant penicillins	31
	V09.1	Cephalosporin resistant organism	1
	V09.71	Antimycobacterial multidrug resistant organism	2
	V09.80	Other nonmultidrug resistant microorganism	1
	V09.90	Unspecified nonmultidrug resistant organism	1
	V09.91	Unspecified multidrug resistant microorganism	4

On multivariate analysis, risk factors associated with infections in this study included injuries occurring during phase II, certain mechanisms of injury (explosive device, bomb, and landmine), and higher ISS value. An analysis of casualties on the US navy ship revealed higher rates of infections with soft tissue and abdominal injuries and increasing ISS on multivariate analysis.[12] Although, ISS was not associated with osteomyelitis in another study of OIF or OEF casualties.[9] A review of a US trauma center's registry noted

Table 6 Infection Coding Based on Injury Pattern and Phase*

	Phase I					Phase II				
	Extremities (n = 340)	Head and Neck (n = 129)	Spine or Back (n = 38)	Torso (n = 87)	Unspecified (n = 251)	Extremities (n = 574)	Head and Neck (n = 281)	Spine or Back (n = 61)	Torso (n = 277)	Unspecified (n = 444)
Clinical and anatomical syndrome or pathogen	27	4	1	11	18	558	268	60	270	429
Infectious complication	6	1	0	4	5	198	123	33	120	157

* Five hundred twenty-one individuals with >1 wound site on record are included in >1 column for each row.

Table 7 Level of Medical Care at Which Infectious Disease Diagnosis was Coded

	Level I	Level IIa	Level IIb	Level III	Level IV	Level V	Total
Anatomical and clinical syndrome	3	7	8	77	95	259	449
Pathogen only				8	127	333	477
Infectious complication				8	130	339	477

See Ref. 10 for definitions of level of care.

Table 8 Univariate and Multivariate Analysis of Risk Factors Associated With Development of an Infectious Complication

	Univariate			Multivariate		
	Odds Ratio	95% Confidence Interval	*p*	Odds Ratio	95% Confidence Interval	*p*
Body region*						
Extremity	1.01	0.7–1.5	0.94			
Head and neck	1.77	1.32–2.38	<0.01			
Spine and back	1.39	0.87–2.21	0.17			
Torso	2.31	1.71–3.12	<0.01			
Battle injury status	4.24	2.94–6.1	<0.01			
ISS score (unit increase)	1.05	1.04–1.06	<0.01			
ISS score 15–29	5.24	3.64–7.54	<0.01	2.33	1.56–3.50	<0.01
ISS score >29	8.56	5.82–12.59	<0.01	3.76	2.47–5.73	<0.01
Phase II	38.1	16.75–86.46	<0.01	20.25	8.58–47.82	<0.01
Mechanism of injury†						
Explosive device	6.89	4.08–11.63	<0.01	1.86	1.04–3.33	0.04
Bomb	8.13	2.27–29.13	<0.01	9.97	1.81–54.82	<0.01
Grenade	2.34	1.21–4.52	0.01			
Gunshot	2.71	1.49–4.94	0.01			
Landmine	7.51	2.91–19.38	<0.01	4.0	1.29–12.4	0.02
Mortar	3.60	1.66–7.78	<0.01			
Unexploded ordnance	1.63	0.34–7.81	0.54			
Motor vehicle crash	1.48	0.70–3.12	0.31			
Machinery/equipment	0.83	0.27–2.55	0.04			
Burn, fall/jump from height, knife or other sharp object, Shrapnel/ fragment‡	0.34	0.097–1.15	0.08			

* Reference group 'Unspecified' (i.e., Barell Matrix Body Region unclassifiable by site).
† Reference group "Other," as implicitly defined in Table 2.
‡ Categories combined due to sparse data.

certain factors to be associated with sepsis to include comorbidities, immunosuppression, Glascow Coma Scale (GCS), and increasing ISS.[16] Although comorbidities, such as diabetes or immunosuppression, were associated with sepsis, these are unlikely occurrences in a population of healthy deployed military personnel. Another predictor was a GCS score of <8; however, the majority of patients suffered a blunt mechanism of injury (86%) in the civilian population. Finally, higher ISS value was associated with sepsis among civilian trauma patients as in our study.

Although this is the first broad assessment of ICs of a purely US population of combat-related injuries, there are a number of limitations in the use of these data. The JTTR has undergone a series of improvements in data collection and entry since its conception, leading to a possibility of discrepancies in data over time which might be reflective of the differences reported between phase I and II in contrast to the differences in ISS or mechanisms or injury. Also, the collection of level V data has been incomplete at many facilities. Unfortunately, this is evident by the lack of outcome data for the majority of casualties. Fortunately, the latest version of the JTTR is being adequately staffed at the major Army level V facilities to minimize this concern. Although charts are now being entered serially into the JTTR by Medical Treatment Facility Unit, the incomplete yearly record completion rate might be associated with a chart selection bias that is not evident at this time. Although, the JTTR is designed as a DoD process, the JTTR was not being implemented at level V Navy and Air Force facilities at the time of this review but is now occurring. There is also a limitation of ICD-9 diagnosis for ICs as they do not provide the clinical granularity necessary to impact patient care. To address this issue, the latest version of the JTTR has a specific infectious disease module being added to enhance infectious disease specific data collection. There are also other performance improvement and research programs under development that could augment the JTTR. This includes the development of a DoD Joint Bacterial Repository to collect infection specific data with associated bacterial isolates. In addition, the Infectious Disease Clinical Research Program is developing a Trauma Infectious Disease Outcome Study for long-term follow-up of casualties to determine chronic combat-related injury ICs.

This initial review of the JTTR has provided some unique descriptions of the challenges facing healthcare providers to mitigate the acute and chronic ICs of combat casualties. There are a number of limitations of the current registry that are actively being addressed. Despite these limitations, data collected from the JTTR will enable improvements in ongoing data collection and provide insight into further improvements in patient care and future research programs. Infectious events occur frequently in combat casualties and likely cause significant adverse clinical outcomes. Understanding the epidemiology is the first step toward an evidence-based intervention program.

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