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Major Article

Timeline of health care–associated infections and pathogens after burn injuries

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Background: Infections are an important cause of morbidity and mortality after burn injuries. Here, we describe the time line of infections and pathogens after burns.
Methods: A retrospective study was performed in a large tertiary care burn center from 2004-2013. Analyses were performed on health care–associated infections (HAIs) meeting Centers for Disease Control and Prevention criteria and on all positive cultures. Incidence rates per 1,000 days were calculated for specific HAI categories and pathogens and across hospitalization time (week 1, weeks 2-3, and week ≥4).
Results: Among 5,524 patients, the median burn size was 4% of total body surface area (interquartile range, 2%-10%). Of the patients, 7% developed an HAI, of whom 33% had >1 HAI episode. Gram-positive bacteria were isolated earlier, and gram-negative bacteria were isolated later during hospitalization. Of 1,788 bacterial isolates, 44% met criteria for multidrug resistance, and 23% met criteria for extensive drug resistance. Bacteria tended to become increasingly resistant to antibiotics as time from admission increased.
Conclusions: We observed differences in infection type, pathogen, and antibiotic-resistant bacterium risk across time of hospitalization. These results may guide infection prevention in various stages of the postburn admission.
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Burn injuries remain an important source of morbidity and mortality in the United States. An estimated 450,000 burn injuries require medical treatment, and 3,400 deaths are related to fires and burns per year in the United States.[1] Burn patients are vulnerable to infections, and especially to infections with multidrug-resistant organisms.[2,3] In the United States, infections caused by resistant organisms add between $21 billion and $34 billion to health care costs annually compared with susceptible organisms.[4]

Outcomes after burn injuries vary; data from the National Burn Repository shows high variability in mortality rates (2%-12% hospital mortality) in high-volume centers, even after adjustment for burn severity.[5] This variability remains mostly unexplained, but it is likely related to factors such as distribution of comorbidities, including substance abuse and infection rates. A burn injury results in an immunocompromised state, both through breakdown of the skin natural barrier function and through systemic mechanisms.[6-9] Unlike other immunocompromised host populations, few studies have been performed that describe the time line of infections and infectious pathogens after burn injuries.[10] Here, we describe the timing of specific infections and pathogens

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during hospitalization in a large cohort of patients with burns.

MATERIALS AND METHODS

Study population and design

All patients admitted to the burn unit of a large tertiary care referral burn center between January 1, 2004, and December 31, 2013, were included. Patients were identified through the North Carolina Jaycee Burn Center Registry, which includes data collected as part of participation in the National Burn Repository. Data were obtained from the NC Jaycee Burn Center Database, electronic health record, laboratory databases, and chart review. In addition, all data on health care–associated infections (HAIs) were obtained from the hospital epidemiology database, which includes hospital-wide surveillance for all HAIs defined by the Centers for Disease Control and Prevention (CDC) and performed in accordance with CDC criteria.[11]

The first hospital admission for each patient aged ≥18 years was reviewed. The data available from all data sources were merged, and as needed additional medical record reviews were performed. Patients with missing discharge dates were excluded (n = 36). This study was approved by the Institutional Review Board of the University of North Carolina.

Microbiology

All microbial isolates from all clinical cultures were considered potential pathogens. In addition, for viral pathogens, the results of nucleic acid amplification tests performed on blood, cerebrospinal fluid, or skin lesions were used as evidence of viral replication. No attempt was made in this study to distinguish colonization from infection. For bacterial isolates, the definitions outlined by Magiorakos et al[12] were used to define multidrug-resistant (MDR), extensively drug-resistant, and pandrug-resistant bacteria. For *Achromobacter* spp and *Burkholderia* spp, multidrug resistance, extensive drug resistance, and pandrug resistance were determined using *Pseudomonas* drug-resistance definitions. MDR status for *Stenotrophomonas maltophilia* and *Streptococcus pneumoniae* was determined by nonsusceptibility to trimethoprim-sulfamethoxazole or penicillin, respectively. Enterobacteriaceae were further divided based on resistance to fluoroquinolones (FREs), presence of an extended-spectrum β-lactamase phenotype as per CDC guidelines (ESBL-E), and resistance to carbapenems (CREs).

Covariates

The revised Baux score was calculated for each patient, as described.[13] The Charlson comorbidity index was also calculated for each patient, as described[14] Total burn surface area (TBSA) was potentially reported multiple times across data sources; if multiple TBSA values were identified, an average TBSA was computed and used for analysis. Burn mechanisms were reported as per National Burn Repository guidelines (contact, chemical, electrical, flame, radiation, scald, and other).[5]

Statistical analysis

Patients were followed from date of admission until death or hospital discharge. Incidence rates (IRs) and 95% confidence intervals (CIs) were calculated based on a Poisson distribution and expressed as number of cases per 1,000 days. IRs and corresponding measures of precision were calculated for specific HAI categories and microbes. Time hospitalized was categorized by week of hospitalization, including week 1 (0-7 days after admission for pathogens, 2-7 days after admission for HAIs), weeks 2-3 (8-21 days after admission), and week ≥4 (≥22 days after admission). Differences in infection rates across hospitalization time intervals were compared using likelihood ratio tests from Poisson regression models. The 90-day cumulative incidence of specific HAIs and pathogens were calculated using Kaplan-Meier survival curves. Only patients at risk for HAIs as per CDC guidelines (ie, hospitalized for ≥2 days) were included in HAI analyses.

All analyses were performed using SAS software version 9.3 (SAS, Cary, NC).

RESULTS

Patient and burn characteristics

From 2004-2013, 5,524 adult patients with burn injuries were included in this study. The median age was 42.3 years (interquartile range [IQR], 29.7-54.8 years), 73% of patients were men, and 53% were white (Table 1). The most common mechanisms of burn were fire-flame (53%) and scald (31%) injury. In addition, 461 (8.4%) patients had inhalational injury on admission. The median burn size as defined by percentage of TBSA was 4% TBSA (IQR, 2%-10% TBSA). The median revised Baux score was 49.9 (IQR, 36.0-64.9). When individually calculated per patient, this corresponded to a median estimated predicted mortality of 0.54% (IQR, 0.19%-1.54%).[13]

Hospitalizations

The median length of stay was 8 days (IQR, 2-10 days); however, 595 (10.8%) of patients had a prolonged hospitalization of >30 days, and 124 (2.4%) of the patients were in the hospital for >90 days. There

Table 1
Demographics and clinical characteristics of patients with burn injuries

Characteristic	Value
No. of participants	5,524
Male	4,011 (72.6)
Race-ethnicity	
White	2,952 (53.4)
Black	1,462 (26.5)
Hispanic	309 (5.6)
Other	801 (14.5)
Age, y	42.3 (29.7-54.8)
Charlson comorbidity index	1 (0-2)
Burn size (% TBSA)	4.0 (2.0-10.0)
Burn mechanism	
Flame	2,936 (53.2)
Scald	1,703 (30.8)
Contact	286 (5.2)
Chemical	235 (4.3)
Electrical	218 (4.0)
Radiation	14 (0.3)
Other burn	107 (1.9)
Unknown	25 (0.5)
Inhalation injury	461 (8.4)
Revised Baux score*	49.9 (36.0-64.9)
Length of stay, d	8 (2-14)
ICU admission	1,832 (33.2)
Mechanical ventilation	740 (13.4)
Disposition	
Death	243 (4.4)
Home	4,903 (88.8)
Long-term care facility	248 (4.5)
Other†	130 (2.4)

NOTE. All data are shown as n (%), median (interquartile range), or as otherwise noted.
ICU, intensive care unit; *TBSA*, total body surface area.
*Revised Baux score defined as age (y) + % TBSA (+ 17, if inhalational injury is present).
†Includes transfers to another hospital units, acute care facilities, mental health facilities or substance abuse programs, and unknown alive disposition.

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