# Healthcare-Associated Infections in Cardiac Surgery Patients With Prolonged Intensive Care Unit Stay

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*Background.* **Healthcare-associated infections (HAIs) are responsible for many deaths of hospitalized patients each year. Patients with prolonged hospitalization are at high risk for HAIs. Increased efforts have been made to decrease these infections, but a recent report from the Centers for Disease Control suggests that some HAIs may be increasing. We hypothesized that HAIs would remain frequent among cardiac surgery patients with prolonged intensive care unit stay and would be associated with increased mortality.**

*Methods.* **We performed a retrospective cohort study of adult cardiac surgery patients with prolonged intensive care unit stay (more than 7 days) over a 3-year period. Mortality differences were calculated based on whether particular HAIs occurred. Multivariable logistic regression was used to examine risk factors associated with the development of HAI. The relationship between HAI and mortality was estimated using propensity score adjusted logistic regression analysis.**

*Results.* **Of 2,595 patients, 388 (15.0%) had a prolonged intensive care unit stay. Of these patients, 48.5% had at least one HAI. Unadjusted inhospital mortality for patients with HAI was 28.7%, versus 13.0% for patients without. Red blood cell transfusion was associated with increased HAI risk. After propensity score adjustment, surgical site infection and central line associated blood stream infection were associated with increased mortality. The HAIs caused by vancomycin-resistant *Enterococcus* sp, methicillin-resistant *Staphylococcus aureus*, and multidrug-resistant organisms appeared to be associated with disproportionally high mortality.**

*Conclusions.* **Healthcare-associated infections remain frequent among cardiac surgery patients with prolonged intensive care unit stay and are associated with increased mortality. Evidence-based strategies are needed to reduce these infections.**

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Approximately 4% of patients die in the hospital after cardiac surgery and the longer that patients stay in the hospital, the more likely they are to die [1] It remains unclear which factors contribute the most to death in cardiac surgery patients with prolonged hospitalization. One factor that has been strongly associated with death among hospitalized patients is healthcare-associated infection (HAI).

According to the World Health Organization, 7 of every 100 hospitalized patients acquires an HAI, with the infections causing approximately 99,000 deaths per year in the United States [2]. Intensive care unit (ICU) patients are at high risk for HAIs, with approximately 20% to 30% of them acquiring an HAI [3, 4]. In a large cohort of European ICU patients, pneumonia increased the hazard for death 1.7 to 3.5 times, and primary bloodstream infections increased the hazard 2.1 to 4.0 times [5]. Multidrug-resistant (MDR) infections are particularly problematic because they are both challenging and extremely expensive to treat and have a fivefold increased risk of mortality [6].

In recent years, there have been focused efforts to reduce HAIs, as many are considered to be preventable. Although some HAIs have decreased since 2008, others have increased [7]. One high-risk group for HAIs is patients with prolonged ICU stay because this group is chronically ill and often has indwelling catheters and requires prolonged mechanical ventilation. There are few contemporary studies of HAI epidemiology in cardiac surgery patients with prolonged ICU stay. We hypothesized that HAIs would remain frequent for this group of patients and would be associated with increased mortality, despite recent efforts to reduce their incidence. Furthermore, we attempted to identify risk factors that were associated with the development of HAI.

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**Abbreviations and Acronyms**

CI = confidence interval
CLABSI = central line-associated blood stream infection
HAI = healthcare-associated infection
ICU = intensive care unit
MDR = multidrug resistant
MRSA = methicillin-resistant *Staphylococcus aureus*
RBC = red blood cells
SSI = surgical site infection
STS = The Society for Thoracic Surgery
UTI = urinary tract infection
VRE = vancomycin-resistant *Enterococcus*

## Patients and Methods

### *Subjects*

Adult patients who had cardiac surgery with cardiopulmonary bypass between January 1, 2011, and December 31, 2013, were identified using The Society for Thoracic Surgery (STS) database at our institution. The University of Maryland Medical Center is a tertiary care hospital whose cardiac surgery program cares for patients having coronary artery bypass surgery, complex valve surgery, ventricular assist device placement, major aortic surgery, and heart and lung transplantation. The cardiac surgery ICU has 21 beds.

Adult patients who had a prolonged ICU course, defined as spending more than 7 days after surgery in the ICU, were identified in the STS database and included in the study. Patients who had heart or lung transplantation were excluded. The University of Maryland, Baltimore, Institutional Review Board approved the study.

### *Study Variables*

Definitions for study variables were based on STS database definitions (versions 2.61 and 2.73, available at: www.sts.org). The following STS variables were collected for the study: age, sex, weight, height, baseline creatinine level, diabetes mellitus, dyslipidemia, hemodialysis, hypertension, infectious endocarditis, chronic lung disease, peripheral vascular disease, cerebral vascular disease, left ventricular ejection fraction, predicted mortality, surgery type, cardiopulmonary bypass time, total red blood cell (RBC) transfusion, total fresh frozen plasma transfusion, total platelet transfusion, total ICU days, postoperative stroke, postoperative acute renal failure, postoperative cardiac arrest, reoperation for bleeding or cardiac tamponade, and inhospital mortality, which was the primary outcome.

### *Definitions for HAI*

Definitions for HAI were based on the Centers for Disease Control/National Healthcare Safety Network definitions. Only HAIs that occurred after surgery and during the index hospitalization were included [8]. For pneumonia, we included only pneumonia 2, which is pneumonia with common bacterial or filamentous fungal pathogens and specific laboratory findings. Quantitative cultures greater than 10,000 CFU/mL were considered significant. Pneumonias 1 and 3 were not included because clinically defined pneumonias are more difficult to confirm through retrospective chart review, and immunocompromised patients were not included in the study. For urinary tract infections (UTI), we included symptomatic UTI, including catheter-associated UTI, and not asymptomatic bacteriuria. Both superficial and deep surgical site infections (SSI) were included. Central line-associated blood stream infection (CLABSI) was defined using the Centers for Disease Control/National Healthcare Safety Network definition for blood stream infection. *Clostridium difficile* infection was defined by a positive polymerase chain reaction assay for *C difficile* toxin and symptoms of clinical colitis including diarrhea, fever, and leukocytosis. For each patient, we recorded the total number of HAI during the index hospitalization.

### *ICU Infection Prevention Practices*

Our ICU has a number of routine infection prevention practices. Patients are screened for methicillin-resistant *Staphylococcus aureus* (MRSA) at admission to the unit, weekly during their stay, and at unit discharge. High-risk patients (eg, those who have an artificial airway or are transferred from another unit or facility where they resided longer than 48 hours) are also screened for MDR gram-negative organisms, including carbapenem-resistant *Enterobacteriaceae* and MDR *Acinetobacter baumannii*. All patients undergo daily chlorhexidine bathing, and there is emphasis on and monitoring of evidenced-based practices aimed at preventing device-related infections. These practices include routine assessments of device need and optimal insertion and maintenance practices. In addition, our facility predominantly utilizes minocycline/rifampin-coated central venous catheters aimed at reducing CLABSI.

### *Culture Data*

For each HAI, culture and antibiotic susceptibility data were recorded from the electronic medical record. The HAIs with the following critical organisms were tallied: MRSA, vancomycin-resistant *Enterococcus* sp (VRE), and *C difficile*. We also recorded which HAIs were MDR, where MDR was defined as resistance to at least three distinct classes of antibiotics [9]. Organisms were considered resistant based on minimum inhibitory concentration testing in our microbiology laboratory.

### *Statistical Analysis*

Statistical analysis was performed using SAS 9.3 software (SAS Institute, Cary, NC). Patients were stratified by whether they had HAI or not. For the two groups, demographic data, medical comorbidities, intraoperative data, and postoperative outcomes were analyzed using frequency tables and histograms. Continuous variables were reported as the median value and interquartile range, and categorical variables were summarized as the number and percentage of patients. Continuous variables