The Importance of Continued Quality Improvement Efforts in Monitoring Hospital-Acquired Infection Rates: A Cardiac Surgery Experience

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Background. **Hospital-acquired infections have been suggested to affect patients' outcomes and raise health care costs. However, research regarding the change in rates and types of infections over time remains limited.**

Methods. **All patients who underwent cardiac surgical procedures from 1995 to 2012 at the Queen Elizabeth II Health Sciences Center in Halifax, Canada were identified. The prevalence of superficial surgical site infection (sSSI), deep surgical site infection (dSSI), urinary tract infection, sepsis, pneumonia, and leg site infection was examined to determine trends in infections over time. Nonparsimonious logistic regression models were created to identify independent preoperative predictors of length of stay and infection onset.**

Results. **A total of 19,333 consecutive patients underwent cardiac surgical procedures, of whom 2,726 (14%) contracted at least one postoperative infection. The incidence of infections increased from 8% to 20% during the 17-year span ($p < 0.0001$). The overall prevalence of infection types, from highest to lowest, was pneumonia (6%), urinary tract infection (6%), sepsis (3%), sSSI (2%), leg infection (2%), and dSSI (1%). After adjusting for clinical differences, postoperative infection was found to be an independent predictor of length of stay longer than 9 days. In turn, independent predictors for contracting a postoperative infection included operative era, advanced age of patients, and complex procedures.**

Conclusions. **The incidence of infection increased nearly threefold since 1995 independent of patient- or procedure-related variables and was found to affect hospital length of stay significantly. Our findings highlight that efforts to monitor only rates of hospital-acquired infections may not in isolation help affect patient care.**

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Hospital-acquired infections (HAIs) affect patients' outcomes and consume a significant amount of our limited Canadian health care resources [1, 2]. In the United States alone, HAIs are among of the leading causes of death, affecting an estimated 2 million people annually and resulting in nearly 100,000 HAI-attributable deaths. With an aging population and a projected increasing demand for complex open heart procedures, these infections pose a growing economic burden on many health care systems regardless of the payers [3]. Yet, there has been surprisingly little work characterizing the incidence of these infections over long periods of time. Although relationships between rates of HAIs after cardiac surgical procedures and poorer health outcomes have previously been suggested [4], the true prevalence and impact of postoperative infections on the Canadian system have yet to be determined [5].

In Halifax, a data-driven continuing quality improvement [CQI] program initially designed as a monitoring tool to look at performance on delivery of cardiac care in Nova Scotia has been in place since 1995. In our CQI program, we review the outcomes of all patients undergoing cardiac surgical procedures on a semiannual basis by using the Maritime Heart Center (MHC) registry, originally modeled on the well-established database of The Society of Thoracic Surgeons (STS). In this article, we aim to clarify the prevalence and impact of postoperative infections over time in a Canadian center using this registry, which provides us with more than 19,000 records from 1995 to the present.

Material and Methods

Setting and Patients

All patients who underwent cardiac surgical procedures between 1995 and 2013 at the Queen Elizabeth II Health Sciences Center (QEII HSC) in Halifax, Canada were identified. The QEII HSC is the only cardiac surgical center for the province of Nova Scotia, and it serves a population of nearly 1 million. The MHC registry is a detailed, prospectively collected clinical database containing preoperative, intraoperative, and postoperative data on all cardiac operations performed. Using the MHC

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Abbreviations and Acronyms

CABG = coronary artery bypass graft
CQI = continued quality improvement
dSSI = deep surgical site infections
HAI = hospital-acquired infection
LOS = length of stay
MHC = Maritime Heart Center
MRSA = methicillin-resistant *Staphylococcus aureus*
QEII HSC = Queen Elizabeth II Health Science Center
ROC = receiver operating characteristic
sSSI = superficial surgical site infection
STS = Society of Thoracic Surgeons
UTI = urinary tract infection

registry, yearly CQI initiatives have been in place to review major mortality and morbidity data with appropriate risk adjustment, as previously described [6, 7]. Patients were excluded from the study if they had any active endocarditis infection at the time of the surgical procedure.

Procedure

Prophylactic antibiotics were administered in all patients and consisted of first-generation cephalosporin continued for two doses after surgery. Penicillin-allergic patients received vancomycin with the same frequency. Skin preparation has remained largely surgeon dependent and could include a combination of iodine and alcohol or a chlorhexidine-based solution. Placement of central catheters was done under strict sterile conditions in the operating room by anesthesiologists. Urinary catheters were also placed under sterile conditions in the operating room and were removed as soon as patients begin to ambulate.

Study Objectives

The primary objective of this study was to examine the change in rates and types of infections over time with regard to two outcomes: in-hospital mortality and hospital length of stay (LOS >9 days). The secondary objective was to develop a risk predictive model for HAIs after cardiac surgical procedures.

Study Design

To classify as a postoperative infection, one of the following three criteria were required: a wound opened with excision of tissue; a positive culture from respiratory secretions or pleural fluid, urine, wound, or blood; or treatment with antibiotics. The exact definitions used for documenting an infection were based on the STS guidelines [8] (Appendix). The database sources were comprehensive and included laboratory reports, progress notes, physicians' orders, and medication records. Low staff turnover ensured that data abstraction practices remained consistent over the duration of the study.

We chose to focus on six infection types because of their high relevance to our study population: (1) superficial surgical site infections (sSSIs), (2) deep surgical site infections (dSSIs;muscle, mediastinum, or bone involvement), (3) urinary tract infections (UTIs), (4) sepsis, (5) pneumonia, and (6) harvest site infections. It is routine practice in the institution that the laboratory provides an antibiogram when infections are identified, but these data were not captured in the MHC registry.

The clinical characteristics of patients who had a hospital LOS longer than 9 days, patients who died in the hospital, and patients who contracted any infection (category described earlier) were examined univariately. LOS is an important surrogate for postoperative morbidity, and we chose an LOS longer than 9 days on the basis of clinical significance because the cut-point represents the upper quartile of distribution from the median LOS reported during the study period. Categorical variables were reported as frequencies and percentages and were analyzed by the χ^2 or Fisher's exact test as appropriate. Design variables were created for reference level coding of categorical variables with more than two levels.

Nonparsimonious logistic regression models were then developed to predict hospital LOS longer than 9 days and the development of postoperative infections. The area under each receiver operating characteristic (ROC) curve was used to assess model discrimination. A bootstrap procedure was used to obtain 1,000 subsamples with replacement. The 2.5th and 97.5th percentiles of the bootstrap distribution were then used to determine the 95% Z confidence interval (CI) of the ROC. Model calibration was assessed by the Hosmer-Lemeshow goodness-of-fit statistic and by applying linear regression analysis to the calibration plot of deciles of observed versus predicted postoperative outcomes (LOS >9 days, in-hospital mortality, or the development of infection).

The SAS software package version 9.3 (SAS, Cary, NC) was used to complete all the statistical analyses. This study was conducted with the full approval of the institutional (Capital District Health Authority) Research Ethics Board.

Results

Patient Population

From 1995 to 2012, 19,333 consecutive patients underwent cardiac surgical procedures at the QEII HSC. Most patients were male (69%), had an average age of 64.7 ± 11.9 years (mean ± standard deviation [SD]), underwent isolated coronary artery bypass graft (CABG) procedures (66%), and had nonelective procedures (51%). Preoperatively, 32% had diabetes mellitus, 14% had a low ejection fraction (≤40%), and 6% had renal insufficiency (serum creatinine ≥176 mmol/L).

A total of 2,762 (14%) patients contracted at least one HAI during their cardiac surgical admission, defined