Hospitalization before surgery increases risk for postoperative infections

Marta Kelava, MD,[a] Michael Robich, MD, MSPH,[b] Penny L. Houghtaling, MS,[c] Joseph F. Sabik III, MD,[b] Steven Gordon, MD,[d] Tomislav Mihaljevic, MD,[b] Eugene H. Blackstone, MD,[b,c] and Colleen G. Koch, MD, MS, MBA[a]

Objectives: Exposure to a health care facility before surgery may increase risk for postoperative infections. Our objectives were to (1) determine whether the prevalence of postoperative infections was higher among patients who were hospitalized before cardiac surgery, (2) identify risk factors for infection, and (3) evaluate in-hospital outcomes.

Methods: A total of 32,707 patients underwent cardiac surgery from January 1, 2000, to January 1, 2011. Forty percent (13,107) were hospitalized before their surgery date or were transfers from other health care facilities, and 60% (19,600) were same-day admissions. The primary outcome consisted of a composite infection: pneumonia, sepsis, surgical site infection, and urinary tract infection. The secondary outcome was in-hospital death. The propensity method was used to compare infectious complications and mortality between groups.

Results: Overall infectious complications occurred in 2327 patients (7.1%). Overall composite and individual infections decreased over the study period (P for trend <.0001). Among 7814 propensity-matched pairs, 522 infections (6.7%) occurred in the same-day admission group versus 676 (8.7%) in the prior hospitalization group, $P < .0001$. In-hospital mortality was 1.5% (n = 120) for the same-day admission group versus 2.8% (n = 221) for the prior hospitalization group ($P < .0001$).

Conclusions: Although the risk of infection decreased over time, the relationship between exposure to a health care facility before surgical intervention and higher infection risk remained substantial. Further investigation into processes of care surrounding infection control is necessary to reduce postoperative infections and associated morbidity. (J Thorac Cardiovasc Surg 2014;148:1615-21)

Supplemental material is available online.

Postoperative nosocomial infections are among the most common noncardiac complications, with an estimated prevalence of 2.7% to 21.7%.[1-3] Although several patient-specific factors are reported to be associated with infection risk, evidence suggests that exposure to a health care facility before surgery increases infectious complications postoperatively.[4-7] Patients who acquire infections postoperatively have higher morbidity and mortality, and use of hospital resources is increased.[1,3,4,8] Because patients cannot be randomized to hospitalization before surgery, this investigation is considered a natural experiment.[9] To propose methods of ameliorating infection risk in cardiac surgery, the objectives of this study were to (1) determine whether the occurrence of postoperative infections was higher among patients who were hospitalized before surgery, (2) identify risk factors for infection, and (3) evaluate in-hospital mortality after infection.

PATIENTS AND METHODS

Patients

From January 1, 2000, to January 1, 2011, 32,707 adult patients underwent isolated coronary artery bypass grafting (CABG), an isolated valve procedure, combined CABG and valve surgery (with or without addition of a maze procedure or atrial septal defect repair), or ascending aorta replacement at Cleveland Clinic. A total of 13,107 patients (40%) were hospitalized before the surgery date or were transferred from other health care facilities; 19,600 (60%) presented for surgery on the day of operation. Patients who underwent heart or lung transplantation, major left ventricular procedures, endarterectomies,

From the Departments of Cardiothoracic Anesthesia[a] and Thoracic and Cardiovascular Surgery,[b] Heart and Vascular Institute, Department of Quantitative Health Sciences,[c] Research Institute, and Department of Infectious Disease,[d] Medicine Institute, Cleveland Clinic, Cleveland, Ohio.

This study was funded in part by the Cleveland Clinic Department of Thoracic and Cardiovascular Surgery, the Sheikh Hamdan bin Rashid Al Maktoum Distinguished Chair in Thoracic and Cardiovascular Surgery (held by Dr Sabik), and the Kenneth Gee and Paula Shaw, PhD, Chair in Heart Research (held by Dr Blackstone).

Disclosures: Authors have nothing to disclose with regard to commercial support.

Received for publication March 25, 2014; revisions received June 2, 2014; accepted for publication June 5, 2014.

Address for reprints: Colleen G. Koch, MD, MS, MBA, Cleveland Clinic, Department of Cardiothoracic Anesthesia, 9500 Euclid Ave, J4-331, Cleveland, OH 44195 (E-mail: kochc@ccf.org).

0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2014.06.067

PM

Abbreviations and Acronyms
CABG = coronary artery bypass grafting
SD = standard deviation

septal myectomies, or other procedures were excluded from this investigation. Perioperative variables were retrieved from the Cardiovascular Information Registry, a prospective database approved for use in research by the Institutional Review Board, with individual patient consent waived.

End Points

Our primary end point was a composite of postoperative infectious complications: surgical incision site infections (sternal wound, thoracotomy incision, leg and arm harvest site), septicemia, pneumonia, and urinary tract infections. A secondary end point was all-cause mortality evaluated with respect to prior hospitalization status.

Statistical Analyses

Categorical data are summarized by frequencies and percentages and continuous data by mean ± standard deviation (SD), or 15th, 50th (median), and 85th percentiles (equivalent to ±1 SD) when the distribution was skewed. Comparisons were made using the χ^2 test, Fisher's exact test, or the Wilcoxon rank-sum test where appropriate. Uncertainty is expressed by confidence limits equivalent to ±1 standard error (68%).

Propensity-Matched Comparison

The characteristics of the patients with prior hospitalization differed substantially from those of patients admitted on the day of surgery (Table 1). Therefore, the propensity-score method was used to obtain 2 cohorts of comparable patients for comparison of hospital outcomes.[10-12] Multivariable logistic regression analysis was used to identify the patient characteristics most associated with prior hospitalization (parsimonious model). The variables considered in this analysis are listed in Appendix E1. Variable selection, with a *P*-value criterion for retention of variables in the model of .05, used bagging (bootstrap aggregation),[13,14] with automated analysis of 500 resampled data sets, followed by tabulation of the frequency of occurrence of both single factors and closely related clusters of factors. Factors with occurrence of 50% or greater were retained in the final model. Thereafter, the parsimonious model was augmented with other variables representing patient demography, symptoms, cardiac and noncardiac comorbidities, and procedure variables (semisaturated propensity model). From this, a propensity score was calculated for each patient by solving the saturated model for the probability of being in the prior hospitalization group.

Using only the propensity score, previously hospitalized patients were matched to same-day surgery patients using a greedy matching strategy.[15] Patients whose propensity scores deviated more than 0.15 were considered unmatched. Greedy matching based on propensity scores yielded 7814 well-matched pairs (Figures 1 and 2 and Table 1).

Risk Factors for Infectious Complications

The occurrence of infection, time to infection, and temporal trends in the occurrence of postoperative infections were assessed. Multivariable logistic regression was performed to identify factors associated with postoperative infectious complications using the variables listed in Appendix E1 and bagging as described in the previous section.

All analyses were performed using SAS statistical software version 9.2 (SAS, Inc, Cary, NC).

RESULTS

Postoperative Infections

Prevalence. There were 2327 postoperative infectious complications overall (7.1%) among the 32,707 patients. Among the 7814 propensity-matched pairs, 676 (8.7%) experienced composite infection in the prior hospitalization group versus 522 (6.7%) in the same-day admission group, $P < .0001$. The difference was largely related to a higher prevalence of septicemia, pneumonia, and urinary tract infections in the prior hospitalization group (Table 2).

Prevalence among unmatched patients. Unmatched patients who were hospitalized before surgery had more comorbidities and a more unstable clinical presentation compared with unmatched same-day admission patients. These unmatched patients with prior hospitalizations had a higher prevalence of postoperative infections, 14% compared with 3.2% for unmatched same-day admission patients, $P < .0001$ (Table E1).

Timing. Among matched patients already hospitalized at the time of surgery, the median time from surgery to postoperative infection was 7.6 days (15th and 85th percentiles, 2.6 and 16 days, respectively; range, 0-74 days). Among matched patients admitted on the same day, the respective duration was 7.5 days (15th and 85th percentiles, 2.7 and 15 days, respectively; range, 0-53 days).

Temporal trends. The overall number of same-day admissions and hospital transfers remained relatively unchanged over the study period (Figure 3). A temporal trend of decreased prevalence of all types of infections was observed ($P < .0001$; Figures 4 and 5).

Risk factors. Several demographic, comorbidity, clinical presentation, and procedural factors were associated with a higher risk of composite infection (Table 3). Hospitalization before surgery was associated with a 1.9-fold increase in infection risk, greater than that of other comorbidities, including diabetes. Emergency surgery and intraoperative red blood cell transfusion were the only other variables that placed a patient at greater or similar risk of infection as prior hospitalization.

Mortality

Unadjusted in-hospital mortality was 0.85% (n = 167) for the same-day admission groups and 4.0% (n = 522) for the prior hospitalization group ($P < .0001$); for matched patients, it was 1.5% (n = 120) and 2.8% (n = 221), respectively ($P < .0001$). Mortality was lower among unmatched same-day admission patients (0.4%) than patients hospitalized before surgery (5.7%; $P < .0001$) (Table E1).

DISCUSSION

Principal Findings

Hospitalization before cardiac surgery was associated with more postoperative infectious complications than

PM