Variation in Tracheal Reintubations Among Patients Undergoing Cardiac Surgery Across Washington State Hospitals

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Objectives: **The objectives of this study were to examine the variation in reintubations across Washington state hospitals that perform cardiac surgery, and explore hospital and patient characteristics associated with variation in reintubation.**

Design: **Retrospective cohort study.**

Setting: **All nonfederal hospitals performing cardiac surgery in Washington state.**

Participants: **A total of 15,103 patients undergoing coronary artery bypass grafting or valvular surgery between January 1, 2008 and September 30, 2011.**

Interventions: **None.**

Measurements and Main Results: **Patient and hospital characteristics were compared between hospitals that had a reintubation frequency $\geq$5% or $<$5%. Multivariate logistic regression was used to compare the odds of reintubation across the hospitals. The authors tested for heterogeneity of odds of reintubation across hospitals by performing a likelihood ratio test on the hospital factor. After adjusting for patient-level characteristics and procedure type, significant heterogeneity in reintubations across hospitals was present ($p = 0.005$). This exploratory analyses suggested that hospitals with lower reintubations were more likely to have more acute care days and teaching intensive care units (ICU).**

Conclusions: **After accounting for patient and procedure characteristics, significant heterogeneity in the relative odds of requiring reintubation was present across 16 nonfederal hospitals performing cardiac surgery in Washington state. The findings suggested that greater hospital volume and ICU teaching status were associated with fewer reintubations.**

KEY WORDS: extubation failure, reintubation, cardiac surgery, critical care, outcomes

IN THE UNITED STATES, PATIENTS undergoing cardiac surgery routinely are transferred to the intensive care unit (ICU) postoperatively for continued mechanical ventilation.[1–3] Terminating mechanical ventilation in the initial postoperative hours after arrival to the ICU has been reported to be associated with fewer days in the ICU, shorter overall hospital length of stay, and fewer postoperative respiratory complications compared to delayed extubation.[1–4] Early extubation also is associated with decreased healthcare costs.[5] For these reasons, efforts are made to identify which patients are at the lowest risk for extubation and/or weaning failure so that invasive mechanical ventilation can be discontinued as early as possible after their admission to the ICU. Inevitably, some of these patients fail extubation and require reintubation.

Preoperative risk factors, which predict the need for prolonged mechanical ventilation in patients undergoing coronary artery bypass grafting (CABG), have been described.[1] Additionally, patient characteristics and predictors of reintubation in cardiac surgery patients have been reported.[6,7] However, little is known about whether or not significant variation in reintubation rates across different hospitals performing cardiac surgery exists and hospital level predictors of extubation failure.

The structure of care delivery also may be a risk factor for prolonged mechanical ventilation in postcardiac surgery patients. Recently, Dale and colleagues[8] reported that hospitals performing cardiac surgery that were using more guideline-adherent analgesia, sedation, and delirium order-sets had reduced duration of mechanical ventilation compared to hospitals with fewer guideline-adherent protocols. Thus, a more detailed understanding of hospital characteristics associated with higher occurrence of reintubation may serve as a target for future interventions to reduce failed extubation. The objectives of this study were to examine whether or not variation in reintubations across Washington state hospitals performing cardiac surgery was present and explore potential hospital characteristics associated with increased reintubation.

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METHODS

The Washington State Clinical Outcomes Assessment Program (COAP)[9] is a regional quality improvement initiative that includes nonfederal hospitals in the state of Washington that perform cardiac surgery. This initiative is housed under the auspices of the Foundation for Health Care Quality, a nonprofit organization designed to improve the quality of care delivered in Washington state. Trained abstractors capture data on all patients undergoing cardiac surgery in participating hospitals. Data are entered and reviewed quarterly and audited at all sites. The COAP database includes data elements from the Society of Thoracic Surgeons (STS) national cardiac surgery database.[10–13] COAP patient-level data were linked to hospital-level data that were collected as part of the Washington State Hospital Sedation Protocol Study.[14]

Using COAP data, the authors performed a retrospective cohort study of adult patients who underwent valvular or CABG cardiac surgery from January 1, 2008 to September 30, 2011 in all 16 nonfederal Washington state hospitals that perform cardiac surgery. Nonfederal hospitals are defined as hospitals not owned and operated by the U.S. Federal Government.[14] Patients were excluded if they underwent cardiac surgery other than valvular repair/replacement, CABG, or a combination of the two. The Human Subjects Division of the University of Washington reviewed the study application and determined it exempt from further review.

The COAP database included basic demographic information, medical comorbidities, preoperative cardiac status, operative procedure, elective versus nonelective status, reoperations, and the STS National Adult Cardiac Surgery Database risk prediction variables for predicted risk of 30-day mortality and prolonged mechanical ventilation.[10–13] Hospital-level variables included total number of hospital and ICU beds, number of acute care days based on 2009 census, open versus closed ICU type, teaching status, presence of computerized order entry system, and membership in a hospital network. Data on provider or nursing staffing or structure were not available. Acute care days represent the sum of intensive care patient days, semi-intensive care patient days and medical-surgical patient days as reported to Washington state for the year 2009, the most recent year for which complete data were available. The number of ICU days represented the total sum of patient days spent in the ICU in 2009. A closed ICU was defined as one where all patients had their care transferred to or directed by an intensivist-led team.[14,15] A hospital was considered a teaching hospital if residents or fellows provided care in the ICU. A hospital network was defined as an organization that operated 2 or more hospitals in Washington state or an adjoining metro area.[8,14]

For the purpose of this study, the authors chose to group hospitals into high reintubation and low reintubation hospitals using 5% as the threshold value of reintubations for descriptive purposes. The value of 5% was chosen as cut-off based on the reported incidence of reintubation in cardiac surgery patients in the literature, which ranged from 4% to7%.[6,7] Reintubation was defined according to the STS National Adult Cardiac Surgery Database definition. All reintubations occurring during the hospital stay after initial postoperative extubation were included in this definition.

The authors assessed the unadjusted proportions of reintubation across the 16 COAP hospitals. Patient and hospital characteristics were compared between hospitals that had a reintubation rate $\geq 5\%$ and hospitals that had a reintubation rate $< 5\%$. Data were expressed as mean (SD) for measured characteristics or in frequency distributions for categoric variables.

The authors descriptively examined the proportion of reintubations compared with hospital volume using funnel plots.[16] Funnel plots are a useful tool for identifying hospitals that may have significantly better or worse performance than others. The plots show the proportion of patients who were reintubated against the total number of patients at each hospital. The authors also included 95% and 99% confidence bands for testing whether the proportion of reintubations at each hospital was equal to the average across all hospitals.

The relative odds of reintubation across the 16 COAP hospitals were compared using multivariate logistic regression; the hospital with the lowest proportion of patients who were reintubated was used as the reference hospital (OR = 1.0). The primary question was to investigate whether or not all hospitals had the same proportion of reintubations (null hypothesis H_0: Reintubation at hospital #1 = #2 = #3… = hospital #16). The authors first examined the unadjusted models. Subsequently, adjusted models included potential confounders as determined a priori based on the literature to be associated with reintubation. The STS risk prediction score for prolonged mechanical ventilation for risk adjustment was used. In the primary analysis, with the exception of type of surgery, the authors did not further adjust for variables that already were included in the STS risk score, including gender, age, diabetes, moderate or severe lung disease, history of cerebrovascular disease, hypertension, active congestive heart failure, history of myocardial infarction, and elective versus emergency status. In addition to the STS score, the authors adjusted for race, body mass index (BMI), reoperations, and type of surgery. They tested for heterogeneity of risk of intubation across hospitals by performing a 15-df likelihood ratio test on the 16-level hospital factor. Sensitivity analyses were performed by fitting a model that included all the individual patient-level variables that were included in the calculation of the STS scores. In addition, for exploratory purposes, a separate logistic regression model was fit to assess the association between reintubation and 30-day mortality in this population. This model adjusted for race, BMI, reoperations, type of surgery, and STS risk prediction score for operative 30-day mortality.

To begin exploration of hospital characteristics that may explain the heterogeneity of reintubation, the authors refit the adjusted logistic regression model from the primary analysis including the hospital characteristics one at a time, instead of the hospital indicator.

All hypothesis tests and p values corresponded to two-sided tests. Because the sample size was so large, the authors provided effect estimates (eg, odds ratios) and associated confidence intervals. Data were analyzed using STATA, version 12.0 (StataCorp., College Station, TX) statistical software.