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

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Abstract

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Background—Patients requiring endotracheal reintubation have higher mortality, increased hospital length of stay and costs. To our knowledge, little is known about the variation in reintubation across hospitals among patients undergoing cardiac surgery.

Objectives—The objectives of this study were to: (1) Examine the variation in reintubations across Washington State hospitals that perform cardiac surgery, and (2) Explore hospital and patient characteristics associated with variation in reintubation.

Design—Retrospective cohort study

Setting—All non-federal hospitals performing cardiac surgery in Washington State

Participants—15,103 patients undergoing CABG or valvular surgery between January 1, 2008 and September 30, 2011

Measurements and Main Results—Patient and hospital characteristics were compared between hospitals that had a reintubation frequency 5% or < 5%. Multivariable logistic regression was used to compare the odds of reintubation across the hospitals. We 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 ($p=0.005$). Our exploratory analyses suggested that hospitals with lower reintubations were more likely to have greater acute care days and teaching ICUs.

Conclusions—After accounting for patient and procedure characteristics, significant heterogeneity in the relative odds of requiring reintubation was present across 16 non-federal hospitals performing cardiac surgery in Washington State. Our findings suggest that greater hospital volume and ICU teaching status are associated with less reintubations.

Keywords

extubation failure; reintubation; cardiac surgery; critical care; outcomes

Introduction

In the United States, patients undergoing cardiac surgery are routinely transferred to the intensive care unit (ICU) postoperatively for continued mechanical ventilation.¹⁻³ Liberation from 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 is also associated with decreased health care 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 may also be a risk factor for prolonged mechanical ventilation in post-cardiac surgery patients. Recently, Dale and colleagues 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 less guideline-adherent protocols.⁸ 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: (1) Examine whether or not variation in reintubations across Washington State hospitals performing cardiac surgery is present and (2) Explore potential hospital characteristics associated with increased reintubation.

Methods

Design and Setting

The Washington State Clinical Outcomes Assessment Program (COAP)⁹ is a regional quality improvement initiative that includes non-federal 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 non-profit 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 We linked COAP patient-level data to hospital-level data that were collected as part of the Washington State Hospital Sedation Protocol Study.¹⁴

Using COAP data, we 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 non-federal Washington State hospitals that perform cardiac surgery. Non-federal hospitals are defined as hospitals not owned and operated by the U.S. Federal government.¹⁴ Patients were excluded if they underwent a cardiac operation 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.

Data collection

The COAP database included basic demographic information, medical comorbidities, preoperative cardiac status, operative procedure, elective versus non-elective status, reoperations, and the Society of Thoracic Surgeons 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 represents 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 provide care in the ICU. A hospital network was defined as an organization that operated two or more hospitals in Washington State or an adjoining metro area.^{8,14}

For the purpose of this study, we 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 ranges from 4-7%.^{6,7} Reintubation was defined according to the Society of Thoracic Surgeons National Adult Cardiac Surgery Database definition. All reintubations occurring during the hospital stay after initial post-operative extubation are included in this definition.

Statistical Analysis

We 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 categorical variables.

We 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. We also include 95% and 99% confidence bands for testing whether the proportion of reintubations at each hospital is equal to the average across all hospitals.

We compared the relative odds of reintubation across the 16 COAP hospitals using multivariable logistic regression; the hospital with the lowest proportion of patients who were re-intubated was used as our reference hospital (OR = 1.0). Our 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). We first examined the unadjusted models. Subsequently, adjusted models included potential confounders as determined *a priori* based on the literature to be associated with reintubation. We used the Society of Thoracic Surgeons (STS) risk prediction score for prolonged mechanical ventilation for risk adjustment. In the primary analysis, with the exception of type of surgery, we did not further adjust for variables that were already 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, we adjusted for race, body mass index (BMI), reoperations, and type of surgery. We tested for

heterogeneity of risk of intubation across hospitals by performing a 15-df likelihood ratio test on our 16-level hospital factor. Sensitivity analyses were performed by fitting a model that included all the individual patient-level variables that are 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 thirty-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.

In order to begin exploration of hospital characteristics that may explain the heterogeneity of reintubation, we re-fit 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 correspond to two-sided tests. Since the sample size is so large, we provide effect estimates (e.g., odds ratios) and associated confidence intervals. Data were analyzed using STATA, version 12.0 (StataCorp., College Station, TX) statistical software.

Results

Patient Characteristics

15,103 patients were included in this study; characteristics of these patients, grouped by high reintubation versus low reintubation hospitals, are displayed in Table 1. Five hospitals were classified as high reintubation group and 11 hospitals were in the low reintubation group. Overall, a total of 678 (4.5%) patients were reintubated during the hospital stay. Hospitals with higher reintubations had slightly younger patients (65 years $\pm$ 12 versus 67 years $\pm$ 11 years) and patients with higher BMIs (30 $\pm$ 6.6 versus 29 $\pm$ 8.0). Additionally, at higher reintubation hospitals more patients had hypertension, moderate or severe lung disease, cerebrovascular disease, and class 3 or 4 NYHA heart failure. There was an association between higher STS score for prolonged mechanical ventilation and hospitals with higher reintubations (0.12 $\pm$ 0.12 versus 0.11 $\pm$ 0.11). There was a small difference between hospitals in proportion of patients requiring reoperation (8% versus 7%, high versus low reintubation hospitals, respectively). There was no difference in the STS score for predicted risk of operative 30-day mortality (mean score 0.03 $\pm$ 0.04 for both groups, Table 1). Patient characteristics grouped by reintubation status are displayed in E-appendix 1.

Hospital characteristics

Higher reintubation hospitals performed more non-elective surgery (49% versus 40%) and more CABG surgeries (68% versus 62%), when compared to low reintubation hospitals. Hospital bed size was similar between high-performing and low-performing hospitals (251 beds $\pm$ 97 versus 249 $\pm$ 88 beds, respectively). The number of ICU days was higher in high reintubation hospitals (22k $\pm$ 20k versus 15k $\pm$ 12k, high versus low reintubation hospitals, respectively). Fewer hospitals in the high reintubation group had teaching ICUs when compared to the low reintubation group [2 (40%) versus 7 (64%), high versus low, respectively]. Fewer hospitals in the high reintubation group had computerized provider order entry [1 (20%) versus 6 (55%), high versus low, respectively]. Additional

characteristics of high reintubation hospitals compared to low reintubation hospitals are displayed in Table 2.

Primary analyses

Figure 1 shows the results from the funnel plot. The average proportion of reintubations across all hospitals was 4.4% and we see that two hospitals perform significantly worse than this average, while one performs significantly better. Overall, the plot supports our choice of the 5% cut-point for reintubation based on the literature: four of the five hospitals considered as having a high proportion of reintubations by the 5% cut-point are at least close to being significantly worse than average. We first examined the unadjusted odds of reintubation across hospitals and found significant heterogeneity ($p < 0.01$). After adjustment for the STS score for risk of prolonged mechanical ventilation, BMI, incidence of reoperation, race and type of surgery, the heterogeneity persisted ($p < 0.01$). Results of full multivariate logistic regression model displayed in E-appendix 2. The adjusted odds of reintubation across the 16 hospitals are displayed in Figure 2, using the hospital with the lowest unadjusted reintubation as a reference.

Secondary analyses

In sensitivity analyses, we added the individual patient-level variables that are included in the STS risk prediction score for prolonged mechanical ventilation into the model and found no difference in results. In exploratory analyses of hospital characteristics associated with reintubation, we found that hospitals with more acute care days had a significantly lower odds of reintubation after adjusting for patient characteristics (OR for 1.1-fold (10%) increase: 0.98, 95% CI: 0.96, 1.0; $p = .03$). We also found that teaching ICUs were associated with significantly lower odds of reintubation (OR: 0.78, 95% CI: 0.65, 0.94; $p < 0.01$). Even though in univariate analyses the number of ICU beds and ICU days appeared higher in high reintubation hospitals, this association was not significant in multivariate analyses [(ICU beds: OR: 1.00, 95% CI: 0.95, 1.05; $p = 0.89$) and (ICU days: OR: 1.00, 95% CI: 0.99, 1.01; $p = 0.56$).

In addition, we explored the association between reintubation and 30-day mortality and found that reintubated patients also had a significantly higher odds of 30-day mortality when compared to non-reintubated patients, after adjusting for race, BMI, reoperation, type of surgery, and STS risk prediction score for operative 30-day mortality (OR 2.8; 95% CI 2.5-3.0; $p < .01$).

Discussion

Our findings demonstrated that (1) there is significant variation in the odds of requiring reintubation across hospitals performing cardiac surgery in Washington State, and (2) this variability persisted after adjusting for patient-level characteristics and other risk factors. Our findings also suggest that hospital structure and processes of care, specifically higher number of acute care days and teaching status, may be associated with reduced reintubations. We also found that patients requiring reintubation had nearly 3-fold higher 30-day mortality than patients who were not postoperatively reintubated. This is consistent with

previous studies observing higher hospital mortality, increased length of ICU and hospital stay, and prolonged mechanical ventilation in patients requiring reintubation during hospitalization.^{1-4,17-25} It is unclear if the worse outcome observed in reintubated patients is related to complications associated with reintubation itself⁶, or to higher patient morbidity, or a combination of both. For these reasons, understanding drivers of variation in reintubation beyond patient risk factors is a potentially important area for targeted interventions to reduce the incidence and morbidity associated with reintubation.

The association between ICU teaching status and lower relative odds of reintubation may be due to several factors. First, teaching hospitals might be better staffed with physicians around the clock to assist in immediate pre- and post-extubation management. Currently, most ventilation weaning protocols help to determine who can breathe unassisted, not necessarily successful extubation.²⁶ Second, teaching status may be a marker for other structural elements of care which may lead to avert reintubation, including greater respiratory therapy support.

Additionally, the finding that a greater number of acute care days was associated with a lower odds of reintubation also suggests that hospital volume may be an important factor contributing to the higher likelihood of reintubation. For the majority of cardiac surgical patients, their ICU length of stay will be <48 hours and the amount of time spent mechanically ventilated will be measured in hours.^{27,28} Thus, we interpret our finding of greater ICU days among high reintubation hospitals as subsequent reintubation(s) contributing to greater duration of mechanical ventilation and resultant ICU length of stay. We cannot exclude the contribution of other complications that may have led to an increase in ICU days independent of duration of mechanical ventilation such as hypoxemia not requiring mechanical ventilation, arrhythmias, continued need for vasopressor and/or inotropes, or persistent agitation/delirium. While the consequence of reintubation is to increase the volume of ICU days, we found that hospitals with higher acute days, i.e. higher volume centers, have overall lower reintubations. The favorable effect of case volume on outcome has already been observed in a variety of settings. For example, Kahn and colleagues found that for mechanically ventilated patients, care in higher volume hospitals was independently associated with a reduction in mortality.²⁹ While hospital volume is not readily modifiable, arguments have been made in support of regionalization of care - an approach that has proven effective in the care of trauma patients and neonates.³⁰⁻³² In addition, specific education regarding assessment for readiness of extubation may have a role in this setting.

A recent report suggested that the use of a preintubation checklist significantly reduced the occurrence of cardiovascular collapse and hypoxemia within 60 minutes of emergent intubation in the ICU.³³ The use of clinical protocols and post-surgical care pathways is common in cardiac surgery and is associated with improved outcomes and decreased costs.³⁴⁻³⁷ For example, Piotto and colleagues found that using a specific protocol for mechanical ventilation weaning in heart patients had better outcomes than weaning carried out without a standardized protocol, leading to shorter weaning times and lower reintubation rates.³⁸ The ability to risk-stratify patients at high risk for extubation failure and implement evidence-based measures to optimize and standardize care, may also potentially improve

patient safety and reduce the incidence of reintubation.^{39,40} Protocol use is variable across teaching ICUs and Washington State⁴¹ and higher volume hospitals have been shown to be associated with higher-quality protocols and improved outcomes.^{8,14} Improving the quality of ICU extubation protocols might lead to better extubation outcomes.

Our study has several strengths. First, to our knowledge, this is the first study to examine the variation in reintubations across a group of hospitals performing cardiac surgery. Second, the COAP database contains high quality data from all non-federal hospitals in WA State, including important elements from the Society of Thoracic Surgeons National Adult Cardiac Surgery Database that enable accurate risk adjustment for patient level factors. Lastly, to our knowledge, this is the only study that explored hospital characteristics that may impact the occurrence of reintubation.

We acknowledge that our study has several limitations. First, our data did not contain the reason for reintubation; however, we did adjust for reoperations to account for reintubations due to operative procedures. We recognize that indications for early versus late reintubation might have different reasons and implications. Second, the hospitals we evaluated are all in one region of the country, thus potentially limiting the generalizability of results to other States. Third, due to the small number of hospital clusters, we recognize that the study is underpowered to detect structure and processes of care characteristics at the hospital level that may affect reintubation. We recognize that our analyses of specific hospital characteristics are only exploratory in nature and should be regarded only as hypothesis generating. Fourth, we recognize that unmeasured patient characteristics may have confounded our results. Lastly, additional elements related to processes of care and structure of hospitals, such as ratio of ICU nurses to patients, provider staffing models, and respiratory therapy involvement would provide more insight into the observed variation in odds of reintubation across hospitals. Nevertheless, describing the variability in reintubations across WA State hospitals performing cardiac surgery provides valuable information that can be used to design future studies aiming at reducing variation in reintubation. Whether or not an extubation safety algorithm can reduce the number of failed extubations and reduce complications associated with reintubation in cardiac surgery patients needs to be determined.

Conclusions

After accounting for patient and procedure characteristics, significant heterogeneity in the relative odds of requiring reintubation was present across 16 non-federal hospitals performing cardiac surgery in Washington State. Our findings suggest that hospital structure and processes of care, specifically higher number of acute care days and ICU teaching status, may contribute to this observed variability, warranting future investigation.

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E-appendix 1

Patient characteristics stratified by reintubation status

Characteristics	All Patients	Re-intubated	Not re-intubated	P value ^a
N (%)	15,103	678 (4.5)	14,425 (95.5)	
Age (years), mean $\pm$ SD	66.6 $\pm$ 11.4	70.4 $\pm$ 10.6	66.4 $\pm$ 11.4	<0.001
Male gender, n (%)	10,890 (72.1)	444 (65.5)	10,446 (72.4)	<0.001
Body mass index (kg/m ²), mean $\pm$ SD	29.6 $\pm$ 7.6	29.2 $\pm$ 6.6	29.6 $\pm$ 7.6	0.08
Race/Ethnicity, n (%)				<0.001
White	13,770 (91.2)	616 (90.9)	13,154 (91.2)	
Black	224 (1.5)	9 (1.3)	215 (1.5)	
Asian	453 (3.0)	31 (4.6)	422 (2.9)	
Other	656 (4.3)	22 (3.2)	634 (4.4)	
Diabetes, n (%)	5,247 (34.7)	259 (38.2)	4,988 (34.6)	0.05
Hypertension, n (%)	11,833 (78.3)	578 (85.3)	11,255 (78.0)	<0.001
Dialysis, n (%)	310 (2.1)	27 (4.0)	283 (2.0)	<0.001
Moderate or severe lung disease, n(%)	1,541 (10.2)	133 (19.6)	1,408 (9.8)	<0.001
Cerebrovascular disease, n (%)	2,312 (15.3)	165 (24.3)	2,147 (14.9)	<0.001
NYHA Classification III or IV of Heart Failure, n(%) Preoperative cardiac status	2307 (60.6)	195 (71.2)	2,112 (59.8)	<0.001
Prior Myocardial Infarction, n (%)	5,530 (36.6)	300 (44.2)	5,230 (36.3)	<0.001
Cardiogenic Shock, n (%)	274 (1.8)	32 (4.7)	242 (1.7)	<0.001
Resuscitation, n (%)	114 (0.8)	12 (1.8)	102 (0.7)	<0.001
Arrhythmia, n (%)	1,818 (12.8)	124 (19.3)	1,694 (12.5)	<0.001
Elective Surgery	8,681 (57.5)	329 (48.5)	8,352 (57.9)	<0.001
Type of Surgery				<0.001
Coronary artery bypass grafting	9,685 (64.1)	387 (57.1)	9,298 (64.5)	
Valve surgery	5,007 (33.2)	250 (36.9)	4,757 (33.0)	
CABG + Valve surgery	411 (2.7)	41 (6.0)	370 (2.6)	
Reoperations	1,058 (7.0)	65 (9.6)	993 (6.9)	0.01
Initial Hours Ventilated	4.9 (3.0, 8.3)	8.0 (4.0, 20.0)	4.7 (3.0, 8.0)	0.06
<u>Society of Thoracic Surgeons Predicted Patient Risk Scores^c</u>				
Predicted risk (% chance) of prolonged (> 24 hours) mechanical ventilation, mean $\pm$ SD ^b	0.114 $\pm$ 0.111	0.189 $\pm$ 0.156	0.111 $\pm$ 0.107	<0.001
Predicted risk (% chance) of operative/30 day mortality, mean $\pm$ SD ^b	0.026 $\pm$ 0.041	0.052 $\pm$ 0.070	0.025 $\pm$ 0.039	<0.001

SD: standard deviation; NYHA: New York Heart Association

^aTwo-sample t-test with assumption of unequal variance or Chi-square test statistic

^bAs predicted by the Society of Thoracic Surgeons National Adult Cardiac Surgery risk adjustment score, version 2.73.

^cVariables included in the risk score: gender, age, diabetes, moderate or severe lung disease, history of cerebrovascular disease, hypertension, active congestive heart failure, and history of myocardial infarction

E-appendix 2

Multivariate logistic regression model

Variable	Coefficient	Std. Error	95% Conf. Interval		p-value
Intercept	-3.116	0.257	-3.620	-2.613	<0.001
Hospital					
0	0 (ref)	--	--	--	--
1	0.102	0.170	-0.231	0.434	0.549
2	-0.076	0.197	-0.462	0.310	0.699
3	0.015	0.192	-0.361	0.391	0.939
4	-0.222	0.241	-0.694	0.249	0.356
5	-0.240	0.251	-0.733	0.252	0.339
6	-0.477	0.236	-0.940	-0.015	0.043
7	-0.303	0.207	-0.709	0.103	0.144
8	-0.271	0.173	-0.610	0.069	0.118
9	-0.458	0.157	-0.766	-0.150	0.004
10	-0.404	0.247	-0.888	0.080	0.102
11	-0.463	0.178	-0.811	-0.114	0.009
12	-0.531	0.232	-0.985	-0.077	0.022
13	-0.443	0.242	-0.917	0.032	0.068
14	-0.900	0.598	-2.071	0.271	0.132
15	-0.612	0.200	-1.004	-0.219	0.002
BMI	-0.009	0.006	-0.022	0.003	0.145
Reoperation	0.049	0.142	-0.230	0.327	0.732
STS risk score	3.575	0.240	3.105	4.046	<0.001
White race	0.044	0.145	-0.239	0.328	0.759
Type of surgery					
CABG	0 (ref)	--	--	--	--
Valve	0.124	0.088	-0.049	0.298	0.16
CABG + Valve	0.329	0.188	-0.039	0.698	0.08

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Figure 1. Funnel plot

The funnel plot shows the estimated proportion of reintubations at each hospital (dots). The average proportion across all hospitals (4.4%) is shown by the solid line. The dashed and dotted lines provide confidence intervals for the test of whether each hospital is significantly worse than average at the 0.05 and 0.01 level of significance, respectively. Thus, if a dot falls above/below the dashed/dotted confidence bands, we may conclude that the proportion of patients reintubated at that hospital is significantly higher/lower than average at a 0.05/0.01 level of significance. Dots: Estimated proportion of reintubations at each hospital; Solid line: Average proportion of patients reintubated across all hospitals; Dashed line: 95% confidence band for average proportion of patients reintubated across all hospitals; Dotted line: 97.5% confidence band for average proportion of patients reintubated across all hospitals

Figure 2.
Adjusted odds ratios (and 95% confidence intervals) of reintubation in cardiac surgery patients (N=14,957) across the 16 Washington State hospitals.

Table 1
Patient Characteristics

Characteristics N (%)	All Patients N=15,103	5% Reintubation n=4,591	< 5% Reintubation n=10,512	p-value
Age (years), mean $\pm$ SD	67 $\pm$ 11	65 $\pm$ 12	67 $\pm$ 11	<0.001
Male gender, n (%)	10,890 (72.1)	3,316 (72.3)	7,574 (72.1)	0.05
Body mass index (kg/m ²), mean $\pm$ SD	29 $\pm$ 8	30 $\pm$ 6.6	29 $\pm$ 8	<0.001
Race/Ethnicity, n (%)				<0.001
White	13,770 (91.2)	4,152 (90.4)	9,618 (91.5)	
Black	224 (1.5)	110 (2.4)	114 (1.1)	
Asian	453 (3.0)	164 (3.6)	289 (2.7)	
Other	656 (4.3)	165 (3.6)	491 (4.7)	
Diabetes, n (%)	5,247 (34.7)	1,621 (35.3)	3,626 (34.5)	0.34
Hypertension, n (%)	11,833 (78.3)	3,694 (80.5)	8,139 (77.4)	<0.001
Dialysis, n (%)	310 (2.1)	95 (2.1)	215 (2.0)	0.69
Moderate or severe chronic lung disease, n (%)	1,541 (10.2)	723 (15.8)	818 (7.8)	<0.001
Cerebrovascular disease, n (%)	2,312 (15.3)	750 (16.3)	1,562 (14.9)	0.02
NYHA Class III or IV of Heart Failure, n (%) ^a	2,307 (60.6)	821 (64.8)	1,486 (58.5)	<0.001
Preoperative cardiac status				
Prior Myocardial Infarction, n (%)	5,530 (36.6)	1,826 (39.8)	3,704 (35.2)	<0.001
Cardiogenic Shock, n (%)	274 (1.8)	117 (2.5)	157 (1.5)	<0.001
Resuscitation, n (%)	114 (0.8)	40 (0.9)	74 (0.7)	0.27
Arrhythmia, n (%)	1,818 (12.8)	566 (13.0)	1,252 (12.7)	0.61
Elective surgery	8,681 (57.5)	2,336 (50.9)	6,345 (60.4)	<0.001
Type of Surgery				<0.001
Coronary artery bypass grafting	9,685 (64.1)	3,127 (68.1)	6,558 (62.4)	
Valve surgery	5,007 (33.2)	1,360 (29.6)	3,647 (34.7)	
CABG + Valve surgery	411 (2.7)	104 (2.3)	307 (2.9)	
Reoperations	1,058 (7.0)	342 (7.5)	716 (6.8)	0.14
Initial hours ventilated, median (IQR) Society of Thoracic Surgeons Predicted Patient Risk Scores ^b	4.9 (3.0, 8.3)	5.0 (3.6, 9.9)	4.4 (3.0, 8.0)	0.27
Society of Thoracic Surgeons Predicted Patient Risk Scores ^b				
Risk of prolonged (> 24 hours) mechanical ventilation, mean $\pm$ SD ^c	0.11 $\pm$ 0.11	0.12 $\pm$ 0.12	0.11 $\pm$ 0.11	<0.001
Risk of operative 30 day mortality, mean $\pm$ SD ^c	0.03 $\pm$ 0.04	0.03 $\pm$ 0.04	0.03 $\pm$ 0.04	0.05

SD: standard deviation; NYHA: New York Heart Association

^aColumn sample sizes: n=3806, n=1267, n=2539, respectively

^bAs predicted by the Society of Thoracic Surgeons National Adult Cardiac Surgery risk adjustment score, version 2.73.

^cVariables included in the risk score: gender, age, diabetes, moderate or severe lung disease, history of cerebrovascular disease, hypertension, active congestive heart failure, history of myocardial infarction, type of surgery and elective/non-elective status

Table 2
Hospital characteristics

Characteristics	All Hospitals N=16	5% Reintubation n=5	< 5% Reintubation n=11	p- value
Number of total hospital beds, mean $\pm$ SD	250 $\pm$ 87	251 $\pm$ 97	249 $\pm$ 88	0.98
Number of ICU beds, mean $\pm$ SD	47 $\pm$ 38	63 $\pm$ 54	39 $\pm$ 29	0.39
Number of cardiac surgery patients, mean $\pm$ SD	944 $\pm$ 538	918 $\pm$ 394	956 $\pm$ 609	0.89
ICU Length of stay, days, median (IQR)	1.1 (0.8, 2.3)	1.9 (1.0, 3.2)	1.0 (0.8, 2.0)	<0.00 1
Duration of initial intubation, hours, median (IQR) ^a	4.9 (3.0, 8.3)	5.0 (3.0, 9.0)	4.7 (3.0, 8.0)	0.05
Number of acute care days 2009, ^a mean $\pm$ SD	71,782 $\pm$ 27,279	70,000 $\pm$ 25,840	72,592 $\pm$ 29,101	0.87
Number of ICU days 2009, ^b mean $\pm$ SD	16,885 $\pm$ 14,276	21,647 $\pm$ 19,794	14,721 $\pm$ 11,512	0.50
One ICU (vs. >1), n (%)	8(50.0)	3 (60.0)	5 (45.5)	0.59
Part of a larger hospital network, n (%)	10(62.5)	3 (60.0)	7 (63.6)	0.89
Teaching ICU, n (%)	9(56.3)	2 (40.0)	7 (63.6)	0.38
Open ICU, n (%)	12(75.0)	3 (60.0)	9 (81.8)	0.35
Computerized provider order entry, n (%)	7(43.8)	1 (20.0)	6 (54.5)	0.20
Order set quality score ^d	12 $\pm$ 5	12 $\pm$ 6	12 $\pm$ 4	0.90

SD: standard deviation; IQR: interquartile range

^aP-value derived from each individual patient's unique value (testing over all subjects)

^b Acute care days are the sum of intensive care patient days, semi-intensive care patient days and medical-surgical patient days as reported to WA State for the year 2009

^c ICU days represent the number of patient days spent in the intensive care unit as reported to WA State for the year 2009

^d Sedation order set quality score