Demographic and Clinical Variables Associated With 30-day Re-Intubation Following Surgical Aortic Valve Replacement

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BACKGROUND: A retrospective study was performed to evaluate factors associated with 30-d re-intubation following surgical aortic valve repair. We hypothesized a significant increase in the odds of re-intubation among patients with preoperative comorbidities. METHODS: The American College of Surgery National Surgical Quality Improvement Program database from 2007 to 2016 was used to evaluate demographic and clinical factors associated with 30-d re-intubation following surgical aortic valve repair. Multivariable logistic regression was used to report factors associated with 30-d re-intubation while controlling for various patient characteristics. RESULTS: The study population consisted of 5,766 adult subjects who underwent surgical aortic valve repair, of whom 258 (4.47%) were re-intubated within 30 d of surgery. The mean ± SD age was 69 ± 12.98 y, and 3,668 (63.6%) were male. The prevalence of diabetes mellitus, shortness of breath, poor functional status, COPD, congestive heart failure, hypertension, and bleeding disorder was higher among subjects who were re-intubated compared to those who were not ($P < .05$). Age, severe COPD, congestive heart failure, and bleeding disorder were associated with this outcome. CONCLUSIONS: Age, COPD, congestive heart failure, and bleeding disorder were associated with 30-d re-intubation in this surgical cohort. If surgical aortic valve repair is deemed non-emergent, patients should be optimized preoperatively and receive careful postoperative planning to reduce the risk of postoperative complications. *Key words: re-intubation; surgical aortic valve repair; optimization; aortic stenosis; ACS NSQIP; comorbidity.* [Respir Care 2021;66(2):248–252. © 2021 Daedalus Enterprises]

Introduction

Symptomatic aortic stenosis leads to heart failure and death and has a 2-y mortality rate of roughly 50%.[1] For patients with low-to-moderate surgical risk, surgical aortic valve replacement (SAVR) is the mainstay treatment. Despite recent advancements in prosthetic valve design, surgical technology, and perioperative management, surgical complications, specifically re-intubation, may occur. Alterations to the respiratory system occur immediately upon induction of general anesthesia, and it may take ~ 6 weeks to return to its preoperative state.[2] As such, pulmonary complications are the second leading cause of postoperative morbidity in cardiac surgical populations.[2,3]

Re-intubation following cardiac surgery is associated with multiple adverse outcomes, including higher rates of morbidity and mortality, longer stay in the ICU, and

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increased hospital costs and resources.[4] However, re-intubation may be necessary to prevent postoperative respiratory failure, which may occur as a postoperative adverse event. A comparison of cardiac surgery mortality rates demonstrates that aortic valve replacement has the highest morbidity and mortality among different types of cardiac surgery.[5] In a retrospective study of 18,571 cardiac surgery subjects, Beverly et al[4] reported that aortic valve replacement was the third most common type of cardiac surgery. This demonstrates the need to further risk stratify this specific surgical population by evaluating risk factors with postoperative outcomes. Because there are few studies assessing predictors for 30-d re-intubation rate after SAVR, we performed a retrospective study to evaluate demographic and clinical factors associated with 30-d re-intubation following SAVR, using the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database. We hypothesized that there will be a combination of modifiable and non-modifiable risk factors for this outcome metric.

QUICK LOOK

Current knowledge

Aortic stenosis may lead to heart failure, and, for patients with low-to-moderate surgical risk, surgical aortic valve repair is the mainstay treatment. Re-intubation following cardiac surgery is associated with higher rates of morbidity and mortality, longer stay in the ICU, and increased hospital costs.

What this paper contributes to our knowledge

This study focused on the relationship between preoperative patient-specific factors and re-intubation among subjects who underwent surgical aortic valve repair. We found that age, COPD, congestive heart failure, and bleeding disorder were associated with 30-d re-intubation.

Methods

Data Collection

The ACS NSQIP registry was used to evaluate demographic and clinical factors associated with 30-d re-intubation following SAVR. This multi-center registry collects demographic and perioperative data from > 600 participating hospitals in the United States.[6] The Institutional Review Board 45 Code of Federal Regulation 46.101 classifies the study as exempt from patient consent. Here, the surgical study population was defined as patients ≥ 18 y old who underwent SAVR between 2007 and 2016, as identified by the common procedural terminology codes of 33405, 33406, 33410, 33411, 33412, and 33413. The primary end point was 30-d re-intubation. ACS NSQIP defines 30-d re-intubation as the need for endotracheal intubation with mechanical ventilation in patients who developed respiratory or cardiac failure as evidenced by hypoxia, hypercarbia, or respiratory acidosis within 30 d following surgery.

Sociodemographic factors included sex, age, and smoking tobacco within 30 d of surgery. Clinical factors included body mass index, diabetes mellitus, preoperative shortness of breath, functional status, COPD, congestive heart failure, hypertension, bleeding disorder, and American Society of Anesthesiology (ASA) Physical Status Classification System (1 = a normal, healthy patient; 2 = a patient with mild systemic disease; and 3 = a patient with severe systemic disease). We categorized body mass index as < 20 kg/m^2 = underweight; 20–24.9 kg/m^2 = normal weight; 25–29.9 kg/m^2 = overweight; 30–39.9 kg/m^2 = obese, and >40 kg/m^2 = severely obese. The case duration, recorded in minutes, was the only intra-operative variable included in the study. ACS NSQIP defines bleeding disorder as patients with "any condition that places the patient at risk for excessive bleeding requiring hospitalization due to a deficiency of blood clotting elements (eg, vitamin K deficiency, hemophilia, thrombocytopenia, chronic anticoagulation therapy that has not been discontinued prior to surgery)."[6]

The association of 30-d re-intubation with postoperative outcomes following SAVR was also reported. Postoperative end-points included hospital stay, mechanical ventilation ≥ 48 h, pneumonia, pulmonary embolism, sepsis, renal complications (eg, urinary tract infection, renal insufficiency, and acute kidney injury), deep venous thrombosis, cardiac complications (eg, myocardial infarction or cardiopulmonary arrest), surgical site infection (eg, superficial, wound infection, or organ space), postoperative transfusion, reoperation, and mortality defined as death within 30 d of SAVR. Postoperative transfusion was defined as ≥ 1 unit of packed or whole red blood cell given up to 72 h postoperatively.

Statistical Analysis

Statistical analysis was performed using R 3.3.3, a software environment for statistical computing. Pearson chi-square and independent samples *t* tests were used to report the unadjusted estimate of sociodemographic, clinical, and postoperative variables with 30-d re-intubation. Pearson chi-square and independent samples *t* tests were used for categorical and continuous variables, respectively. Multivariable logistic regression was used to report factors associated with 30-d re-intubation while controlling for various patient characteristics. The 2-tailed significance level was set at $P < .05$.

Table 1. Study Characteristics Among Subjects Undergoing Surgical Aortic Valve Repair

	Study Population ($N = 5,766$)	Not Re-intubated ($n = 5,508$)	Re-intubated ($n = 258$)	P
Male	3,668 (63.6)	3,502 (63.6)	166 (64.3)	.86
Age, y	69.0 ± 13.0	68.8 ± 13.0	72.7 ± 11.7	< .001
Body mass index, kg/m^2				.41
< 20	136 (2.4)	126 (2.3)	10 (3.9)	
20–24.9	1,016 (17.6)	971 (17.6)	45 (17.4)	
25–29.9	1,839 (31.9)	1,758 (31.9)	81 (31.4)	
30–39.9	1,815 (31.5)	1,741 (31.6)	74 (28.7)	
> 40	960 (16.6)	912 (16.6)	48 (18.6)	
Diabetes mellitus				.004
No	4,302 (74.6)	4,132 (75.0)	170 (65.9)	
Non-insulin dependent	944 (16.4)	888 (16.1)	56 (21.7)	
Insulin dependent	520 (9.0)	488 (8.9)	32 (12.4)	
Active smoker	741 (12.9)	707 (12.8)	34 (13.2)	.95
Shortness of breath				< .001
No	2,527 (43.8)	2,443 (44.4)	84 (32.6)	
Moderate exertion	2,898 (50.3)	2,753 (50.0)	145 (56.2)	
At rest	341 (5.9)	312 (5.7)	29 (11.2)	
Poor functional status	230 (4.0)	212 (3.8)	18 (7.0)	.02
COPD	502 (8.7)	453 (8.2)	49 (19.0)	< .001
Congestive heart failure	1035 (18.0)	950 (17.2)	85 (32.9)	< .001
Hypertension	4309 (74.7)	4097 (74.4)	212 (82.2)	.006
Bleeding disorder	337 (5.8)	305 (5.5)	32 (12.4)	< .001
Case duration	257.54 ± 99.87	255.61 ± 98.50	298.80 ± 118.66	< .001
ASA class ≥ 4	4,572 (79.3)	4,357 (79.1)	215 (83.3)	.12

Data are presented as n (%) or mean ± SD.
ASA = American Society of Anesthesiology

For multivariable logistic regression, the odds ratio and 95% CIs for all regression estimates were reported.

Results

The study population consisted of 5,766 adult subjects who underwent SAVR. Of these subjects, 258 (4.47%) were re-intubated within 30 d after surgery. Table 1 lists the overall study population and factors associated with 30-d re-intubation. Among the study population, the mean ± SD age was 69 ± 13 y; 3,668 (63.6%) subjects were male, and 1,839 (31.9%) had a body mass index of 25–25.9 kg/m^2. The prevalence of non-insulin-dependent and insulin-dependent diabetes mellitus were 944 (16.4%) and 520 (9.0%), respectively. Roughly 741 (12.9%) of subjects smoked tobacco within 30 d of surgery. The majority of subjects had preoperative shortness of breath either with moderate exertion or at rest, hypertension, and ASA class ≥ 4. A significantly higher mean ± SD age was observed among re-intubated subjects (72.7 ± 11.7 y) versus those who were not re-intubated (68.8 ± 13.0 y) ($P < .001$). There was also a higher prevalence of diabetes mellitus, shortness of breath, poor functional status, COPD, congestive heart failure, hypertension, and bleeding disorder among subjects who were re-intubated compared to those who were not ($P < .05$).

Table 2 shows the unadjusted rates of postoperative complications. The rate of postoperative complications was significantly higher between subjects who were re-intubated compared to those who were not. There were no significant differences in surgical site infection among the cohorts. Figure 1 shows the results of the multivariable logistic regression analysis, in which age, COPD, congestive heart failure, and a bleeding disorder were associated with 30-d re-intubation.

Discussion

In this retrospective analysis utilizing the NSQIP database, factors associated with 30-d re-intubation following SAVR were reported. A statistically significantly increase in re-intubation was present in patients with congestive heart failure, COPD, and a bleeding disorder. Moreover, there was a 33% increase in the 30-d re-intubation rate for every 10-y increase in age. The unadjusted analysis shows that 30-d re-intubation was associated with several adverse postoperative outcomes. While some of these factors may not be modified, depending on the urgency of the

Table 2. Postoperative Outcomes Among Subjects Undergoing Surgical Aortic Valve Repair

	Study Population ($N = 5,766$)	Not Re-intubated ($n = 5,508$)	Re-intubated ($n = 258$)	P
Length of hospital stay, d	9.89 ± 12.09	9.52 ± 10.34	17.79 ± 30.37	< .001
Mechanical ventilation > 48 h	432 (7.5)	267 (4.8)	165 (64.0)	< .001
Pneumonia	278 (4.8)	193 (3.5)	85 (32.9)	< .001
Pulmonary embolism	23 (0.4)	17 (0.30)	6 (2.32)	< .001
Sepsis	200 (3.5)	140 (2.5)	60 (23.3)	< .001
Renal complications	336 (5.8)	270 (4.9)	66 (25.6)	< .001
Deep venous thrombosis	84 (1.45)	69 (1.25)	15 (5.81)	< .001
Stroke	118 (2.0)	96 (1.7)	22 (8.5)	< .001
Cardiac complications	165 (2.9)	94 (1.7)	71 (27.5)	< .001
Surgical site infection	144 (2.5)	133 (2.4)	11 (4.3)	.10
Postoperative transfusion	2913 (50.5)	2737 (49.7)	176 (68.2)	< .001
Reoperation	491 (8.5)	414 (7.5)	77 (29.8)	< .001
Mortality	225 (3.9)	162 (2.9)	63 (24.4)	< .001

Data are presented as n (%) or mean ± SD.

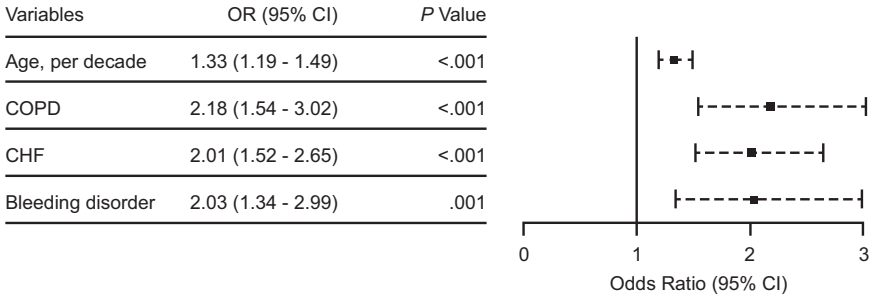

Fig. 1. Multivariable logistic regression analysis of variables associated with 30-d re-intubation following surgical aortic valve replacement. CHF = congestive heart failure; OR = odds ratio.

procedure, patients may be optimized preoperatively with appropriate postoperative planning.

Re-intubation following cardiac surgery remains a persistent problem and is associated with both increased cost and 30-d morbidity.[4,7] Thus, there exists an increasing impetus toward minimizing postoperative complications and excess cost by identifying independent predictors of re-intubation in cardiac surgery. The overall incidence of re-intubation following SAVR in this study was 4.47%, falling below the reported incidence of 10.0%, and 14.8% in a smaller cohort study of subjects who underwent SAVR.[8] The incidence of re-intubation generally ranges between 3.82% and 6.6% depending on the type of cardiac surgery.[4,9] A recent NSQIP study including cardiac surgeries, found a comparable prevalence of comorbidities which included diabetes mellitus (33.4% vs 34.1%), baseline dyspnea at rest (14.3 vs 11.3%) and moderate exertion (46.7% vs 56.2%), COPD (19.2% vs 19.0%), and congestive heart failure (30.6% vs 25.4%) among those re-intubated versus not re-intubated.[4]

Age is a well-documented predictor of postoperative pulmonary complications (39.6%) following cardiac surgery, and these findings are consistent with the literature. In a recent 2016 multi-institutional retrospective analysis of 18,571 subjects undergoing cardiac surgery, re-intubation was associated with increased age.[4] This study reported a 3-fold increase in the risk of re-intubation for subjects > 80 y old. Furthermore, in a smaller multi-institutional study, postoperative complication rates were markedly increased in subjects > 80 y old.[10] COPD is an important independent medical risk factor of re-intubation for both noncardiac and cardiac surgery.[11-13] In an NSQIP study of approximately 450,000 subjects, the unadjusted rate of re-intubation was 5.5% among those with COPD.[14]

A 2-fold increase in the odds of 30-d re-intubation was observed in subjects with a bleeding disorder compared to those without. NSQIP defines bleeding disorders as those that are often inherited but may be also acquired such as vitamin K deficiency, chronic anticoagulation not discontinued prior to surgery, hemophilia, and thrombocytopenia. In high-risk patients, bleeding disorders may clinically manifest as postoperative hemorrhage and, in the worst scenario, lead to clinical decompensation necessitating protection of the airway with positive-pressure ventilation.

Physicians should continue to optimize patients with a bleeding diathesis preoperatively. Lastly, the data suggest a 2-fold increase in 30-d re-intubation for subjects with congestive heart failure compared to those without. In a single-center study, Yazdanian et al[15] reported that preoperative heart failure with systolic dysfunction was associated with a higher rate of re-intubation after coronary artery bypass graft.

This study has its limitations. Although NSQIP is a validated surgical outcomes database, the use of NSQIP precludes the use of detailed data. Unfortunately, the database does not classify COPD or congestive heart failure. Furthermore, the database does not have data regarding the etiology of the bleeding disorder. Other important information is not included in NSQIP, including whether patients had obstructive sleep apnea, which is an important preoperative variable in patients who receive general anesthesia. NSQIP also does not collect anesthesia history and prior complications which may play a role in postoperative re-intubation.

Conclusions

Age, COPD, congestive heart failure, and bleeding disorder were associated with 30-d re-intubation in this surgical cohort. While age is not a modifiable risk factor, patients with COPD, congestive heart failure, and a bleeding disorder may benefit from preoperative risk stratification and optimization. Also, enhanced recovery pathways with multimodal anesthesia may alleviate the need for perioperative opioids and postoperative respiratory depression. If SAVR is deemed non-emergent, patients should be optimized preoperatively and receive careful postoperative planning to reduce the risk of postoperative complications. Further research is needed. The NSQIP database does not collect information regarding the severity of comorbidities, which is important in developing clinical practice and guidelines. This study serves to generate further hypotheses regarding risk factors associated with re-intubation following SAVR. Additional studies are needed in the form of multi-institutional prospective or retrospective studies that evaluate the extent to which these comorbidities influence the rate and reason for intubation.

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