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Incidence and implications of postoperative supraventricular tachycardia following pulmonary lobectomy

Gregory P. Giambrone, MS[1], **Xian Wu, MPH**[2], **Licia K. Gaber-Baylis, BA**[1], **Akshay U. Bhat, MEng**[3], **Ramin Zabih, PhD**[3], **Nasser K. Altorki, MD**[*,4], **Peter M. Fleischut, MD**[*,1], and **Brendon M Stiles, MD**[*,4]

[1]Department of Anesthesiology, New York-Presbyterian Hospital, Weill Cornell Medical College, New York, NY

[2]Department of Healthcare Policy and Research, Division of Biostatistics and Epidemiology, Weill Cornell Medical College, New York, NY

[3]Department of Computer Science, Cornell University, Ithaca, NY

[4]Department of Cardiothoracic Surgery, Thoracic Division, New York-Presbyterian Hospital, Weill Cornell Medical College, New York, NY

Abstract

Objective—We sought to determine the rate of postoperative supraventricular tachycardia (POSVT) in patients undergoing pulmonary lobectomy and to identify its association with adverse outcomes.

Methods—Analyzing the State Inpatient Databases, Healthcare Cost and Utilization Project, we reviewed lobectomies performed (2009–2011) in California, Florida, and New York to determine the incidence of POSVT. Patients were grouped by the presence or absence of POSVT with or without other complications. Stroke rates were analyzed independently from other complications. Multivariable regression analysis (MVA) was used to determine factors associated with POSVT.

Results—Among 20,695 lobectomies performed, 2,449 (11.8%) patients had POSVT, including 1,116 (5.4%) with isolated POSVT and 1,333 (6.4%) with POSVT with other complications. Clinical predictors of SVT by MVA included age ≥75, male gender, white race, COPD, CHF, thoracotomy surgical approach, and pulmonary complications. POSVT was associated with an increase of stroke (OR 1.74, CI 1.03–2.94), in-hospital death (OR 1.85, CI 1.45–2.35), LOS (OR 1.33, CI 1.29–1.37), and readmission (OR 1.29, CI 1.04–1.60). The stroke rate was <1% in patients with isolated POSVT and was 1.5% in patients with POSVT with other complications. Patients with isolated POSVT also had increased readmission and LOS, and a marginal increase in stroke rate when compared to patients with an uncomplicated course.

Address correspondence to Dr. Brendon Stiles, Division of Thoracic Surgery, Department of Cardiothoracic Surgery, Suite M404, Weill Medical College of Cornell University, 525 East 68th St., New York, NY10021; brs9035@med.cornell.edu.
*Co-Senior Authors

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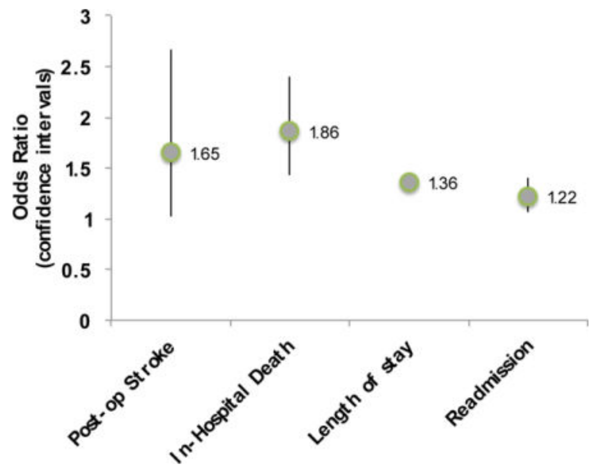
Conclusions—POSVT is common in patients undergoing pulmonary lobectomy and is associated with adverse outcomes. Comparative studies are needed to determine whether strict adherence to recently published guidelines will decrease the rate of stroke, readmission, and death following POSVT in thoracic surgical patients.

Graphical abstract

Central Picture: Postoperative supraventricular tachycardia is associated with adverse outcomes following pulmonary lobectomy.



INTRODUCTION

New onset supraventricular tachycardias (SVT) including atrial fibrillation and atrial flutter are common in patients following pulmonary lobectomy (1–3). Several non-modifiable risk factors exist for postoperative SVT (POSVT) including advanced age, male gender, white race, and history of arrhythmias (1–5). Additionally, several modifiable risk factors also exist including, among others, medical control of hypertension and congestive heart failure, tobacco and alcohol use, and the surgical approach chosen (1–5). Similarly, modifiable postoperative factors may also exist including fluid overload, hypoxia, and heart rate control. Once present, POSVT has been previously associated with increased morbidity, length of stay (LOS), and cost in patients undergoing thoracic surgery (1,3,6). Because POSVT represents a potentially preventable adverse outcome, the American Association for Thoracic Surgery (AATS) and the Society of Thoracic Surgeons (STS) recently published evidence-based guidelines for the prophylaxis and treatment of POSVT in patients undergoing general thoracic surgical procedures (7,8). In the AATS guidelines, both open and thoracoscopic lobectomy were classified as high-risk procedures for POSVT, with an estimated incidence greater than 15%. As such, it is recommended that these patients be monitored continuously for at least 48–72 hours and that pharmacologic prophylaxis should be considered. However, it is likely that there is a spectrum of individual risk with some patients at low risk and some patients at high risk.

To perform a broad investigation of POSVT following pulmonary lobectomy, we utilized the State Inpatient Databases (SID), Healthcare Cost and Utilization Project (HCUP) sponsored by the Agency for Healthcare Research and Quality (9). We anticipate that a better

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understanding of factors associated with POSVT in this large patient population will allow for better risk stratification of patients for POSVT and for stroke following POSVT. For example, it is unknown how strongly the risk of POSVT depends upon patient-based factors versus perioperative factors. Additionally, the risk of isolated POSVT is largely unknown. We therefore sought to compare the clinical outcomes of isolated POSVT versus POSVT associated with other postoperative complications. It has been suggested that isolated POSVT may have little independent association with adverse postoperative outcomes (3). The objective of this study is to generate hypotheses for clinical comparative studies to evaluate whether adherence to AATS guidelines influences the rate of POSVT and associated complications.

Methods

Database and study population

We examined hospitalizations for adults (age ≥ 18 years) using 2009 – 2011 discharge data from California, Florida, and New York from the SID-HCUP. All study activities were approved by the Weill Cornell Medical College Institutional Review Board. SID is an all-payer inpatient database, containing discharges from non-federal, non-psychiatric community hospitals. It contains more than one hundred clinical and non-clinical variables such as principal and secondary diagnoses and procedures, admission and discharge status, patient demographics, LOS, and total charges (9). To identify the difference between preexisting diagnoses and complications occurring after hospital admission, a unique identifier corresponding to each diagnosis code was used. For analysis of uncomplicated versus complicated POSVT, the patient cohort was divided into four groups, those with no POSVT or other complications, those with only POSVT as a complication, those with other complications but no POSVT, and those with other complications in addition to POSVT. For the purposes of segregating patients into the four groups, we excluded stroke as a complication in order to determine any association of isolated POSVT with stroke. To determine variability between rates of POSVT in the patient cohort based upon surgical volume of the hospitals at which the lobectomy was performed, hospitals were divided into quartiles based upon cumulative cases performed over the three year period and then analyzed.

International Classification of Diseases, Ninth Revision, Clinical Modification Codes

ICD-9M codes were used to identify patients undergoing pulmonary lobectomy: open lobectomy (OL – 32.49 (other lobectomy of lung), 32.4 (lobectomy of lung); excluding 34.03 (reopening of thoracotomy), 32.41 (thoracoscopic lobectomy), 34.21 (transpleural thoracoscopy), 17.4x (robotic-assisted procedure)) or minimally invasive lobectomy (MIL – Thoracoscopic Lobectomy: 32.41; excluding 32.4, 32.49, 34.03, 17.4x and Robotic Lobectomy: 17.4x and 32.4, 32.41, or 32.49; excluding 34.03, 34.21). Similarly ICD-9M codes were used to identify patients with POSVT, not present on admission: atrial fibrillation and flutter (427.3); atrial fibrillation (427.31); atrial flutter (427.32); and paroxysmal supraventricular tachycardia (427.0). Each diagnosis was coded with a separate identifier denoting whether or not it was present on admission, allowing discrimination between pre-existing diagnoses and those occurring after admission. Records indicating

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SVT upon admission were excluded from further analyses. Additionally, patients aged 17 or younger and those with missing age or gender were also excluded.

Covariates

Data were obtained for patient demographics (age, gender, race, state, and insurance status), LOS, comorbidities (with the indication of present on admission) and in-hospital events not present on admission (supraventricular arrhythmia, myocardial infarction, postoperative stroke, deep venous thrombosis, pulmonary embolism, pneumonia, postoperative acute respiratory insufficiency, postoperative acute pneumothorax, postoperative pulmonary edema, pulmonary collapse, empyema with and without fistula, mechanical ventilation, noninvasive ventilation, tracheostomy, sepsis/shock, urinary tract infection, postoperative wound infection, accidental puncture or laceration complicating surgery, bleeding complicating procedure). Baseline comorbidities were compared using the modified Deyo index which adapts the commonly used Charlson index for predicting adjusted relative risk of one-year mortality to administrative data, and the Elixhauser co-morbidity index (10,11).

Statistical analysis

We analyzed patient baseline demographic, clinical, and postoperative characteristics using frequencies and proportions for categorical variables and means, medians, and interquartile ranges for continuous variables. The differences in preoperative and postoperative characteristics between patients with and without POSVT were evaluated by the two-sample t-test, Pearson's chi-square, or Kruskal-Wallis tests as appropriate.

Logistic regression was used to identify factors associated with new-onset POSVT. Factors of interest were identified a priori and included baseline patient demographics, state, Elixhauser comorbidities and postoperative pulmonary complications. Variables with P-values of 0.05 or less in bivariate analyses were kept in the multivariable logistic regression model. To analyze the association of POSVT with outcomes, we constructed multivariable logistic regression models for postoperative stroke, in-hospital mortality, and 30-day readmission, and multivariable linear regression model for log-transformed LOS. Models were adjusted for statistically significant variables that had bivariate association with each outcome ($p < 0.05$) from among patient demographics, chronic comorbidities, procedure type (OL and MIL) and postoperative pulmonary complications. Generalized estimating equations with exchangeable variance estimation were used to account for the clustering of outcome measures at the hospital level. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) of POSVT were calculated. SAS version 9.3 (SAS Institute, Cary, NC) was used to perform all statistical analyses. All P-values are two sided with statistical significance evaluated at the 0.05 alpha level.

Results

During the time period studied (2009–2011), we identified a total of 23,043 pulmonary lobectomies, of which 20,695 records met the study criteria (SVT not present on admission, non-missing age and gender, and age ≥ 18). There was a relatively equal distribution between California (n=7,226; 34.9%), Florida (n=7,019; 33.9%), and New York (n=6,450,

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31.2%). Most lobectomies were performed via OL (n=12,154; 58.7%), while 41.3% (n=8,541) were MIL, including 36.8% (n=7,611) by video assisted thoracoscopic surgery (VATS) and 4.5% (n=930) by robotic assisted thoracoscopic surgery (RATS). A majority of patients (n=11,335; 54.8%) were female. Most patients were white (n=15,921; 76.9%). The median age for the cohort was 67 years (IQ range 59;74). The median modified Deyo index of this cohort of patients was 3 (IQ range, 2;4). Among comorbidities, 85.1% of patients (n=17,617) had a diagnosis of cancer, 43.3% of patients (n=8,965) were noted to have chronic obstructive pulmonary disease (COPD), and 2.3% of patients (n=479) had congestive heart failure.

The overall rate of complications was 39.7% in the OL group and 31.5% in the MIL group. Pulmonary complications were present in 36.5% of patients in the OL group and 29.3% of patients in the MIL group. Among these 20,695 patients undergoing pulmonary lobectomy, 2,449 patients (11.8%) were documented to have new onset POSVT. This included 1,116 patients (5.4%) who had POSVT as an isolated complication (excluding stroke) and 1,333 patients (6.4%) who had POSVT along with other complications. We compared patients with (n=2,449) and without (n=18,246) POSVT to determine differences in baseline characteristics between the two cohorts. Table 1 displays the characteristics of patients undergoing pulmonary lobectomy stratified by POSVT status.

We next performed multivariable analysis to determine independent factors associated with new-onset POSVT following pulmonary lobectomy (Table 2). Factors associated with new onset POSVT included demographic distinctions (increasing age, male gender, white race), comorbidities (higher Deyo index, hypertension, COPD, CHF, valvular heart disease), and perioperative factors (OL versus MIL, pulmonary complications).

We further sought to examine whether there existed an association between POSVT and outcome variables, in particular in-hospital stroke, in-hospital mortality, LOS, and readmission. We performed a multivariable analysis for each outcome adjusting for age, gender, race, comorbidities, and acute perioperative factors (Figure 1). POSVT was independently associated with an increased risk for stroke (OR: 1.74; 95% CI: 1.03–2.94), in-hospital mortality (OR: 1.85; CI: 1.45–2.35), LOS (OR: 1.33; CI: 1.29–1.37), and 30-day readmission (OR: 1.29; 1.04–1.60).

Having demonstrated the adverse outcomes associated with POSVT, we sought to further examine the data to determine whether the context of POSVT with regard to other complications was important. In particular, we wanted to determine whether isolated POSVT without other complications was associated with adverse outcomes. The patient cohort was therefore divided into four groups, those with no POSVT or other complications, those with only POSVT as a complication, those with other complications but no POSVT, and those with other complications in addition to POSVT (Table 3). For the purpose of the study, any complication as determined from ICD-9 codes was included. From the SID database, it is not possible to identify the temporal sequence of complications. Patients without any other complications excluding stroke (n=13,180) had a lower overall rate of POSVT (8.5%) than did patients (n=7,515) with other complications (17.7%; <0.0001). When comparing patients with no complications to those with isolated POSVT and no other

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complications, there was no difference in in-hospital mortality. Patients with isolated POSVT had significantly higher rates of postoperative stroke, longer LOS (6 vs. 5 days), and higher rates of 90-day readmission (20.3% vs. 16.6%). However, isolated POSVT patients were also older (median age 72 vs. 67 years, p<0.001) and had more cumulative comorbidities (mean Deyo index 3.69 vs. 3.42, p=0.001). We therefore performed distinct multivariable analyses in this cohort without other complications to determine whether POSVT had independent associations with stroke, mortality, or LOS. However, there were not enough events (n=28) to determine an association with stroke. POSVT was independently associated with prolonged LOS (OR 1.33, CI 1.29–1.37) and 30-day readmission (OR 1.29, CI 1.04–1.60) in this cohort of uncomplicated patients.

Notably, patients with POSVT with other complications did quite poorly, even compared to other patients with complications. These POSVT patients had higher rates of stroke (1.5% vs. 0.8%, p=0.009), higher in-hospital mortality (7.7% vs. 3.7%, p<0.001), longer median LOS (10 days vs. 7 days, p<0.001), higher rates of 90-day readmission (27.2% vs. 22.2%, p<0.001), and higher rates of readmission with stroke (1.8% vs. 0.8%, p=0.001) than patients with other complications excluding POSVT.

Discussion

POSVT has long been recognized as a common complication following thoracic surgical procedures. POSVT has previously been associated with increased morbidity, mortality, LOS, and cost in single institutional studies and in a study by Onaitis et al. utilizing the STS General Thoracic Surgery Database (1,3,6). We are not aware of previous studies using insurance databases to validate prospectively reported rates of POSVT and associated complications following non-cardiac thoracic surgery. However, the SID database has previously been used to determine rates of new onset atrial fibrillation in patients hospitalized with severe sepsis and to determine associated morbidity and mortality (12). In that study, patients with new onset atrial fibrillation were at increased risk for stroke and death.

In the current manuscript, we sought to use the SID database to confirm the previously published self-reported incidences of POSVT in patients undergoing pulmonary lobectomy, to define demographic characteristics which are associated with higher rates of POSVT, and to determine the association of POSVT with adverse outcomes including stroke, in-hospital mortality, LOS, and readmission. We acknowledge that limitations of the data include the lack of temporal descriptors, the absence of oncological details, and the absence of important clinical details such as pulmonary function, performance status, and medication use. Although such limitations are inherent in administrative databases, previous studies have demonstrated that reported rates of complications using claims data can approximate those reported in prospective databases (13,14). Enomoto et al. suggested that discordance may exist between clinical and administrative databases, however, their rates of reported cardiovascular complications were within 2% of each other. Campbell et al. reported that ICD-9-based reporting was actually more accurate than prospective data accrual for capturing new cardiac events. Furthermore, although it is possible that claims data may be less sensitive than prospective thoracic surgical databases for capturing episodes of new

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onset POSVT, this may be an advantage if only medically significant episodes of POSVT are recorded by billing specialists. Patients with clinically insignificant, untreated short runs of atrial tachycardia or those not captured by telemetry would likely not have been coded as having POSVT. It is not clear how often prospective self-reported surgical databases include these patients. In our study, the reported overall rate of complications was slightly higher than that reported from the STS database and slightly lower than that reported from the Nationwide Inpatient Sample (NIS) database (15,16).

In order to attempt to homogenize our patient cohort from the SID-HCUP dataset in which cancer staging details are not available, we elected to focus only on patients undergoing pulmonary lobectomy, rather than including other lung resections such as wedge resection, segmentectomy, or pneumonectomy. It is well established that the more extensive the lung resection, the higher the risk of POSVT (1,3). For example, in the study by Onaitis et al., compared to lobectomy, pneumonectomy and bilobectomy had odds ratios of 2.01 and 1.64 respectively in the predictive model used (3). The focus of this study on lobectomy alone should allow patient characteristics to dominate association models, rather than the operation performed. We found patient characteristics associated with POSVT to include age, male gender, white race, and history of valvular heart disease, congestive heart disease, pulmonary circulation disorders, and chronic obstructive pulmonary disease. The demographic associations with POSVT were all noted in the STS study and in previous single institution studies (1,2,3,5). The effect of congestive heart failure and of chronic obstructive pulmonary disease were not apparent in the STS study, although evaluation of both of these variables suffered from missing data points in the STS database (3). We believe it is likely that these two comorbidities increase the risk of POSVT. Interestingly, the surgical approach chosen, OL versus MIL (either VATS or RATS), also appeared to affect the rate of POSVT (OR 1.18). The association of thoracotomy with increased POSVT has previously been demonstrated in propensity-matched studies from the STS database and from the NIS database, although the surgical approach was not significant in the STS study by Onaitis et al (3,15,16). From this contemporary study with a higher rate of minimally invasive surgery than previous studies, it seems likely that a real effect exists.

This data makes it abundantly clear that there is variability in the risk of POSVT in patients undergoing pulmonary lobectomy. Although in the recently published guidelines from the AATS, all patients undergoing lobectomy were deemed to be high risk (>15%) for postoperative atrial arrhythmias, we suggest that there is a spectrum of risk that should be evaluated before considering monitoring and prevention strategies for individual patients (7). We would support development of a risk calculator for general use on the STS website as suggested by Onaitis et al. (3). Such a risk calculator could be used to stratify patients into groups for prospective studies evaluating intensity of monitoring of postoperative patients and for studies evaluating prophylaxis against POSVT.

As noted in previous studies, the consequences of POSVT seem to be significant. As patients who develop POSVT are older and have more comorbidities, direct causal effects of POSVT with adverse outcomes are sometimes difficult to tease out. We have no data on the timing or nature of strokes or of other complications with regard to POSVT. However, in our multivariable model adjusted for numerous potential confounding factors, POSVT was

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independently associated with stroke, in-hospital mortality, LOS, and readmission. This confirms the findings of previous studies (1–3). In particular, the consequences of POSVT when it occurs with other complications appear to be particularly dire, with a stroke rate of 1.5%, a median LOS of 10 days, and an in-hospital mortality rate of 7.7%. From the coding in the SID-HCUP database, it is impossible to determine whether POSVT preceded or followed other complications. Nonetheless, when patients develop POSVT and other complications, it would seem that they should be managed in a carefully monitored setting and that consideration should be given to anticoagulation when safe to do so.

In contrast to those high-risk patients with multiple complications, the impact of “uncomplicated” POSVT is less clear. It has previously been suggested that atrial arrhythmias may be transient and relatively harmless in this setting (3). We sought to evaluate this by defining a group of patients with uncomplicated POSVT. We excluded stroke as a complication in order to determine the association of POSVT with stroke. We selected patients who were documented as having no other postoperative complications other than atrial fibrillation, atrial flutter, or paroxysmal atrial tachycardia. Among our cohort, 5.4% of patients undergoing pulmonary lobectomy had uncomplicated POSVT. In this setting, POSVT did not increase in-hospital mortality. However, POSVT was still associated with an increase in the incidence of stroke, median LOS, and readmission. This would suggest that even uncomplicated POSVT complicates the care of these pulmonary lobectomy patients and puts them at risk for adverse outcomes.

Finally, we are left with the question of whether guidelines and evidence-based medicine can be used to reduce the rate of POSVT and associated adverse outcomes in patients undergoing pulmonary lobectomy. Unfortunately, the SID-HCUP database does not contain any information pertaining to medical prophylaxis or to management algorithms for POSVT. This is certainly a limitation of the study, along with lack of cancer staging information, lack of detailed comorbidity information, and unmeasured variability in postoperative monitoring for POSVT. Additionally, ICD-9-CM codes lack detailed standard clinical definitions that can be universally applied and are thus open to coding interpretation. Nevertheless, we believe that such ambiguity of definitions is also apparent in prospective databases with regard to POSVT. This administrative data, carefully evaluated to exclude preoperative diagnoses of SVT, is widely generalizable and not restricted to the outcomes of specialized, experienced centers. The overall rate of POSVT was remarkably similar to that reported for patients in the STS database study (11.8% vs. 12.6%), in which 87.5% of patients underwent lobectomy (3). Based upon our findings, we believe that further studies are needed to evaluate the role of rate control, rhythm conversion, and anticoagulation in these patients, ideally in patients segregated into low- and high-risk cohorts. Among high-risk patients, POSVT may not be as preventable as we like to think, given its dependence upon non-modifiable demographic variables and clinical characteristics.

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Glossary of Abbreviations

POSVT	Postoperative supraventricular tachycardia
MVA	Multivariable analysis
OR	Odds ratio
COPD	Chronic obstructive pulmonary disease
CHF	Congestive heart failure
LOS	Length of stay
AATS	American Association for Thoracic Surgery
STS	Society of Thoracic Surgery
SID	State Inpatient Database
HCUP	Healthcare Cost and Utilization Project
MIL	Minimally invasive lobectomy
OL	Open lobectomy
VATS	Video assisted thoracoscopic surgery
RATS	Robotic assisted thoracic surgery

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Perspective Statement

Postoperative atrial arrhythmias are common following pulmonary lobectomy and are associated with stroke, death, increased length of stay, and readmission. Identifying at-risk patients will allow for tailored prophylaxis strategies.

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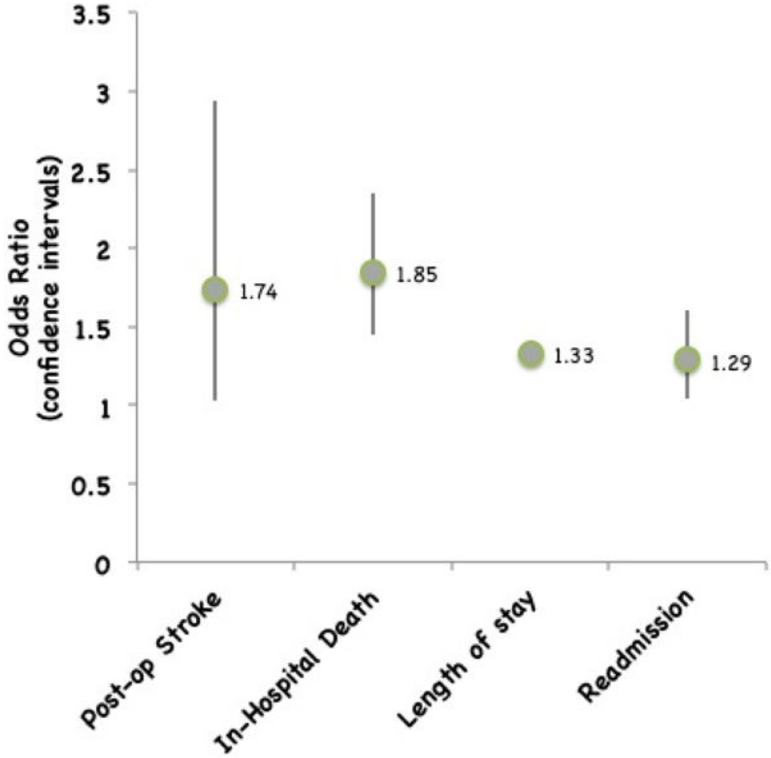

Figure 1.

Association between postoperative supraventricular tachycardia and adverse outcomes following pulmonary lobectomy. Odds ratios (circles) and confidence intervals are presented for post-operative stroke (p=0.04), in-hospital death (p<0.001), length of stay (p<0.001), and 30-day readmission (p=0.02).

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Table 1

Characteristics of patients undergoing pulmonary lobectomy with or without postoperative supraventricular tachycardia.

Variable	No POSVT (n=18,246)	POSVT (n=2,449)	p-value
Age, median (Q1;Q3)	67 (59; 74)	72 (66; 78)	<.001
Male gender	8,027 (44.0)	1,333 (54.4)	<.001
White race	13,850 (75.9)	2,071 (84.6)	<.001
Mean Deyo index (95% CI)	3.43 (3.40; 3.47)	3.72 (3.62; 3.83)	<.001
Median Deyo index (Q1; Q3)	3 (2; 3)	3 (2; 4)	<.001
Chronic obstructive pulmonary disease	7,712 (42.3)	1,253 (51.2)	<.001
Renal failure	863 (4.7)	184 (7.5)	<.001
Congestive heart failure	381 (2.1)	98 (4.0)	<.001
Valvular heart disease	532 (2.9)	167 (6.8)	<.001
Pulmonary circulation disorders	139 (0.8)	65 (2.7)	<.001
Peripheral vascular disorders	1,161 (6.4)	223 (9.1)	<.001
Hypertension, uncomplicated	9,226 (50.6)	1,321 (53.9)	0.002
Hypertension, complicated	900 (4.9)	198 (8.1)	<.001
Solid tumor without metastasis	15,343 (84.1)	2,189 (89.4)	<.001

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Table 2

Factors associated with postoperative supraventricular tachycardia among pulmonary lobectomy patients.

Variable	Subcategory	Multivariable logistic regression analysis*			
		OR	95% CI of OR		p-value
Patient demographics					
Gender	Male	1.44	1.31	1.59	<.001
Age	18–54	Referent			
	55–64	2.34	1.84	2.99	<0.001
	65–74	4.18	3.11	5.62	<0.001
	>=75	6.21	4.56	8.46	<0.001
Race	White	Referent			
	Black	0.61	0.50	0.74	<0.001
	Hispanic	0.59	0.49	0.71	<0.001
	Other	0.80	0.66	0.96	0.020
Comorbidities					
Congestive heart failure		1.31	1.04	1.64	0.020
Valvular disease		1.79	1.43	2.24	<0.001
Pulmonary circulation disorders		2.58	1.77	3.78	<0.001
Chronic obstructive pulmonary disease		1.17	1.07	1.26	<0.001
Perioperative					
Surgical approach: Thoracotomy vs. minimally invasive		1.21	1.09	1.34	<0.001
Pulmonary complications		1.95	1.75	2.18	<0.001

*Excludes 274 patients (1.32%) with missing race variable

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Table 3

Clinical impact of isolated versus complicated postoperative supraventricular tachycardia.

Outcome	No SVT, uncomplicated course (n=12,064)	Isolated SVT, no other complications (n=1,116)	p-value	No SVT, other complications (n=6,182)	SVT, with other complications (n=1,333)	p-value
Postoperative stroke	22 (0.2%)	<11 (<1.0%) *	<0.05 *	47 (0.8%)	20 (1.5%)	0.009
In-hospital mortality	26 (0.2%)	<11 (<1.0%) *	>0.70 *	229 (3.7%)	103 (7.7%)	<0.001
Median length of stay (Q1;Q3)	5 (4;6)	6 (5;8)	<0.001	7 (5;12)	10 (7;16)	<0.001
90-day readmission	1,807 (16.6%)	205 (20.3%)	0.003	1,207 (22.2%)	309 (27.2%)	<0.001
90-day readmission with stroke	69 (0.6%)	14 (1.4%)	0.006	41 (0.8%)	20 (1.8%)	0.001

* The HCUP Data Use Agreement prohibits the reporting of fewer than 11 observations. Sample size and p-values are masked to prevent identification.