Earlier Versus Later Tracheostomy in Patients With Respiratory Failure After Cardiac Surgery in the United States

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Objectives: **The objective of this study was to evaluate the impact of timing of tracheostomy on outcomes of patients with respiratory failure after cardiac surgery.**

Design: **Retrospective analysis of national database.**

Setting: **United States hospitals.**

Participants: **A weighted estimate of 2,063,227 patients (475,773 case records) undergoing cardiac surgery identified from the Nationwide Inpatient Sample between 2002-2010**

Interventions: **Early versus late tracheostomy.**

Measurements and Main Results: **The incidence of postoperative respiratory failure was 7.8%. The strongest independent predictors of respiratory failure included female gender (odds ratio [OR] 1.3, 95% confidence interval [CI] 1.28-1.31), age (OR 1.13 for each decade, 95% CI 1.12-1.13), chronic obstructive airways disease (OR 2.16, 95% CI 2.13-2.19), chronic renal insufficiency (OR 2.28, 95% CI 2.25-2.31), and valve surgery (OR 1.62, 95% CI 1.6-1.64). Tracheostomy was performed in 22.9% of patients with respiratory failure; 13.6% of tracheostomies were performed within 5 days of surgery (or within 5 days of intubation in patients who underwent reintubation), and 20.5% were performed on postoperative day 21 or later. Compared with tracheostomy performed within 5 days of intubation, there was a near-stepwise increase in risk of mortality with delayed tracheostomy performed between days 11-15 (OR 1.29, 95% CI 1.16-1.43), days 16-20 (OR 1.25, 95% CI 1.11-1.41), and day 21 or later (OR 1.53, 95% CI 1.37-1.71).**

Conclusions: **In this analysis of outcomes of patients with respiratory failure after cardiac surgery in the United States, deferring tracheostomy did not appear to improve patient outcomes after cardiac surgery.**

KEY WORDS: respiratory insufficiency, tracheostomy, cardiac surgical procedures, mediastinitis, mortality

THE OPTIMAL TIMING of tracheostomy in the setting of acute respiratory failure remains controversial.[1,2] Although tracheostomy is a safe procedure that facilitates the management and weaning of patients requiring prolonged mechanical ventilation after cardiac surgery, its comparative invasiveness combined with the potential for significant complications may discourage early intervention.[3,4] Data focusing on patients who have undergone cardiac surgery are limited to small single-center series with conflicting findings.[3–7] This study, therefore, was designed to evaluate whether patients with respiratory failure after cardiac surgery who underwent early tracheostomy had different clinical outcomes compared with similar patients who underwent later tracheostomy, using the Nationwide Inpatient Sample.

MATERIALS AND METHODS

Patients who underwent cardiac surgery between 2002 and 2010 were identified using the Nationwide Inpatient Sample (NIS). The database contains information on every inpatient admission from more than 1,000 hospitals in 45 states. The included hospitals change each year and are selected to provide a representative sample of care provision in the United States. Each record in the database represents one inpatient admission and includes both clinical and nonclinical data, such as principal and secondary diagnoses, procedures, discharge status, and total charges. Additionally, each record includes data regarding demographic (geographic region and urban *v* rural location) and hospital (teaching status and bed size) characteristics, which may be used to weight each record to provide estimates of national trends and practice. Diagnoses and procedures are coded according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM).

The NIS has the capacity for a maximum of 25 diagnosis codes on any individual record (before 2009, 15 codes were available), but the maximum number of diagnosis codes that hospitals actually record—the diagnosis coding capacity—varies by state and by hospital. To avoid "crowding out," whereby secondary diagnoses including major complications are not coded because the diagnosis coding capacity is set too low (a particular issue when analyzing critically ill patients with extended hospitals stays), this study was limited to patients treated at hospitals with a diagnosis coding capacity of at least 15. The diagnosis coding capacity of each hospital was designated by identifying the highest number of diagnosis codes each hospital assigned to their records.

A weighted estimate of 2,063,227 patients (475,773 case records) from the NIS between 2002 and 2010 underwent coronary artery bypass grafting, valve surgery, or both. Patients undergoing closed cardiac valvotomy, percutaneous valvuloplasty, any pulmonic valve procedure, or any procedure on an unspecified valve were excluded. The baseline characteristics that were assessed are listed in Table 1. The study protocol was reviewed by the Institutional Review Board, which waived the need for informed consent because the source consisted of de-identified, publically available data.

Patients with postoperative respiratory failure were defined by the presence of any of the following: Acute respiratory failure, acute and chronic respiratory failure, reintubation (defined as endotracheal intubation occurring after postoperative day 1), mechanical ventilation for 96 consecutive hours or more occurring after postoperative day 1, mechanical ventilation for an unspecified duration occurring after postoperative day 2, or postoperative tracheostomy in the setting of respiratory conditions including acute respiratory distress syndrome, pneumonia, pulmonary edema, aspiration, or respiratory arrest. Time to tracheostomy was defined as days from initial surgery or, in the case of patients recorded as being reintubated, number of days from the second intubation. Early tracheostomy was defined as time to tracheostomy of 5 days or less.

The primary endpoint was in-hospital mortality. Secondary endpoints were infection, length of hospital stay, and total charges. Continuous variables are expressed as means with standard deviations.

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1053-0770/2601-0001$36.00/0

http://dx.doi.org/10.1053/j.jvca.2013.07.023

Table 1. Baseline Characteristics

Baseline Characteristic	All Cardiac Surgery Patients, (100%), n = 434,519	No Respiratory Failure Patients, (92.2%), n = 400,750	Respiratory Failure, No Tracheostomy, (6.0%), n = 26,046	Respiratory Failure with Tracheostomy, (1.8%), n = 7,723	*p Value
Demographic characteristics					
Age (mean ± SD)	65.66 ± 11.71	65.46 ± 11.68	67.31 ± 11.84	70.30 ± 11.34	<0.001
Octogenarians (%)	11.4	10.9	15.1	21.1	<0.001
Female (%)	31.5	30.8	38.5	44.2	<0.001
Preoperative characteristics					
Diabetes mellitus (%)	33.8	33.9	35.3	25.1	<0.001
Obesity (%)	13.6	13.7	14.0	8.8	<0.001
Previous stroke (%)	1.4	1.4	1.5	1.2	<0.001
Chronic obstructive lung disease	17.0	15.9	30.8	25.0	<0.001
Pulmonary hypertension (%)	5.3	5.1	8.0	6.1	<0.001
Peripheral vascular disease (%)	13.9	13.7	16.3	13.6	<0.001
Chronic renal failure (%)	10.1	9.1	21.0	24.5	<0.001
End-stage renal failure requiring dialysis (%)	1.5	1.2	4.1	5.9	<0.001
Type of cardiac surgery					
Elective surgery (%)	50.8	52.1	35.8	36.8	<0.001
Isolated CABG (%)	70.2	71.2	61.7	49.5	<0.001
Single-valve surgery ± CABG (%)	27.1	26.4	33.4	41.8	<0.001
Double- or triple-valve surgery ± CABG (%)	2.7	2.5	4.9	8.7	<0.001

Abbreviation: CABG, coronary artery bypass grafting; SD, standard deviation.
*p value is for univariate comparison between respiratory failure patients with and without tracheostomy.

Categoric variables are expressed as proportions. Differences between groups were detected using χ^2 test for categoric variables and Student *t* test for continuous variables. Binary logistic regression analysis models were performed to determine independent predictors of postoperative respiratory failure. Patients who developed respiratory failure then were selected to determine if specific etiologies of respiratory failure were independent predictors of mortality or postoperative tracheostomy. Finally, patients who underwent postoperative tracheostomy were selected to determine whether or not timing of tracheostomy was an independent predictor of outcomes. Results are reported as odds ratios (OR) and 95% confidence intervals (CI). All tests were two-tailed. A p value of <0.05 was considered to be statistically significant. The statistical analysis was performed using SPSS Statistics for Windows, Version 21 (IBM Corporation, Armonk, New York).

RESULTS

The overall incidence of postoperative respiratory failure was 7.8%, which did not change significantly over the study period. The patient demographic characteristics and clinical comorbidities for the overall population are listed in Table 1 according to the presence of respiratory failure and tracheostomy. Generally, patients with respiratory failure were older (octogenarians) than those without respiratory failure (16.5% *v* 10.9%, $p < 0.001$), and more likely to have chronic obstructive lung disease (29.5% *v* 15.9%, $p < 0.001$) or chronic renal insufficiency (21.8% *v* 9.1%, $p < 0.001$); patients with respiratory failure also were less likely to have undergone isolated coronary artery bypass than those without respiratory failure (58.9% *v* 71.2%, $p < 0.001$). The strongest independent predictors of respiratory failure included female gender, increasing age, chronic obstructive airways disease, chronic renal insufficiency, and valve surgery (Table 2). The etiology of postoperative respiratory failure was diagnosed as acute respiratory distress syndrome in 21.6%, aspiration in 9.2%, and bacterial pneumonia in 10.2% (Table 3).

Respiratory failure was associated with increased risk of in-hospital mortality (OR 8.31, 95% CI 8.16-8.47), sepsis (OR 10.66, 95% CI 10.46-10.86), length of stay greater then 30-days (OR 12.22, 95% CI 11.99-12.46), and discharge to a skilled care facility (OR 2.19, 95% CI 2.16-2.22) (Table 4). In multivariate analysis, pulmonary embolism (OR 1.61, 95% CI 1.33-1.96, $p < 0.001$) was an independent predictor of mortality in patients with respiratory failure.

Tracheostomy was performed in 22.9% of patients with respiratory failure (weighted estimate n = 36,674). Patients with respiratory failure who underwent tracheostomy were more

Table 2. Predictors of Respiratory Failure in Cardiac Surgery Patients

Baseline Characteristic	Adjusted Odds Ratio	95% Confidence Interval	p Value
Age (per 10 years)	1.13	1.12-1.13	<0.001
Female	1.30	1.28-1.31	<0.001
Obesity	1.02	1.01-1.04	0.008
Previous stroke	1.00	0.95-1.04	0.860
Chronic obstructive pulmonary disease	2.16	2.13-2.19	<0.001
Pulmonary hypertension	1.01	0.99-1.04	0.283
Peripheral vascular disease	1.02	1.01-1.03	0.031
Chronic renal failure	2.28	2.25-2.31	<0.001
Liver disease	1.72	1.65-1.80	<0.001
Type of cardiac surgery			
Elective surgery	0.53	0.52-0.53	<0.001
Single-valve* surgery ± CABG	1.62	1.60-1.64	<0.001
Double- or triple-valve* surgery ± CABG	2.41	2.35-2.48	<0.001

Abbreviation: CABG, coronary artery bypass grafting.
*Odds ratio compared to isolated CABG.