Tracheostomy after Cardiac Surgery: A 17-years single center experience

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Abstract

Background and aim of the study: A regular post-cardiac surgery course does not require a prolonged stay in the cardiac surgery intensive care unit (ICU). However, a complicated postoperative period, can lead to prolonged ICU stay and prolonged ventilation, and may require a tracheostomy. Nonetheless, there is currently no consensus regarding the proper timing of tracheostomy. Data regarding long-term outcomes of early versus late tracheostomy are limited. This study represents the largest single-center experience with post-cardiac surgery tracheostomy. The aim of this study was to assess the timing of tracheostomy as a risk factor for mortality. **Methods :** This is a retrospective study of prospectively collected data. Patients were divided into three groups according to the timing of tracheostomy; early (4-10 days); intermediate (11-20 days) and late ([?]21 days). The primary outcomes were early, intermediate, and long-term mortality. For statistical analysis we use multivariable Cox proportional hazards model. **Results :** Between 09.2004 and 08.2021, 12,782 patients underwent cardiac surgery at our institution, of whom 407 (3.18%) required postoperative tracheostomy. 147 (36.1%) had early, 195 (47.9%) intermediate and 65 (16%) late tracheostomy. The three groups were similar regarding their baseline characteristics and operative data. Early, 30-day and in-hospital mortality was similar for all groups. However, patients, who underwent early- and intermediate tracheostomy, demonstrating statistically significant lower mortality after 1- and 5-year (42.8%; 57.4%; 64.6%; and 55.8%; 68.7%; 75.4%, respectively; $p<0.001$). In our patient's cohort Cox model show age [1.025 (1.014-1.036)] and time to tracheostomy [0.315 (0.159-0.757)] as significant factor for mortality. **Conclusions :** This study demonstrates a relationship between the timing of tracheostomy after cardiac surgery and mortality: early tracheostomy within 4-10 days of mechanical ventilation associated with better intermediate- and long-term survival. Short-term mortality does not seem to be affected by the timing of tracheostomy. Optimal timing of tracheostomy requires further evaluation.

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Methods: This is a retrospective study of prospectively collected data. Patients were divided into three groups according to the timing of tracheostomy; early (4-10 days); intermediate (11-20 days) and late ([?]21 days). The primary outcomes were early, intermediate, and long-term mortality. For statistical analysis we use multivariable Cox proportional hazards model.

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Conclusions: This study demonstrates a relationship between the timing of tracheostomy after cardiac surgery and mortality: early tracheostomy within 4-10 days of mechanical ventilation associated with better intermediate- and long-term survival. Short-term mortality does not seem to be affected by the timing of tracheostomy. Optimal timing of tracheostomy requires further evaluation.

Introduction

Most patients undergoing cardiac surgery at our institution have a postoperative course characterized by a short period of post-operative mechanical ventilation and a short stay in the cardiac surgery intensive care unit (CSICU). A complicated postoperative period, on the other hand, due to infection, cardiac failure, respiratory distress, or other complications can lead to prolonged ICU stay and prolonged ventilation, and may require a tracheostomy. With the increased complexity of both the patient population and surgical procedures performed in recent years, the number of patients requiring prolonged mechanical ventilation after cardiac surgery has increased. This is consistent with similar trends reported in the literature[1,2] .

Consequently, many high volume centers have implemented specialized tracheostomy teams as this has proven to be the safest and most cost effective model to meet this increased need[3].

Tracheostomy may reduce mortality in the subgroup of patients requiring long-term mechanical ventilation[4]. Despite the growing experience in the management of these patients, no consensus exists regarding the proper timing for tracheostomy. Several studies have investigated the outcomes of early versus late tracheostomy. However, early tracheostomy may associated with increased risk of sternal wound infection[5]. Nevertheless, data regarding mortality associated with early versus late tracheostomy is controversial. The aim of this study was to assess the timing of tracheostomy as a risk factor for early, intermediate, and late mortality. The second aim of the study was assessment of the incidence of sternal wound infection (SWI), both superficial and deep.

Methods

2.1 Study design and setting. This is a retrospective, observational study of prospectively collected data of patients undergoing cardiac surgery at a large tertiary care university hospital. The study was approved by the Sheba Medical Center Institutional Ethics Committee (Protocol No 4257) and written informed consent was waived due to the retrospective nature of the study. Data were collected from collection forms entered into a computerized departmental database. All patients undergoing cardiac surgery were included in the cohort. The indications for tracheostomy were as follows: patients were still on mechanical ventilation at least 4 days; had not successfully passed a mechanical ventilation weaning screening test or spontaneous breathing trial; and were expected to require mechanical ventilation for 7 or more days. Patients were grouped according to time between surgery and tracheostomy. Based on previous studies[6], patients were divided into three groups according to the timing of tracheostomy; early group (4-10 days); intermediate group (11-20 days) and late group ([?]21 days). The relative incidence of tracheostomies did not change during all the years of the study. We compared the groups based on preoperative demographic data, medical comorbidities and operative data. Demographic data included sex and age. Medical comorbidities included chronic obstructive pulmonary disease (COPD), smoking history, congestive heart failure (CHF) (New York Heart Association [NYHA] III-IV), cardiac arrhythmia, diabetes mellitus, dialysis-dependent renal failure, peripheral vascular disease (PVD), left ventricular ejection fraction (LVEF), previous myocardial infarction (MI), previous cerebrovascular accident (CVA)/transient ischemic attack (TIA), systemic and pulmonary hypertension, previous cardiac surgery, priority of surgery (elective, urgent, or emergent) and logistic and standard EuroSCORE. Operative data regarding the type of surgery was simplified into simple (isolated valve or coronary artery bypass graft (CABG) surgery) versus complex surgery (combined procedures or aortic procedures). We also compared early (30-day and in-hospital), intermediate (1-year, 2-year) and late (5-year) mortality since tracheostomy, which was the primary outcome of the study.

During the initial period of the study, from 01.09.2004 to 31.12.2006, the CSICU functioned by an open model, under the supervision of a cardiac surgeon. On 01.01.2007, the CSICU was converted to a semi-closed model, and since then until the end of this study was supervised by a board-certified intensivist. In the period between 09.2004 and 01.2007 tracheostomies were performed by open approach by ENT surgeons. From 0.2.2007, all tracheostomies were performed at the bedside by an experienced thoracic surgical team, which includes 5-6 surgeons and 2-3 anesthesiologists, using the percutaneous dilatation technique (Portex® Griggs Forceps Percutaneous Dilation Tracheostomy Kits, Smith Medical, St. Paul, MN). During the study, no other major changes in hospital policy, surgical or anesthesiological techniques were introduced.

2.2 Statistical Analysis

Data are presented as mean +- standard deviation if normally distributed or as median values and interquartile range. Continuous variables were tested with the Kolmogorov-Smirnov test for normal distribution. Categorical variables are given as frequencies and percentages. A chi-square test was used for comparison of categorical variables between the groups. Student's t-test and One Way ANOVA was performed for comparison of normally distributed continuous variables. For non-normal distribution variables we used Mann-Whitney U test and Kruskal-Wallis

To explore the independent association of tracheostomy timing on mortality, we used the multivariate multivariable Cox Proportional hazards model with time-dependent covariates. In the multivariate analysis, we included covariates that differed significantly in the univariate. Therefore, the Cox Proportional hazards model included the following covariates: age, sex, morbid obesity, smoking, and tracheostomy timing.

Statistical significance was assumed when the null hypothesis could be rejected at $p < 0.05$. All P-values are the results of two-sided tests. Statistical analyses were conducted using SPSS (version 27).

3. Results

3.1. Baseline characteristics and operative data

During seventeen-years study period, between 09.2004 and 08.2021, 12,782 patients underwent cardiac surgery at our institution, of whom 407 (3.18%) required postoperative tracheostomy (See Table 1). 147 (36.1%) had early; 195 (47.9%) intermediate and 65 (16%) late tracheostomy. The three groups were similar regarding their baseline characteristics and operative data. 47 patients were underwent open, surgical procedure and 360 – percutaneous procedure. From a surgical procedure perspective, also there were no significant differences between the groups, regarding frequency and type of procedure, duration of cardiopulmonary bypass time and the cross-clamp time. (See Table 2.)

3.2. Outcome . Postoperatively, early tracheostomy was not associated with sternal wound infection There was a higher rate of deep sternal wound infection observed in the late tracheostomy group (p <0.001), although most of the patients in this grou

p had known, ongoing sternal or another infection at the time of tracheostomy (See Table 3). Only small number of patients were extubated and follow re-intubated (5.3%; 3.9% to 8% between the groups, p=0.278). Re-intubation itself has no influence on mortality. Incidence of sternal wound infection (SWI), both superficial and deep, was higher in the late group (18.4%) (p <0.001) to compare with early (6.8%) and intermediate (7.7%) groups, and infection in the most cases developed before tracheostomy (See Table 3). All sternal wound infection treated by opening of the wound at the bedside and/or application waccum device and defined as surgical complication Grade I according to Dindo classification[7].

In our study, as we demonstrated, early, 30-day mortality was similar for all four groups. However, patients, who underwent early- and intermediate tracheostomy, demonstrating statistically significant lower mortality after 1- and 2-year. Also 5-year mortality were significantly low (55.8%; 68.7%; and 75.4%, respectively; p <0.001)

(See Table 3). Cox model is show, that covariate as time from operation to tracheostomy and age as significant factor for mortality (See Table 4).

4. **Discussion**

4.1. Main discussion. Up to 12% of the 800,000 patients who undergo mechanical ventilation in the United States every year require tracheostomies in the general ICU population[8]. Studies, performed in trauma populations, shoved incidence of tracheostomy as 24.7%[9], in the patients suffering from acute myocardial infarction with cardiogenic shock – 5.7%[10]. In the patients after cardiac surgery rate varies between 1.4% and 6.2%[2,11,12]. In our study tracheostomy rate is 3.2%.

Tracheostomy after cardiac surgery was first described in 1964 by Robertson[13]. The percutaneous tracheostomy technique was introduced in1985 by Ciaglia, and today has proven to be a safer as standard surgical tracheostomy[14]. Over the last two decades, the utilization of tracheostomy for cardiac surgical patients requiring prolonged mechanical ventilation has become more frequent. The reasons for this trend are multifactorial, including an aging surgical population, increased prevalence of serious comorbidities in the surgical population and associated increased operative risk, increased number of patients undergoing redo surgery, increased utilization of ECMO, and broader surgical indications[1,2,15].

Tracheostomy offers few advantages over orotracheal intubation. Tracheostomy reduces dead space and airway resistance, thereby decreasing the work of breathing and possibly allowing earlier liberation from mechanical ventilation [5,16]. In addition, tracheostomy potentially reduces the need for sedation, which allows for patient mobilization, communication, nutrition and lowers the incidence of VAP[16-19]. Conversely, the possible disadvantage of early tracheostomy is the risk of sternal wound infection which may be explained by the close proximity of respiratory secretions to the sternotomy incision. Few studies showed increased the risk of sternal wound infection and mediastinitis in patients with a median sternotomy because of possible bacterial contamination from the tracheostomy[20,21]. Pilarczyk *et al* .[22] reported a significantly higher incidence of deep sternal wound infection when tracheostomy is performed within 48 hours after surgery. But, current literature, however, seems to have disproved this association. In their series, Rahmanian et *al* .[23] showed no correlation between early tracheostomy and deep sternal infection. Ben-Avi *et al* .[1]reported high incidence of SWI in the late group (more than 15 days). In a meta-analysis, Toeg *et al* .[24] found that patients who had undergone early or late tracheostomy after cardiac surgery had comparable rates of sternal wound infection, and tracheostomy itself may not be a risk factor for SWI, but indicator of patient critical illness. In our study incidence of SWI, both superficial and deep was higher in the late group (18.4%) to compare with early (6.8%) and intermediate (7.7%) groups, and infection in the most cases developed before tracheostomy.

What remains controversial, however, is the optimal timing for performing the procedure. In post-cardiac surgical patients, a recent large national analysis of 33,765 patients undergoing tracheostomy by Sareh *et al* .[2], demonstrated similar early postoperative outcomes (sternal wound infection, in-hospital mortality) in early (<14 days) versus late (14-30 days) tracheostomy groups. A smaller study by Affronti *et al.* [15], including 112 patients demonstrated shortened ventilation time and CSICU stay for the early tracheostomy group, but no differences in short or long-term mortality. Devarian *et al* .[25]concluded that early tracheostomy after cardiac surgery was associated with reduced cardiac morbidity (14% vs. 33%) and lower in-hospital mortality (21.1% vs. 40.4%), but unlike the present study, the authors included only isolated CABG or isolate valve procedures. In a single-center study, Ben-Avi *et al* .[1] did not report any differences in terms of ventilation time, ICU stay, hospital stay, and 30-day mortality, but found lower mid-term mortality for the early tracheostomy group. In the systematic review by Adly *et al* .[6], all studies were divided into three groups, according to tracheostomy time: within the 7, 14 or 21 days of endotracheal intubation. There was a significant difference in favor of early tracheostomy regarding reduced duration of mechanical ventilation, hospital-acquired pneumonia, less mortality rates and less duration of stay in ICU. Studies defining early tracheostomy as that done within 7 days of intubation had better results than those that done within 14 or 21 days of intubation.

We assume that not the tracheostomy per se is responsible for mortality. However, we do believe that it is not implausible to consider a link between a complicated postoperative course to mortality. We report the findings of our study, which tracheostomy time were found to be statistically significant regarding the long-term mortality. In addition, it is necessary to remember that we are talking only about a small, very specific group of patients with tracheostomy, and not about all patients.

In contrary, a randomized trial by Trouillet *et al* .[12] compare immediate early percutaneous tracheotomy or prolonged intubation with tracheotomy 15 days after randomization and concluded that early tracheostomy provided no benefit in terms of mortality or infectious complications.

Overall, the survival rate for patients undergoing tracheostomy after cardiac surgery remains low. Ben-Avi *et al* .[1]described a 1- and 2-year survival rate of 34% and 32%, respectively. Similar results reported Ballotta *et al* .[26]. In this study the hospital mortality rate was 49%, survival rate for patients discharged from the hospital was 61% at 1 year, 49% at 2 years, 45% at 3 years, and 34% at 5 years. Krebs *et al* .[11] reported, that tracheostomy patients had high short-term and long-term mortality, with a median survival of 6 months, 1-year survival of 41%, and 5-year survival of 29.1%. Affronti*et al* .[15] reported 1- and 2-year survival of

43.8% and 35.7% respectively, and Walts *et al* .[27] described 30 days and 2 years survival 75% and 31% respectively.

The 407 patients in the present study represent the single-center cohort of post-cardiac surgical patients undergoing tracheostomy. The short-term mortality results reported here correlate with previously documented data. However, unlike previous studies, this study demonstrates a significant mid and long term survival benefit associated with earlier tracheostomy. These results, in conjunction with the other advantageous aspects of early tracheostomy suggest that earlier is better when a tracheostomy is required.

4.2. Study limitations

There are several potential limitations to this study. First, a non-randomized retrospective trial it is subject to selection bias. Second, during the study period the CSICU was converted from an open care model to a semi-closed model, and which may have impacted outcomes as well. Third, in the initial period between tracheostomies were performed by open approach by ENT surgeons, and follow tracheostomies were performed at the bedside using the percutaneous dilatation technique. Fourth, we don't investigate secondary outcomes as use of prolonged sedation, rate of VAP, length of hospital stay, and number of ventilator-free days. It was beyond scope of the study. Five, authors have no data on the number of patients who were discharged home/nursing home/rehabilitation facility or remained in hospital. Also, we do not have information on the number of decanulated patients. And sixth: we agree that it is difficult to assess the causality of timing of tracheostomy and long-term survival. It is possible that those who received a later tracheostomy were not initially indicated for a tracheostomy at all.

5. Conclusion

This study demonstrates a relationship between the timing of tracheostomy after cardiac surgery and mid and late-term mortality: early postoperative tracheostomy within 4-10 days of mechanical ventilation associated with better long-term survival. Short-term mortality does not seem to be affected by the timing of tracheostomy. On the basis of our findings, we believe that early, within 4-10 days tracheostomy should be considered for post-cardiac surgical patients who require prolonged mechanical ventilation. In conclusion authors want to rephrase the rule from Marino's ICU Book[28]: "The indication for intubation and mechanical ventilation is thinking of it", e.g. the indication for tracheostomy is thinking of it. If you do a tracheostomy - is sooner rather than later.

Availability of data

The data underlying this article will be shared on reasonable request to the corresponding author.

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Legend for Figure 1: Survival rate according to tracheostomy time

Table 1: Patients Data

	Tracheostomy	**No Tracheostomy**	p **Value**
N	**407**	**12610**	
Age	67.8±12.6	63.9±13.4	<0.001
Male	244 (60.1%)	8720 (69.2%)	<0.001
Elective	164 (40.4%)	6938 (55.0%)	<0.001
FC III	143(41.9%)	3043 (29.0%)	<0.001
FC IV	63 (18.5%)	583 (5.5%)	
NYHA III-IV	206 (60.4%)	3626 (34.5%)	<0.001
Previous MI	87 (21.4%)	2709 (21.5%)	0.996
PVD	69 (18.0%)	930 (7.7%)	<0.001
Hypertension	268 (68.4%)	7652 (61.5%)	0.006
Diabetes	163 (41.2%)	3722 (29.9%)	<0.001
Hypercholesterolemia	229 (57.8%)	7014 (56.5%)	0.606
COPD	56 (14.1%)	751 (6.1%)	<0.001
Active smoking	76 (19.7%)	2129 (17.4%)	0.248
Previous CVA	63 (16.7%)	1086 (8.9%)	<0.001
Obesity	146 (36.4%)	3723 (29.7%)	0.004
Dialysis	13 (4.7%)	131 (1.2%)	<0.001
Arrhythmia	229 (82.7%)	6434 (74.7%)	0.002
Previous operation	112 (27.6%)	1783 (14.1%)	<0.001
Pulmonary pressure (mm Hg)*	50.5 (39.0-62.0)	37.0 (30.0-49.0)	<0.001
EF (%)*	50.0 (30.0-60.0)	58.0 (47.0-60.0)	<0.001
Standard EuroSCORE I*	9.0 (7.0-12.0)	5.0 (3.0-7.0)	<0.001
Logistic EuroSCORE I*	16.8 (8.5-30.8)	4.4 (2.1-9.1)	<0.001

Abbreviations: FC: functional class; NIHA: New York Heart Association; MI: myocardial infarction PVD: peripheral vascular disease; COPD: chronic obstructive lung disease; CVA: cerebrovascular accident; EF: ejection fraction; *Median (interquartile range)

Table 2. Perioperative patient's parameters according to groups

	Early tracheostomy (4-10 days)	Intermediate tracheostomy (11-20 days)	Late tracheostomy ([?]21 days)	p
N	**147**	**194**	**65**	
Age	66±12	69±12	67±15	0.177
Male	101 (68.7%)	110 (56.7%)	33 (50.8%)	0.020
Elective	58 (39.5%)	79 (40.7%)	27 (41.5%)	0.952
FC III	53 (43.8%)	67 (41.4%)	23 (39.7%)	0.853
FC IV	26 (21.5%)	27 (16.7%)	10 (17.2%)	
NYHA III-IV	79 (65.3%)	94 (58.1%)	33 (56.9%)	0.389
Previous MI	22 (15.0%)	46 (23.7%)	19 (29.2%)	0.037
PVD	25 (17.9%)	31 (17.2%)	13 (20.6%)	0.830
Hypertension	99 (70.7%)	126 (67.0%)	43 (67.2%)	0.758
Diabetes	57 (39.9%)	77 (41.0%)	29 (44.6%)	0.809
Hypercholesterolemia	84 (59.2%)	108 (57.1%)	37 (56.9%)	0.923
COPD	28 (19.6%)	18 (9.6%)	10 (15.4%)	0.033
Smoking	36 (26.1%)	29 (15.7%)	11 (17.5%)	0.059

	Early tracheostomy (4-10 days)	Intermediate tracheostomy (11-20 days)	Late tracheostomy ([?]21 days)	*p*
Previous CVA	21 (15.6%)	30 (16.8%)	12 (18.8%)	0.852
Obesity	61 (41.8%)	63 (33.0%)	22 (34.4%)	0.234
Dialysis	1 (1.0%)	10 (7.2%)	2 (4.5%)	0.087
Arrhythmia	96 (85.7%)	103 (79.8%)	30 (83.3%)	0.483
Previous operation	37 (25.2%)	58 (29.9%)	17 (26.2%)	0.602
Pulmonary pressure (mm Hg)*	50.0 (33.0-60.0)	45.0 (30.0-60.0)	50.0 (30.0-60.0)	0.919
EF (%)*	54 (42.5%)	91 (51.4%)	25 (43.9%)	0.268
Standard EuroSCORE I*	9.0 (7.0-12.0)	10.0 (7.0-12.0)	9.0 (7.0-11.0)	0.774
Logistic EuroSCORE I*	18.3 (7.7-32.3)	16.6 (8.9-31.7)	14.9 (8.1-27.2)	0.879
Bypass time (min)*	134.5 (93.3-176.3)	134.0 (94.0-187.0)	108.0 (81.8-171.8)	0.496
Cross-clamp time (min)*	85.0 (60.3-129.3)	90.0(64.5-121.5)	71.5(55.0-98.3)	0.237
Isolated CABG surgery	20 (13.6%)	18 (9.3%)	11 (16.9%)	0.207
Isolated valve surgery	16 (10.9%)	31 (16%)	10 (15.3%)	0.569
Combined surgery	111 (75.5%)	145 (74.7%)	44 (67.7%)	0.457

Abbreviations: FC: functional class; NIHA: New York Heart Association; MI: myocardial infarction PVD: peripheral vascular disease; COPD: chronic obstructive lung disease; CVA: cerebrovascular accident; EF: ejection fraction; *Median (interquartile range)

Table 3. Mortality and sternal wound infection according to groups

	Early tracheostomy (4-10 days)	Intermediate tracheostomy (11-20 days)	Late tracheostomy ([?]21 days)	p
N	**147**	**195**	**65**	
30 days mortality	34 (23.1%)	45 (23.1%)	24 (36.9%)	0.065
1 year mortality	63 (42.9%)	112 (57.4%)	42 (64.6%)	0.003
2 years mortality	66 (44.9%)	118 (60.5%)	47 (72.3%)	<0.001
5 years mortality	82 (55.8%)	134 (68.7%)	49 (75.4%)	0.007
Superficial sternal wound infection	7 (4.8%)	8 (4.1%)	1 (1.5%)	0.104
Deep sternal wound infection	3 (2%)	7 (3.6%)	11 (16.9%)	<0.001

Table 4. Cox Regression for mortality with tracheostomy as a time-varying covariate

	B	Sig	Exp (B)	95.0% CI for Exp (B)	95.0% CI for Exp (B)
				Lover	Upper
Age	.025	0.002	0.025	0.013	0.037
Gender	-.156	0.237	0.856	0.661	1.108
Time to tracheostomy	-.154	0.008	0.135	0.135	0.138
Smoking	-.197	0.321	0.821	0.556	1.213
Morbid Obesity	-.131	0.365	0.877	0.661	1.165

Figure 1. Kaplan-Meier survival by according to groups

0-10 ________

11-20 ________

21+ ________

Log Rank= 0.015

Patient at risk

4-10 147 75 66 52 37 24 22

11-20 195 78 66 54 42 32 25

21+ 65 20 14 11 10 10 8