Risk Factors for the Development of Nosocomial Pneumonia and Its Clinical Impact in Cardiac Surgery

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Abstract

Background

The development of nosocomial pneumonia after cardiac surgery is a significant post-operative complication that may lead to increased morbidity, mortality, and hospital cost. We aimed to identify risk factors associated with it and to determine its clinical impact in terms of in-hospital mortality and morbidity.

Methods

This is a retrospective cohort study conducted among all adult patients who underwent cardiac surgery from 2014-2019 in St. Luke's Medical Center, Quezon City, Philippines. Baseline characteristics and possible risk factors for pneumonia were retrieved from medical records. Nosocomial pneumonia was based on the Centers for Disease Control and Prevention criteria. Clinical outcomes include in-hospital mortality and morbidity. Odds ratios from logistic regression was computed to determine risk factors associated with pneumonia using STATA 15.0.

Results

Out of 373 patients included in this study, 104 (28%) patients acquired pneumonia. Most surgeries were coronary artery bypass graft (CABG) (71.58%), followed by valve repair/replacement (29.76%). Neither age, sex, BMI, diabetes, LV dysfunction, renal dysfunction, COPD/asthma, urgency of surgery, surgical time, nor smoking showed association in the development of pneumonia. However, preoperative stay of >2 days was associated with 92.3% (95%CI 18–213%) increased odds of having pneumonia (p=.009). Also, every additional hour on mechanical ventilation conferred 0.8% (95%CI, 0.3–1%) greater odds of acquiring pneumonia (p=.003).

Patients who developed pneumonia had 3.9 times odds of mortality (95%CI 1.51–9.89, p=.005), 3.8 times odds of prolonged hospitalization (95%CI 1.81–7.90,p<.001), 6.4 times odds of prolonged ICU stay (95%CI 3.59–11.35,p<.001), and 9.5 times odds of postoperative reintubation (95%CI 3.01–29.76,p<.001).

Conclusion

Among adult patients undergoing cardiac surgeries, prolonged preoperative hospital stay and prolonged mechanical ventilation were both associated with an increased risk for nosocomial pneumonia. Those who developed pneumonia had worse outcomes with significantly increased in-hospital mortality, prolonged hospitalization, prolonged ICU stay, and increased postoperative re-intubation. Clinicians should therefore minimize delays in surgery to avoid unnecessary exposure to pathogenic organisms. Also, timely liberation from mechanical ventilation after surgery should be encouraged.

Highlights

- Prolonged preoperative hospital stay and prolonged mechanical ventilation are both significantly associated with an increased risk for nosocomial pneumonia among adult patients undergoing cardiac surgeries.
- Clinicians should minimize delays in surgery to avoid unnecessary exposure to pathogenic organisms.
- Timely liberation from mechanical ventilation after cardiac surgery should be encouraged.

Introduction

The development of nosocomial pneumonia after cardiac surgery is a significant post-operative complication that may lead to increased morbidity, mortality, and hospital cost[1,2]. Published rates of pneumonia after cardiac surgery ranges from 2–10%[3–8]. This translates to an attributable mortality rate ranging from 5–70%[2,9]. Limited data exist on its clinical burden in the local setting.

Some of the co-morbidities of patients with cardiac diseases are also considered to be risk factors for hospital acquired infections. These include advanced age, chronic lung disease, heart failure and diabetes mellitus[10]. Hence, cardiac surgery patients with multiple co-morbidities are particularly prone to develop hospital infections such as postoperative pneumonia.

In addition, the impairment in pulmonary mechanics may result to atelectasis and pneumonia. Cardiac surgery involves the need for sternotomy and thoracotomy to access the heart. These deep incisions result to pain, hence diminishing the patients' capacity for deep breathing and coughing. Furthermore, cardiopulmonary bypass, with its release of systemic inflammatory mediators may contribute to the development of pneumonia[11]. Prolonged mechanical ventilation after cardiac surgery may also increase the risk for pneumonia[12].

Apart from host factors, several hospital management processes may also affect the incidence of postoperative pneumonia[13,14]. These may include level of fluid administration, antibiotic prophylaxis, mechanical ventilatory management, strictness of handwashing implementation among healthcare personnel, number of visitors allowed at any given time, and cardiac Intensive Care Unit (ICU) admission protocols. However, only a few have looked into the relationship of these "processes of care" and postoperative pneumonia in the cardiac setting.

Our aim was to determine the time course and identify risk factors of postoperative nosocomial pneumonia in adult patients undergoing cardiac surgery. Also, we aimed to determine the clinical impact of pneumonia in terms of in-hospital morbidity and mortality. The results of this study may help cardiovascular clinicians in the determination of the most appropriate perioperative strategy to prevent the occurrence of pneumonia in the cardiac surgery setting.

Methods

Study design

This was a single-center retrospective cohort study conducted among consecutive adult patients aged > or = 19 years who underwent cardiac surgeries from the period of January 1, 2014 up to December 31, 2019. Our 650-bed capacity academic medical center, St. Luke's Medical Center, Quezon City, Philippines, approved our study protocol (including the institutional Ethics Review Committee). It has a coronary care unit (CCU) with 11 beds. The average rate of adult cardiac surgeries being done in the institution is 76 per year.

Study Population

Included patients were all adult patients at least 19 years of age who underwent cardiac surgical interventions, regardless of urgency, type, and patient's risk for cardiac surgery. Excluded were patients who had active concomitant infections requiring systemic antibiotics at the time of surgery.

Data for the following variables were obtained from the electronic medical records of the patients as follows: Demographics and co-morbidities such as age, sex, body mass index (BMI), presence or absence of the following: hypertension, Diabetes Mellitus (DM), dyslipidemia, renal dysfunction, history of smoking, asthma, chronic obstructive pulmonary disease (COPD) and left ventricular systolic dysfunction, and operative factors such as type of operative procedure, urgency of procedure, bypass time, ischemic time, total surgical time, preoperative length of hospital stay and duration of mechanical ventilatory support.

The primary clinical outcome investigated was the development of nosocomial pneumonia after the index cardiac surgery and within the hospitalization. Other clinical outcomes include in-hospital mortality and in-hospital morbidity (prolonged hospital stay, prolonged ICU stay, and post-operative re-intubation). All clinical outcomes were reviewed by two independent event adjudicators (MN, KR).

Operational Definitions

Cardiac Surgery: any surgery involving the heart wherein the patient is connected to a heart-lung bypass machine, or bypass pump. This may include: coronary artery bypass grafting, valvular repair or replacement, repair of aortic aneurysms and congenital heart diseases.

A. Risk Factors

Duration of mechanical ventilatory support: Duration in hours from the time of intubation to the time of extubation from mechanical ventilation.

Ischemic time: defined as the time interval in minutes from the application of aortic cross-clamp to release of cross-clamp applied during the cardiac surgery.

Bypass time: defined as the total time in minutes that the patient is hooked to a cardiopulmonary bypass machine.

Pre-operative length of hospital stay: Number of days of hospital stay prior to undergoing the index cardiac surgery.

Length of surgery: Total length of surgical procedure in hours as documented in the operating room record.

B. Clinical Outcomes

The nosocomial pneumonia selection criteria based on the Centers for Disease Control and Prevention (CDC) Guidelines[15]. It must meet one of the following criteria:

1. Rales or dullness to percussion on physical examination of chest and any of the following:

   a. New onset of purulent sputum or change in character of sputum
   b. Organism isolated from blood culture
   c. Isolation of pathogen from specimen obtained by transtracheal aspirate, bronchial brushing, or biopsy

2. Chest radiographic examination showing new or progressive infiltrate, consolidation, cavitation, or pleural effusion and any of the following:

   a. New onset of purulent sputum or change in character of sputum
   b. Organism isolated from blood culture
   c. Isolation of pathogen from specimen obtained by transtracheal aspirate, bronchial brushing, or biopsy
   d. Isolation of virus or detection of viral antigen in respiratory secretions
   e. Diagnostic single antibody titer (IgM) or fourfold increase in paired serum samples (IgG) for pathogen
   f. Histopathologic evidence of pneumonia

In-hospital Morbidity: Defined as having any of the following:

1. Prolonged hospital stay: defined as having more than eight days of total hospitalization days after index cardiac surgery.

2. Prolonged intensive care unit stay: defined as having more than five days of total CCU stay after index cardiac surgery.

3. Post-operative re-intubation: Re-intubation of a cardiac surgery patient after an initial extubation post-op, regardless of indication of re-intubation.

In-hospital Mortality: Defined as patient demise during or after the index cardiac surgery and before hospital discharge, regardless of etiology.

Statistical Analysis

Descriptive statistics was used to summarize the general and clinical characteristics of the participants. Shapiro-Wilk test was used to determine the normality of continuous variables. Frequency and proportion were used for nominal variables. interval/ratio variables. Continuous quantitative data that meet normality assumption was summarized using mean and standard deviation (SD), while those that do not was described using median and range.

Independent sample T-test, Mann-Whitney U test, and Fisher's exact/Chi-square test was used to determine the differences in distributions of means, medians and nominal data of those who had pneumonia versus those without, respectively.

Odds ratios and the corresponding 95% confidence intervals from logistic regression was computed to determine the risk factors associated with pneumonia. Cumulative incidence and incidence density rate of pneumonia were likewise estimated.

Time to event (pneumonia and mortality) analysis was performed using standard Kaplan-Meier survival analysis techniques. Patients last known to be alive without an event were censored at the date of last contact (discharge).

All valid data was included in the analysis. Missing variables was neither replaced nor estimated. Null hypothesis was rejected at 0.05α-level of significance. STATA 15.0 was used for data analysis.

Results

A total of 460 patients undergoing cardiac surgery were considered for inclusion in this study. Eighty-seven patients were excluded due to the presence of active systemic infection at the time of surgery and/or are aged 18 years and below. A total of 373 patients were reviewed in the final analysis. They had a median age of 59 (range 19–90) years (Table 1). Males comprised 74%. The median BMI was 26.45 (range 15.22–42.46) kg/m2. Hypertension (74%), diabetes (46%), and dyslipidemia (27%) were the most frequent comorbidities. The smoking history of 32% indicated a median of 20 (range 1–150) pack-years.

Most surgeries were CABG (71.58%) (Table 2), followed by valve repair or replacement (29.76%). Almost all (99%) patients had elective cardiac surgeries. The median bypass time, ischemic time, and surgical time were 135 minutes, 113 minutes, and 5.22 hours, respectively.

Characteristics of patients who developed pneumonia

A total of 104 (28%) patients acquired pneumonia (Table 1). They were mostly males (72%), with a median age of 61 years, BMI of 26.51 kg/m^2 and had a smoking history of 20 pack years. Most common co-morbidities were hypertension (72%), DM (52%) and dyslipidemia (34%). The two groups were comparable in terms of their baseline characteristics.

Most patients (70.19%) had CABG, followed by valve repair or replacement (31.73%). (Table 2) The median bypass time, ischemic time, and surgical time were 138 minutes, 114 minutes, and 5.3 hours, respectively. Those who developed pneumonia after cardiac surgery were comparable to those who did not in terms of operative characteristics.

In contrast, patients who developed pneumonia had significantly longer median pre-operative stay (3 days vs. 2 days, $p = .011$) and duration of mechanical ventilation (10.2 hours vs. 9 hours, $p < .001$).

The incidence of pneumonia among post-cardiac surgery is above 10% at 3 days post-surgery; it is estimated at 17.60% (95% CI 14–22%). This estimate increases steadily within the first 2 weeks after surgery, and by 13 days post-surgery (Fig. 1), the incidence is at 31.42% (95% CI 26–37%), which means that three out of 10 cardiac surgery patients would have developed pneumonia within the first 2 weeks post-operatively. The incidence density rate of pneumonia is at 29 patients per 1000 patient-years.

Seventeen (4.55%) cardiac surgery patients in our study population died. The mortality rate for patients with and without pneumonia were 2.7% and 1.9%, respectively. Table 4 shows the survival probability of post-cardiac surgery patients at 7 days, 15 days, and 30 days after surgery. There is a marked difference between the 30-day survival of those with versus without pneumonia; those with pneumonia have a survival probability with a 95% CI of 63–91.5%, which is lower (and non-overlapping) than the 95% CI of those without pneumonia, which is a survival probability of 91.6–98.6%. Figure 2 depicts the time-varying effect of pneumonia on patient survival.

On both crude and adjusted analyses, neither age, sex, BMI, diabetes, LV dysfunction, renal dysfunction, COPD or asthma, priority of surgery, surgical time, nor smoking history status showed an association with the development of postoperative pneumonia (Table 3). However, more than two days of preoperative hospital stay was associated with a 92.3% (95% CI 18–213%) increased odds of having pneumonia compared to those with shorter preoperative stay ($p = .009$). Also, every additional hour on mechanical ventilation conferred a 0.8% (95% CI, 0.3–1%) greater odds of acquiring pneumonia ($p = .003$).

Patients with pneumonia demonstrated increased odds (Table 4) for undesirable outcomes in comparison with those who did not develop this complication, with the former having about 3.9 times the odds of mortality, 3.8 times the odds of prolonged hospitalization, 6.4 times the odds of prolonged ICU stay, and 9.5 times the odds of needing postoperative reintubation.

Discussion

Incidence of postoperative pneumonia

Postoperative pneumonia occurred in 28% (104/373) of patients after cardiac surgeries, most occurred (95%) within 7 days post-surgery. This incidence is higher than the reported incidence in other countries ranging from 2–10%[3–8].This variation could be related to several factors such as ethnic, cultural, and economic differences of the population studied, management practices and processes of care of

hospitals, epidemiological surveillance adopted per institution, and level of compliance to infection control measures[16].

Risk factors associated with pneumonia

Patients undergoing cardiac surgery have a higher risk of developing nosocomial infections. Risk factors for developing coronary artery disease, as well as various cardiac conditions, are also considered risk factors in the development of hospital infection. These include advanced age, diabetes mellitus, and smoking.

In our study, however, preoperative patient characteristics such as age, sex, BMI, DM, severe left ventricular systolic dysfunction, renal dysfunction, lung diseases, and smoking were not associated with the development of pneumonia. Likewise, other surgical factors such as ischemic time, bypass time, total surgical time, and urgency of surgery were not associated with pneumonia development.

In contrast, our results showed that more than two days of preoperative hospital stay and longer time on mechanical ventilation were both associated with an increased risk of developing pneumonia.

Prior to their cardiac surgery, these patients may be admitted to the intensive units for a variable period of time due to several reasons. They may present with cardiac symptoms necessitating hospital admission prior to surgery. Moreover, some patients have had acute coronary events which would take an additional 5–7 days to washout the antiplatelet agents given prior to CABG. These patients may have longer hospital stay before their scheduled operation, thus may be subjected to longer exposure to the hospital environment and possibly to pathogens.

Several studies have shown that prolonged intubation and mechanical ventilation increases the risk of postoperative pneumonia, length of hospital stay, and in-hospital complications[12]. Thus, one of the prominent focus of cardiac surgical quality improvement has been early weaning and extubation. Our study found a 0.8% increase in acquiring pneumonia for every hour delay of extubation from mechanical ventilation, hence, re-emphasizing the importance of timely postoperative extubations.

Impact of pneumonia on clinical outcomes

The overall in-hospital mortality observed was 4.55%, which is 17 out of the 373 patients included in the study. Ten out of the 17 patients who died had postoperative pneumonia. This translates to an attributable mortality rate of 58.8% among patients undergoing cardiac surgery who developed pneumonia. This is higher compared to a study done in eight European countries which showed a mortality rate of 35%[4]. On analysis, the development of postoperative pneumonia in our study was associated with a nearly 4-fold increase in in-hospital mortality.

In addition to mortality, pneumonia conferred a significant burden on patient morbidity. It is associated with a 4-fold increase in prolonged hospitalization, 6-fold increase in prolonged ICU stay, and a 9-fold increase in postoperative re-intubation.

Our study did not analyze the economic impact of pneumonia in the cardiac surgery population. However, due to the findings of prolonged hospitalization and ICU stay among patients who had pneumonia, it may be surmised that pneumonia may also incur an increased burden on resource utilization. A study by Ailawadi et al. [10] among cardiac surgery patients showed that the occurrence of major hospital acquired infection incurred an additional $38,000 to hospital cost on an individual level.

Timing of pneumonia and relationship to mortality

The median time to the onset of postoperative pneumonia was 3 days, ranging from 1 to 13 days. Ninety-five percent of patients who had pneumonia acquired it within 7 days post cardiac surgery. This is expected as majority of pneumonia would manifest early after surgery due to the occurrence of postoperative pain and need for narcotics, both resulting to inadequate respiratory mechanics.

Our study showed that at around 13th post-operative day, the probability of acquiring pneumonia is at 31% (Fig. 1). Given the chance of developing pneumonia even after first week post-surgery, this emphasizes the need for continuation and maintenance of intensive postoperative pulmonary care. This may include early ambulation and progressive cardiac rehabilitation. A study done by Stolbrink et al. among medical inpatients showed that early ambulation significantly decreased the incidence of hospital-acquired pneumonia ($p < 0.0001$)[17]. Furthermore, a study by Ferreira[18] showed that an inspiratory muscle rehabilitation program significantly improved the respiratory mechanics of patients among post cardiac surgery patients. Herdy et al.[19] also demonstrated decreased incidence of postoperative pneumonia among CABG patients who had early postoperative cardiopulmonary rehabilitation compared to those who had standard care ($p = 0.004$).

The median time to mortality is 8 days post cardiac surgery (range of 1 to 35 days). The probability of survival decreases in the presence of pneumonia, with Kaplan Meier curves beginning to diverge after around 3 days (Fig. 2). Further, among patients who had pneumonia, the estimated 30-day survival is 81.70%. This is in contrast to a 96.51% 30-day estimated survival to those who did not acquire pneumonia. Thus, clinicians should be aggressive in the management upon onset of nosocomial pneumonia. A study done by Luna et al[20] showed that early initiation of antibiotic therapy improves survival of patients with ventilator associated pneumonia compared to those who had delayed initiation, with reported mortality rates of 29.2% versus 58.3%, respectively.

Our study has several limitations. Since the average length of stay of routine cardiac surgeries such as CABG is 5–7 days, the true incidence of pneumonia may be underestimated given the retrospective nature of this study. Late onset pneumonias which may have occurred after hospital discharge and during re-admissions could have been missed. Also, the results and conclusions of this study is based on a single center result, which cannot be extrapolated to other institutions. The differences in hospital preventive measures that are implemented and the level of compliance of health care professionals to infection control policies may be varied among hospitals.

Implications for Practice

Given the significantly increased in-hospital mortality and morbidity among those who acquired pneumonia, this study highlights the importance of infection control and preventive measures in the perioperative cardiac setting. Such emphases require behavioral and probably cultural changes which may be accomplished through repeated hospital education, audit, and feedback.

We recommend the creation and implementation of a clinical pathway for patients undergoing cardiac surgeries with a goal of improving clinical outcomes and hospital cost. The pathway should aim to provide coordinated care amongst health professionals, with particular emphasis on infection control and preventive measures.

Implications for Research

Future studies are needed to identify the different pathogenic organisms responsible for nosocomial pneumonia, as well as to determine the role of antibiotic prophylaxis in the prevention of infection in the cardiac surgical setting. Likewise, it would also be pertinent to determine the financial impact of postoperative pneumonia with the goal of improving hospital processes of care.

Conclusion

Among adult patients undergoing cardiac surgeries, prolonged preoperative hospital stay and prolonged mechanical ventilation were both associated with an increased risk for nosocomial pneumonia. Those who developed pneumonia had worse outcomes with significantly increased in-hospital mortality, prolonged hospitalization, prolonged ICU stay, and increased postoperative re-intubation. Clinicians should therefore minimize delays in surgery to avoid unnecessary exposure to pathogenic organisms. Also, timely liberation from mechanical ventilation after surgery should be encouraged.

Abbreviations

ICU – Intensive Care Unit

CCU – Coronary Care Unit

BMI – body mass index

DM – Diabetes Mellitus

COPD – Chronic obstructive pulmonary disease

CDC – center for disease control and prevention

SD – standard deviation

CABG – coronary artery bypass grafting

Declarations

This research has been reviewed, approved and checked for quality and integrity by the St. Luke's Medical Center Institutional Research Board. Data were collected in an ethical manner and have been approved by our Institutional Ethics Review Board (St. Luke's Medical Center). The authors give consent to Journal of Cardiothoracic Surgery for review and possible publication. This research is an original work. The research is not currently under review at another journal and not forthcoming.

Declaration of competing interests

The authors state no conflict of interest

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None.

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None.

Authors' Contributions

FG was involved in research project conceptualization, organization, execution, data collection, statistical analysis and main manuscript writing. EO, RC, AM, and DD were involved in research projection conceptualization, organization, execution, manuscript writing and critique. ER, HG and CN were involved in data collection and statistical analysis. All authors read and approved the final manuscript.

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Tables

Table 1
Clinico-demographic profile of patients who underwent cardiac surgery

	All (n = 373)	With Pneumonia (n = 104)	No Pneumonia (n = 269)	*p*
	Median (Range); Frequency (%); Mean ± SD			
Age, years	59 (19–90)	61 (20–88)	58 (19–90)	.071*
Sex				.555†
Male	277 (74.26)	75 (72.12)	202 (75.09)	
Female	96 (25.74)	29 (27.88)	67 (24.91)	
Height, cm	164.32 ± 8.58	163.15 ± 8.51	164.78 ± 8.57	.101‡
Weight, kg	72 (35–132)	72 (35–117)	72.5 (38–132)	.908*
BMI, kg/m^2	26.45 (15.22–42.46)	26.51 (15.77–41.45)	26.4 (15.22–42.46)	.434*
Comorbidities				
Hypertension	275 (73.73)	75 (72.12)	200 (74.35)	.660†
Diabetes mellitus	173 (46.38)	54 (51.92)	119 (44.24)	.182†
Dyslipidemia	101 (27.08)	35 (33.65)	66 (24.54)	.076†
COPD or asthma	68 (18.23)	20 (19.23)	48 (17.84)	.756†
Renal dysfunction	53 (14.21)	18 (17.31)	35 (13.01)	.287†
LV dysfunction	44 (11.80)	10 (9.62)	34 (12.64)	.417†
With smoking history	120 (32.17)	34 (32.69)	86 (31.97)	.894†
Pack-years	20 (1–150)	20 (1–150)	23 (1–150)	.595
Current smoker	18 (4.83)	3 (2.88)	15 (5.58)	.277
Statistical Tests Used: *–Mann Whitney U test; †–Chi-square Test of Independence; ‡–Independent t-test				

Table 2
Operative characteristics of patients who underwent cardiac surgery

	All (n = 373)	With Pneumonia (n = 104)	No Pneumonia (n = 269)	*p*
	Frequency (%); Median (Range)			
Type of surgery				
CABG	267 (71.58)	73 (70.19)	194 (72.12)	.711†
Valve repair or replacement	111 (29.76)	33 (31.73)	78 (29)	.604†
Aortic repair	7 (1.88)	4 (3.85)	3 (1.12)	.098§
Congenital surgery	9 (2.41)	2 (1.92)	7 (2.60)	1.00§
Others	9 (2.41)	5 (4.81)	4 (1.49)	.123§
Priority of surgery				.135§
Urgent	5 (1.34)	3 (2.88)	2 (0.74)	
Elective	368 (98.66)	101 (97.12)	267 (99.26)	
Bypass time, mins	[n = 367]	[n = 101]	[n = 266]	.326*
	135 (48–599)	138 (64–346)	134 (48–599)	
Ischemic time, mins	[n = 366]	[n = 101]	[n = 265]	.987*
	113 (0–282)	114 (12–282)	112 (0–274)	
Surgical time, hours	5.22 (1.63–16.58)	5.3 (1.63–16.58)	5.17 (2.7–12.87)	.093*
Mechanical ventilation, hours	9 (5–516)	10.2 (7–480)	9 (5–516)	**< .001***
Preoperative stay, days	2 (0–35)	3 (0–18)	2 (1–35)	**.011***
≤ 2	220 (58.98)	51 (49.04)	169 (62.83)	
> 2	153 (41.02)	53 (50.96)	100 (37.17)	

CABG, coronary artery bypass grafting.

Statistical tests used: †–Chi-square Test of Independence; §–Fisher's Exact test; *–Mann Whitney U test.

Table 3
Correlates of pneumonia among patients who underwent cardiac surgery

	Crude Odds Ratio (95% CI)	***p***	**Adjusted Odds Ratio (95% CI)**	***p***
Age	1.015 (0.998–1.03)	0.091	1.012 (0.99–1.03)	0.229
Sex				
Male	Reference	-	Reference	-
Female	1.166 (0.70–1.94)	0.556	1.328 (0.74–2.40)	0.347
BMI, kg/m^2	1.019 (0.97–1.07)	0.431	1.013 (0.96–1.07)	0.617
Diabetes mellitus	1.361 (0.86–2.14)	.183	1.462 (0.87–2.46)	0.154
LV dysfunction	0.735 (0.35–1.55)	.418	0.559 (0.25–1.26)	0.160
Renal dysfunction	1.399 (0.75–2.60)	.288	0.974 (0.49–1.93)	0.940
COPD/ Asthma	1.096 (0.61–1.96)	.756	1.084 (0.57–2.05)	0.803
Preoperative stay, days				
≤ 2	Reference	-	Reference	-
> 2	**1.756 (1.11–2.77)**	**.016**	**1.923 (1.18–3.13)**	**.009**
Priority of surgery				
Elective	Reference	-	Reference	-
Urgent	3.965 (0.65–24.08)	.134	4.600 (0.70–30.13)	0.111
Surgical time, hours	1.134 (0.99–1.31)	.079	1.078 (0.92–1.26)	0.339
Mechanical ventilation, hours	**1.008 (1.003–1.01)**	**.002**	**1.008 (1.003–1.01)**	**0.004**
With smoking history	1.034 (0.64–1.68)	.894	1.024 (0.57–1.83)	0.229

Table 4
Odds ratio for clinical outcomes with pneumonia as exposure

	In-hospital Mortality	**Prolonged Hospital Stay**	**Prolonged ICU Stay**	**Postoperative Reintubation**
Crude OR (95% CI)	3.859 (1.51–9.89)	3.785 (1.81–7.90)	6.380 (3.59–11.35)	9.464 (3.01–29.76)
p	**.005**	**< .001**	**< .001**	**< .001**

Figures

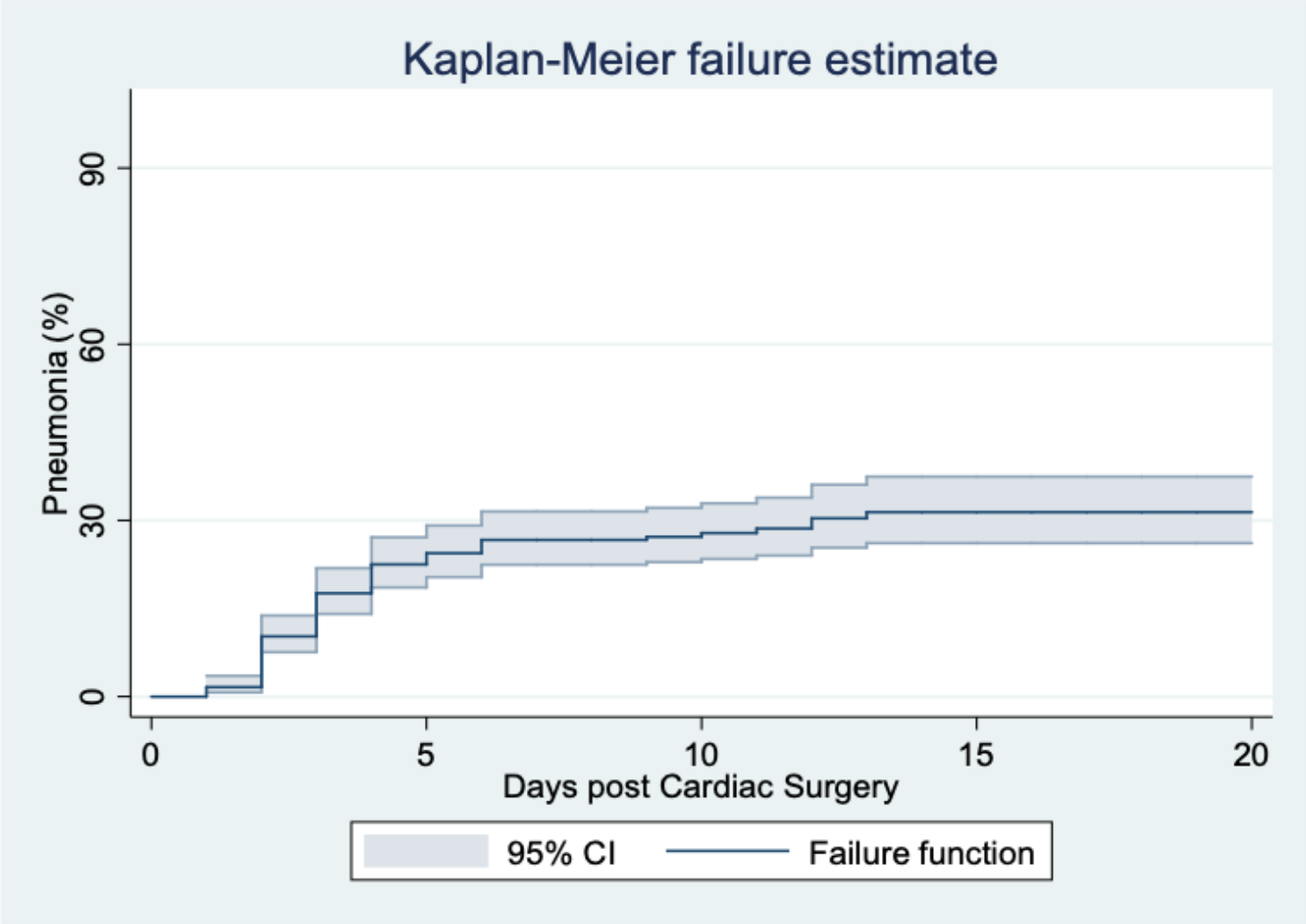

Figure 1

Cumulative incidence function with 95% confidence interval for postoperative pneumonia among cardiac surgery patients

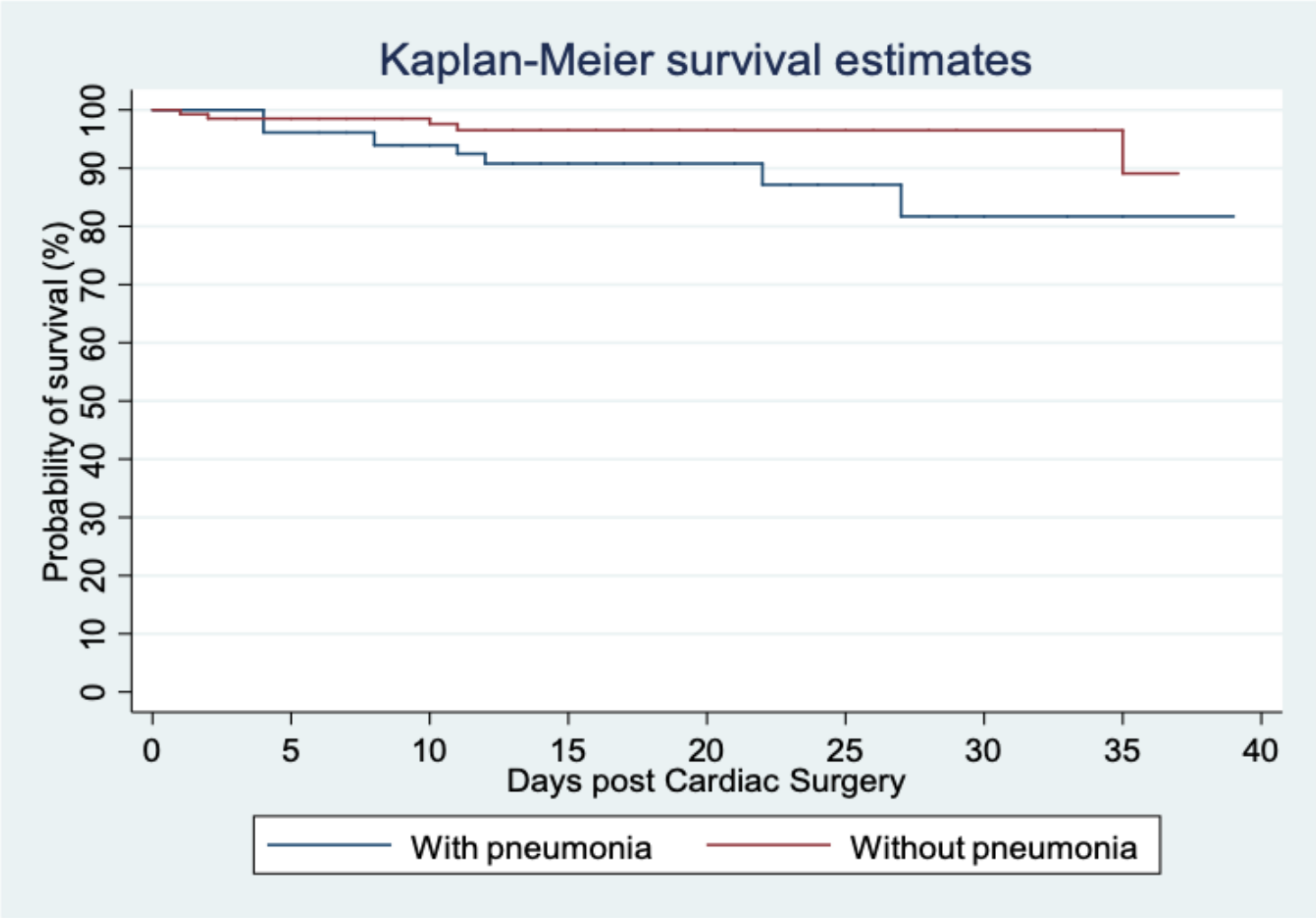

Figure 2

Kaplan-Meier curve for mortality stratified according to the presence or absence of postoperative pneumonia.