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Risk Factor for Postoperative Pneumonia after Coronary Artery Bypass Grafting

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Abstract

Background: Postoperative pneumonia (POP) is a common infectious complication of coronary artery bypass grafting (CABG), leading to significant morbidity, mortality, and increased healthcare costs. This study found that the prevalence of POP was nearly double that reported in previous studies, underscoring the urgent need to identify specific risk factors. These findings emphasize the importance of local data in refining preventive strategies and improving clinical outcomes in CABG patients.

Material and Methods: This is a retrospective cohort study. The subjects comprised patients who underwent CABG procedures at a single institution between June 2020 and June 2024. A logistic regression analysis model for evaluating the risk of POP was established.

Results: This study observed a POP rate of 41.7%, significantly exceeding the 2–24% range reported in previous studies. Key risk factors included elevated creatinine levels, eGFR <60 ml/min/1.73 m^2, and low early postoperative albumin. POP strongly correlated with prolonged hospitalization, with an odds ratio of 13.043 (95% CI: 6.130–27.751, p<0.001), underscoring its substantial impact on patient outcomes.

Conclusions: The present study delineates renal impairment and hypoalbuminemia postoperative as pivotal risk factors for POP following CABG. It emphasizes the importance of tailored interventions, structured institutional practices, and continuous research to enhance preventive strategies and patient outcomes.

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Keywords: *Coronary artery bypass grafting; postoperative pneumonia; risk factor*.

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Introduction

Coronary revascularization may be conducted through two principal approaches: surgical coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI). CABG is generally considered a higher-risk procedure in comparison to PCI and is frequently linked to a more extended recovery period. Nevertheless, in the long term, CABG is correlated with a reduced recurrence rate of coronary artery disease.[1,2] Despite advancements in CABG, significant risks persist due to complications during and after the procedure, raising morbidity and mortality rates. To reduce these risks, comprehensive strategies for preventing, monitoring, evaluating, and promptly managing complications are essential. Understanding patient risk factors, healthcare performance, and postoperative conditions is crucial to effectively prevent and manage post-CABG complications. Addressing these factors is key to improving patient outcomes and reducing complication rates procedures.[3]

Postoperative infections are common complications, occurring in up to 16% of cases. They can delay healing, prolong hospital stays, and increase mortality. Various strategies exist to reduce these infections, starting with preoperative screening and extending to postoperative care ICU.[4] Postoperative pneumonia constitutes a significant infectious complication subsequent to cardiac surgery, resulting in substantial increases in morbidity, mortality, and healthcare expenditures. Postoperative pneumonia incidence varies between 2.1% and 21.6%. The demographic profile of cardiac surgery patients has evolved significantly. Despite advancements in surgical techniques and anesthesia, the aging population with multiple comorbidities and rising antibiotic-resistant pathogens increases the number of high-risk patients for complications POP.[6]

The majority of investigations concerning risk factors associated with POP have taken place in developed regions, including the United States and Europe, while data from Southeast Asia remain limited. Variations in patient demographics and medical histories have the potential to affect these risk factors, thereby underscoring the necessity for region-specific research. This study endeavors to fill this gap by identifying crucial risk factors for POP following CABG and aims to offer valuable insights that could enhance clinical outcomes in Southeast Asian populations.

Materials and Methods

This study utilized an analytical observational approach with a retrospective cohort design. The target population was CAD patients after CABG-only surgery. The accessible population in this study were CAD patients after CABG-only surgery registered in the "Cardiac Surgery Registry" at Dr. Hasan Sadikin General Hospital, Bandung, with the ethical number DP.04.03/D.XIV.6.5/324/2024.

The research focused on patients with heart disease who underwent CABG procedures at Dr. Hasan Sadikin General Hospital in Bandung. The study included all CABG patients from June 2020 to June 2024. Patients with the following conditions were excluded from this study: acquired pneumonia within two weeks before surgery, death or discharge within 48 hours after surgery, and combination surgery with another procedure besides CABG. Patients who had the CABG procedure more than once were also excluded.

Clinical data were collected from the hospital's records system. Preoperative variables included demographics (sex, age, height, weight, BMI, smoking history), comorbidities (hypertension, diabetes, Chronic Obstructive Pulmonary Disease COPD, peripheral arterial disease, renal disease), left ventricular ejection fraction, and laboratory values. Intraoperative variables included CPB time. Postoperative variables covered mechanical ventilation duration, early albumin levels, hospital stay length, and mortality.

Postoperative pneumonia was defined by new or progressive pulmonary infiltrates on chest radiographs and at least one of the following: fever over 38 °C without known cause, leukocytosis $>12\times10^9$/L, leukopenia $<4\times10^9$/L, and purulent secretions. Semiquantitative cultures were employed to ascertain the microbiological etiology of pneumonia from sputum through initial microscopic examination alongside quantitative bacterial cultures. Hypertension is defined as a blood pressure of 140/90 mmHg or higher, a prior diagnosis, or the use of antihypertensive medication. Diabetes mellitus is characterized by fasting glucose of 126 mg/dl or more, random glucose of 200 mg/dl or higher, a past diagnosis, or the use of diabetes medication. A history of smoking includes both current and past daily

Table 1. Baseline Characteristics of Patients.

Variable	N=206
Age	
Mean±Std	57.76±8.485
Age Category	
>=60 y.o	92(44.7%)
<60 y.o	114(55.3%)
Sex	
Male	171(83.0%)
Female	35(17.0%)
BMI	
Median	24.70
IQR (Q1-Q3)	4.34(22.86-27.20)
BMI Category	
>22.9	151(73.3%)
<22.9	55(26.7%)
Risk Factors	
DM	56(27.2%)
Hypertension	123(59.7%)
Dyslipidemia	75(36.4%)
Smoking	147(71.4%)
COPD (n=97)	8(8.2%)
PAD	89(43.2%)
LVEF	
Median	50.00
Range (min-max)	22.00(38.00-60.00)
LVEF Category	
<=40%	63(30.6%)
>40%	143(69.4%)
Hemoglobin	
Mean±Std	13.80±1.799
WBC	
Median	7925.00
IQR (Q1-Q3)	2227.50(6932.50-9160.00)
Platelet	
Median	260000.00
IQR (Q1-Q3)	83500.00(220500.00-304000.00)
Creatinin	
Median	1.10
IQR (Q1-Q3)	0.40(0.93-1.33)
eGFR	
Mean±Std	73.51±23.103
eGFR Category	
<60	50(24.3%)
>60	156(75.7%)
Early Postoperative Albumin	
Mean±Std	2.93±0.568
Early Postoperative Albumin	
<=2.93 g/dL	119(57.8%)
>2.93 g/dL	87(42.2%)
NLR	
Median	2.15
IQR (Q1-Q3)	1.52(1.67-3.18)
RDW-CV	
Median	13.15
IQR (Q1-Q3)	1.20(12.70-13.90)
RDW-SD	
Median	41.50
IQR (Q1-Q3)	3.93(39.88-43.80)
Clinical presentation preoperative	
ACS	40(19.4%)
CCS	166(80.6%)
Pump CABG	
On pump	77(37.4%)
Off pump	129(62.6%)
CPB Time	
Median	0.00
IQR (Q1-Q3)	81.25(0.00-81.25)
CPB Time Category	
>92 minutes	36(17.5%)
<92 minutes	170(82.5%)
Mechanical Ventilaton Duration	
Median	0.00
IQR (Q1-Q3)	1.00(0.00-1.00)
Hospital LOS	
Median	7.00
IQR (Q1-Q3)	4.00(5.00-9.00)
Complication	
Dengan POP	86(41.7%)
Tanpa POP	120(58.3%)
Mortality	
Yes	10(4.9%)
No	196(95.1%)

Descriptions: SD: Standard Deviation; BMI: Body-Mass Index; CABG: Coronary Artery Bypass Grafting; COPD: Chronic Obstructive Pulmonary Disease; eGFR: estimated Glomerular Filtration Rate; LOS: Length of Stay; LVEF: Left Ventricle Ejection Fraction; PAD: Peripheral Artery Disease; POP: Postoperative Pneumonia; WBC: White Blood Cell.

Table 2. Univariate analysis of risk factors for POP.

Predictors	Complication		OR (95% CI)	p-value
	With POP N=86	Without POP N=120		
Age				0.446
Mean±Std	58.29±7.633	57.38±9.059		
Age Category			1.049	0.866
>=60 y.o	39(45.3%)	53(44.2%)	(0.601-1.831)	
<60 y.o	47(54.7%)	67(55.8%)		
Sex			1.705	0.174
Male	75(87.2%)	96(80.0%)	(0.785-3.700)	
Female	11(12.8%)	24(20.0%)		
BMI				0.630
Median	25.37	24.38		
IQR (Q1-Q3)	4.60(22.74-27.34)	4.09(22.89-26.99)		
BMI Category			0.996	0.990
>22.9	63(73.3%)	88(73.3%)	(0.533-1.862)	
<22.9	23(26.7%)	32(26.7%)		
Risk factors				
DM	21(24.4%)	35(29.2%)	0.785	
(0.418-1.473)	0.450			
Hypetension	52(60.5%)	71(59.2%)	1.056	
(0.600-1.857)	0.851			
Dyslipidemia	35(40.7%)	40(33.3%)	1.373	
(0.773-2.436)	0.279			
Smoking	65(75.6%)	82(68.3%)	1.434	
(0.768-2.678)	0.256			
COPD (n=97)	6(13.3%)	2(3.8%)	3.846	
(0.736-20.111)	0.139			
Peripheral Artery Disease	37(43.0%)	52(43.3%)	0.987	
(0.565-1.727)	0.965			
LVEF				0.699
Median	49.00	53.00		
Range (min-max)	21.25(38.00-59.25)	22.00(38.00-60.00)		
LVEF Category			0.972	
(0.533-1.774)	0.926			
<=40%	26(30.2%)	37(30.8%)		
>40%	60(69.8%)	83(69.2%)		
Hemoglobin				0.662
Mean±Std	13.74±1.810	13.85±1.798		
WBC				0.831
Median	7950.00	7805.00		
IQR (Q1-Q3)	2317.50(6812.50-9130.00)	2242.50(6945.00-9187.50)		
Platelet				0.578
Median	263000.00	256500.00		
IQR (Q1-Q3)	76500.00(220500.00-297000.00)	97750.00(219000.00-316750.00)		
Creatinin				0.186
Median	1.15	1.10		
IQR (Q1-Q3)	0.52(0.95-1.47)	00.34(0.92-1.26)		
eGFR				0.281
Mean±Std	71.45±22.681	74.98±23.383		
eGFR Category			2.150	
(1.127-4.103)	0.019			
<60	28(32.6%)	22(18.3%)		
>60	58(67.4%)	98(81.7%)		
Early Postoperative Albumin				<0.001
Mean±Std	2.73±0.488	3.07±0.580		
Early Postoperative Albumin			3.438	
(1.881-6.283)	<0.001			
<=2.93 g/dL	64(74.4%)	55(45.8%)		

>2.93 g/dL	22(25.6%)	65(54.2%)		
NLR				0.126
Median	2.02	2.42		
IQR (Q1-Q3)	1.46(1.62-3.08)	1.48(1.71-3.19)		
RDW-CV				0.244
Median	13.20	13.10		
IQR (Q1-Q3)	1.30(12.70-14.00)	0.88(12.70-13.58)		
RDW-SD				0.569
Median	41.55	41.50		
IQR (Q1-Q3)	4.95(39.05-44.00)	3.60(40.00-43.60)		
Clinical Presentation preoperative			2.869	
(1.405-5.857)	0.003			
ACS	25(29.1%)	15(12.5%)		
CCS	61(70.9%)	105(87.5%)		
Pump CABG			1.387	0.260
On pump	36(41.9%)	41(34.2%)	(0.784-2.455)	
Off pump	50(58.1%)	79(65.8%)		
CPB Time				0.077
Mean±Std	42.79±53.303	29.37±42.961		
Median	0.00	0.00		
IQR (Q1-Q3)	94.75(0.00-94.75)	77.75(0.00-77.75)		
CPB Time category			3.005	0.003*
>92 minutes	23(26.7%)	13(10.8%)	(1.422-6.348)	
<92 minutes	63(73.3%)	107(89.2%)		
Mechanical Ventilaton Duration				0.083
Median	0.00	0.00		
IQR (Q1-Q3)	1.00(0.00-1.00)	1.00(0.00-1.00)		
Hospital LOS				<0.001
Median	8.00	5.50		
IQR (Q1-Q3)	6.00(7.00-13.00)	2.00(5.00-7.00)		
Hospital LOS Category			13.103	<0.001
>6 days	73(84.9%)	36(30.0%)	(6.458-26.584)	
<6 days	13(15.1%)	84(70.0%)		
Mortality			2.175	0.326
Yes	6(7.0%)	4(3.3%)	(0.595-7.955)	
No	80(93.0%)	116(96.7%)		

smoking habits. (COPD) is defined by an FEV1/FVC ratio of ≤0.7 from spirometry. Renal insufficiency is indicated by serum creatinine >1.24 mg/dL or a prior diagnosis. The creatinine level and estimated glomerular filtration rate (eGFR) were calculated one day prior to surgery. Early postoperative albumin refers to the serum albumin levels measured within the first 24 hours following surgery. The area under the curve in the receiver operating characteristic plot is utilized as a cutoff point for analysis.

Statistical analysis was performed using SPSS (IBM SPSS Statistics, version 26). Patients with and without POP were compared by univariate analysis using the Chi-Square test for categorical variables and the Fisher exact test for discrete variables. Variables with a p-value <0.25 on univariate analysis were entered into a multivariate logistic regression analysis to identify the independent risk factors. Significance was considered at a p-value <0.05.

Results

From June 2020 to June 2024, 256 CABG procedures were performed. Fifty patients were excluded from the analysis: thirty patients underwent combination cardiac surgery besides CABG (valvular surgery, closure defects intracardiac, repair septal rupture), sixteen patients died during the first 48 hours, and four patients got pneumonia before surgery. The remaining 206 patients underwent isolated CABG procedures instituted by the cohort. POP was diagnosed in the 86 patients (41.7%). Table 1 shows the baseline characteristics of patients.

The most common microorganism isolated in this study was *Klebsiella pneumoniae* (16%), followed by *Staphylococcus epidermidis, Pseudomonas aeruginosa,* and *Staphylococcus haemolyticus* (9%). Polymicrobial POP was detected in 14% of cases. However, in 54% of cases, no microorganism growth was found in culture

Table 3. Multivariate analysis of risk factors of POP.

		B	S.E.	Wald	Nilai P	OR	CI 95%	
							Lower	Upper
INITIAL MODEL	Sex	0.805	0.575	1.962	0.161	2.238	0.725	6.905
	Creatinin	1.429	0.712	4.024	0.045	4.176	1.033	16.873
	eGFR Category	2.131	0.722	8.720	0.003	8.427	2.048	34.682
	Early Postoperative Albumin Category	1.111	0.388	8.191	0.004	3.037	1.419	6.501
	NLR	0.176	0.114	2.386	0.122	1.192	0.954	1.491
	RDW-CV	0.007	0.151	0.002	0.961	1.007	0.749	1.355
	Clincial Presentation Preoperative	0.247	0.465	0.283	0.595	1.280	0.515	3.185
	CPB Time Category	0.527	0.485	1.182	0.277	1.694	0.655	4.384
	Mechanical Ventilation Duration	0.018	0.144	0.016	0.899	1.019	0.767	1.352
	Hospital LOS Category	2.427	0.412	34.669	<0.001	11.320	5.047	25.388
FINAL MODEL	Creatinin	1.357	0.670	4.101	0.043	3.883	1.045	14.434
	eGFR Category	1.937	0.669	8.379	0.004	6.935	1.869	25.734
	Early Postoperative Albumin Category	1.168	0.375	9.713	0.002	3.215	1.542	6.700
	Hospital LOS Category	2.568	0.385	44.450	<0.001	13.043	6.130	27.751

examination. The prophylactic antibiotic administered to patients is ceftriaxone 2 grams. According to the antibiotic resistance data gathered from our hospital, *Klebsiella pneumoniae* has been identified as the second most prevalent microorganism isolated from sputum cultures, following *Acinetobacter baumannii*, in the intensive care unit. This organism demonstrates the highest level of sensitivity to amikacin (>64%). Sensitivity to ceftriaxone has been documented to vary between 15% and 30%. *Pseudomonas aeruginosa* ranks as the third most prevalent microorganism isolated from sputum cultures within our hospital, exhibiting the highest sensitivity level recorded towards amikacin (>64%). Currently, there is no available data concerning pseudomonas sensitivity to the aforementioned antibiotic ceftriaxone.

No statistically significant differences were observed in univariate analysis between POP and non-POP patients, except for estimated GFR <60 (32.6% in the POP group vs. 18.3% in the non-POP group; p=0.019), early postoperative albumin (2.73 ± 0.49 in the POP group vs. 3.07 ± 0.58 in the non-POP group; p<0.001), acute clinical presentation preoperatively (29.1% in the POP group vs. 12.5% in the non-POP group; p=0.003), cardiopulmonary bypass duration (26.7% in the POP group vs. 10.8% in the non-POP group; p=0.003), and hospital length of stay (84.9% in the POP group vs. 30% in the non-POP group; p<0.001).

Univariate analysis of risk factors for POP is presented in Table 2. Some variables had a p-value of less than 0.25: sex, COPD, creatinine, eGFR < 60 ml/min/1.73 m², early postoperative albumin, NLR value, RDW-CV value, preoperative clinical presentation, CPB time, duration of mechanical ventilation, and hospital LOS. Chronic obstructive pulmonary disease has a p-value of less than 0.25, but it has missing data of more than 5%; therefore, to prevent substantial bias that may weaken the integrity of multivariate analysis, this variable cannot be processed further into multivariate analysis.

Multivariate analysis identified three independent risk factors for POP (Table 3): creatinine level (odds ratio [OR], 3.88; 95% CI, 1.04–14.43), eGFR < 60 ml/min/1.73 m² (odds ratio [OR], 6.93; 95% CI, 1.87–25.73), and early postoperative albumin < 2.93 g/dL (OR, 3.22; 95% CI, 1.54–6.7). POP occurrence has a strong association with prolonged hospital stays (odds ratio [OR], 13.04; 95% CI 6.13-27.75).

Discussion

Predictive models for postoperative pneumonia (POP) after cardiac surgery exist, but data on CABG-only procedures are limited, especially in Southeast Asia. CABG is the most common cardiac surgery globally, making it vital to explore unique risk factors for POP in these cases. Independent risk factors for

POP differ across studies due to variations in population characteristics and diagnostic definitions. This study offers insights into POP risk factors for CABG-only procedures, addressing a regional gap and enhancing global understanding of this complication. Identified patient characteristics align with previous research, underscoring the need for tailored risk assessment and management approaches to prevention.

Kilic et al. developed a validated 33-point risk score for POP from 6,222 patients (2005–2012), noting a 4.5% incidence. Their model identified six key perioperative predictors: advanced age, chronic lung disease, peripheral vascular disease, prolonged cardiopulmonary bypass (CPB) time, intraoperative blood transfusion, and use of an intra-aortic balloon pump period.[8] Wang et al. reported a higher incidence of POP (9.96%) among 5,323 patients and developed a 32-point risk score incorporating 13 independent risk factors, including age > 60 years, hypertension, diabetes mellitus, smoking, COPD, BMI > 24 kg/m², renal insufficiency, NYHA class III-IV, preoperative anemia, hypoalbuminemia, CPB time > 120 minutes, and blood transfusion.[9] Allou et al. proposed a scoring system from a study of 5,582 patients with a 3.1% incidence of POP. Their model identified four key risk factors: advanced age, COPD, low preoperative LVEF, and the interaction of RBC transfusion with prolonged CPB duration.[10] These studies underscore the multifactorial nature of POP risk and the importance of identifying patient-specific and procedure-specific factors to guide preventive strategies.

This study identified three independent risk factors for postoperative pneumonia (POP) following CABG: elevated creatinine levels, eGFR <60 ml/min/1.73 m², and early postoperative albumin <2.93 g/dL. The observed POP rate of 41.7% was significantly higher than previously reported rates (2–24%).[11–15] Gram-negative bacteria were the predominant pathogens, with *Klebsiella pneumoniae, Pseudomonas aeruginosa, Staphylococcus epidermidis,* and *Staphylococcus haemolyticus* as the most frequently isolated species. These findings align with prior studies in which K. pneumoniae and P. aeruginosa were common causes of POP after cardiac surgery.[9,10,16] Mortality among patients with POP was significantly higher compared to that of those without pneumonia, underscoring the severe impact of POP on outcomes. While the overall mortality rate was consistent with previous studies, these findings highlight the critical need for effective prevention and management of POP to reduce associated mortality risks.[11]

In the present study, both elevated creatinine levels and reduced eGFR were identified as independent risk factors for POP after cardiac surgery. Elevated creatinine levels were significantly associated with POP, with an odds ratio (OR) of 3.883 (95% CI: 1.045–14.434, p = 0.043) in the final model. Similarly, reduced eGFR <60 ml/min/1.73m² showed an even stronger association, with an OR of 6.935 (95% CI: 1.869–25.734, p = 0.004). Impaired renal function, indicated by these markers, likely contributes to systemic inflammation, immune dysfunction, and fluid imbalances, increasing susceptibility to pulmonary infections. Research by Wang et al. and Kilic et al. highlighted similar associations, with creatinine and eGFR serving as robust predictors of postoperative complications, particularly infections.[8,9] Estimated GFR <60 ml/min/1.73 m² was observed in 24.3% of patients, predisposing them to infection due to systemic inflammation, fluid imbalance, and impaired immune function. Studies have consistently shown that renal dysfunction is a strong predictor of postoperative complications, including pneumonia.[9,14,17] Improving renal function preoperatively may reduce complications and enhance prognosis in renal dysfunction patients.

In the early postoperative period, albumin levels at or below 2.93 g/dL were observed in 57.8% of patients, thereby indicating nutritional deficiencies. Hypoalbuminemia undermines wound healing, reduces immune responses, and increases infection susceptibility. Malnutrition adversely affects surgical outcomes, leading to higher complication rates, longer recovery, and extended hospitalization. Albumin, the main human protein, is a key nutritional status marker and predicts surgical outcomes. Its quick decline post-surgery indicates surgical stress and metabolic response. Hubner et al. showed that postoperative serum albumin reductions correlate with surgical stress and predict a more complicated recovery course.[18] Perioperative nutritional support, including immune-modulating formulas, has been shown to reduce infectious complications and hospital stays after major surgeries.[19]

The mean age of patients with POP in this study was 58.29 ± 7.633 years, which is lower than the mean age reported in previous studies (68 ± 13 years).[10] Older patients face higher complication risks due to weakened

immune function, reduced pulmonary reserve, and age-related comorbidities. However, the lower POP rate in earlier studies suggests other influential factors. In this research, younger patients might have had greater comorbidity burdens, indicated by renal impairment, smoking history, and hypoalbuminemia—strong risk factors for POP. These conditions likely outweigh the benefits of youth. In contrast, older populations in prior studies might have had fewer risk factors or benefited from improved perioperative care, resulting in lower complication rates age.

In this study, 87.2% of patients with POP were male compared to 65% in Allou et al.'s study. The higher proportion of male patients with POP compared to females suggests that gender may play a role in the increased incidence of pneumonia following surgery. Male patients also often have higher rates of smoking, which can impair lung function and increase vulnerability to respiratory infections.[21] In this study, 75.6% of patients with POP had a smoking history compared with 20% in the previous study. This behavior is strongly linked to increased risks of postoperative complications, including pneumonia.

This study found a lower occurrence of COPD among POP patients compared to Allou's study; however, missing data exceeding 5% rendered it inappropriate for multivariate analysis. This limitation restricts the ability to fully evaluate the impact of COPD on POP rates within this study. However, the univariate analysis indicated a COPD prevalence of 13.3% among POP patients, with an OR of 3.846 (95% CI: 0.736–20.111, p = 0.139). Although not statistically significant, these findings suggest that COPD remains a relevant factor influencing POP risk. However, the inability to analyze COPD data in the multivariate model underscores the challenge of accurately assessing its independent contribution to POP in this cohort.

In this study, neither the neutrophil-to-lymphocyte ratio (NLR) nor the red cell distribution width (RDW) significantly influenced postoperative pneumonia (POP). Univariate analysis revealed median NLR values of 2.02 in POP patients and 2.42 in non-POP patients (p = 0.126). Similarly, the median RDW-CV was 13.20 in POP patients and 13.10 in non-POP patients (p = 0.244). These findings indicate that NLR and RDW failed to differentiate between POP and non-POP patients in this cohort. NLR and RDW are nonspecific markers of systemic inflammation, influenced by factors like infections, comorbidities, and perioperative stress. The lack of significant differences in comorbidities between POP and non-POP groups limits variability in baseline inflammation, reducing NLR and RDW's predictive power.

Left Ventricular Ejection Fraction of less than 40% is a widely recognized indicator of heart failure with reduced ejection fraction (HFrEF), which is significantly correlated with postoperative complications, particularly pulmonary infections. Research conducted by Hosseini et al. revealed an odds ratio (OR) of 2.95 (95% CI: 1.2–7.6) for pneumonia among patients exhibiting LVEF below 40%, thereby underscoring its predictive value strength.[22] In a similar vein, Pieri et al. identified LVEF <40% as a significant predictor of complications following cardiac procedures surgery.[23] In this study, however, LVEF was not significantly correlated with POP occurrence. The median LVEF was comparable between POP and non-POP groups: 49% (38–59.25%) vs. 53% (38–60%) (p = 0.699). The prevalence of LVEF ≤40% was nearly identical (30.2% vs. 30.8%, OR = 0.972, p = 0.926). Unlike prior studies with higher proportions of patients with severe heart failure, such as Allou et al., this cohort had a moderate proportion of reduced LVEF cases (30.6%), with most patients presenting LVEF >40% (69.4%). This discrepancy highlights cohort variations, where fewer reduced heart failure cases may have weakened the statistical power to confirm LVEF <40% as an independent risk factor for POP. More research with higher reduced heart failure proportions is needed to clarify its predictive value.

This study found no significant correlation between mechanical ventilation duration and POP occurrence, unlike previous studies that identified prolonged ventilation as a major predictor, particularly for VAP. The lack of significance might be due to shorter ventilation in this cohort or improvements in respiratory therapy and early extubation. Larger studies with clinically relevant ventilation thresholds are needed to clarify this impact on POP.

Patients who developed POP had a substantially higher likelihood of requiring extended hospitalization. Specifically, 84.9% of POP patients had a hospital stay longer than 6 days, compared to only 30.0% of non-POP patients. The odds ratio (OR) for extended LOS

among POP patients in the final analysis was 13.043 (95% CI: 6.130–27.751, p<0.001), indicating a strong association between the occurrence of POP and longer hospital stays.

Study Limitations

This study has several limitations. The lack of data on COPD over 5% prevented its inclusion in the multivariate analysis and may have affected the assessment of its link to POP. Additionally, inadequate preoperative albumin data hindered the analysis of delta albumin. The single-center design and small sample size limit the generalizability of the findings. Unmeasured confounding factors, such as infection control practices, intraoperative transfusions, provider performance, and postoperative care quality, were not addressed and might have influenced POP incidence. Future research should further explore these variables using multi-center designs to validate and enhance these findings.

Conclusions

This study identifies renal impairment and hypoalbuminemia as key risk factors for POP after isolated CABG, providing insights for perioperative risk stratification. It emphasizes the importance of institutional practices and patient-specific factors, highlighting the need for tailored interventions to optimize outcomes. Additionally, it lays a groundwork for future research to explore unmeasured variables and improve preventive strategies, thus enhancing care for CABG patients.

List of Abbreviations

CABG	Coronary artery bypass grafting
COPD	Chronic Obstructive Pulmonary Disease
CPB	Cardiopulmonary bypass
eGFR	Estimated glomerular filtration rate
LOS	Length of Stay
LVEF	Left Ventricle Ejection Fraction
NLR	Peripheral Artery Disease
PCI	Percutaneous coronary intervention
POP	Postoperative pneumonia
RDW	Red cell distribution width
WBC	White Blood Cell.

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