Relationship between the degree of pulmonary hypertension and postoperative mortality in adult cardiac surgery

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Abstract

***Objective*: This study aimed to investigate the association between the intensity of pulmonary hypertension and the probability of mortality following cardiac surgery in adults.**

***Design*: This study employed an analytical observational methodology, utilizing a retrospective approach and a cross-sectional design.**

***Setting*: The medical record of the Integrated Heart Center Intensive Care Unit (ICU) of Dr. Wahidin Sudirohusodo Central General Hospital Makassar, South Sulawesi. The study was conducted on 1-15 July 2023.**

***Patient and participants*: Adults with a diagnosis of pulmonary hypertension who required therapy in the ICU following heart surgery.**

***Interventions*: None.**

***Measurement and results*: The data collected included demographic data (age, gender, diagnosis), heart disease data (degree of pulmonary hypertension based on echocardiography examination), and mortality data (data on survivors and non-survivors after surgery and causes of mortality after surgery). The degree of pulmonary hypertension was divided into low-, intermediate-, and high-probability. Significant differences were found between the three groups ($p<0.05$) when comparing the incidence of mortality.**

***Conclusions*: A direct relationship exists between the occurrence of pulmonary hypertension and the rate of death after heart surgery among patients at the Integrated Heart Centre ICU of Dr. Wahidin Sudirohusodo General Hospital.**

Key words: Cardiac surgery, intensive care unit, mortality, pulmonary hypertension.

Introduction

Pulmonary hypertension (PH) is a medical condition in which the pulmonary artery pressure is more than 25 mmHg at rest or 30 mmHg during activity. (1-3) The risk of complications and death after adult cardiac surgery is increased in patients with PH as reported by Kennedy et al. (4) The presence of PH prior to, during, and after surgery affects the outcome of the procedure, indirectly impacting mortality and morbidity, particularly through its effect on right ventricular function, as stated by Denault et al. (5) PH is a significant factor that can independently predict a higher likelihood of experiencing negative health outcomes and death (ranging from 4% to 24%) following surgery. The level of risk for these individuals depends on the severity of their condition and the specific surgical operation being performed. Ramakrishna et al. reported that patients with PH who underwent thoracic surgical procedures had a significantly greater likelihood of experiencing perioperative morbidity (over 60%) compared to those who received gynecologic, dermatologic, breast, or plastic surgery (16.7%). (3)

The post-operative death rate for heart illness is a metric for assessing the quality of care provided for

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heart disease. (6,7) Common cardiac procedures include coronary artery bypass graft (CABG) surgery, mitral and tricuspid valve surgery, and atrial and ventricular septal defect (ASD and VSD) closure. CABG is a popular operation used to relieve the narrowing of the coronary arteries. (8) CABG is the prevailing cardiac surgical treatment conducted worldwide. (9) However, there are problems related to cases of mortality after CABG surgery for heart disease. (10)

Multiple studies document instances of death following CABG surgery for cardiovascular disease. Research conducted in 5 European nations revealed that the 30-day death rate in hospitals following CABG surgery was 3.0%. The death rate in low-volume hospitals was 5.2%, whereas that in high-volume hospitals was just 2.1%. (11) Research at Dr. Kariadi Central General Hospital Semarang from January 1 to December 31, 2014, revealed that there were 14.3% cases of death in post-CABG heart surgery patients, and the most common cause of mortality was cardiogenic shock (50%). (12) Research at Dr. Hasan Sadikin Central General Hospital Bandung in 2014-2016 reported a post-CABG surgery mortality rate of 15.15%. (7) The death rate among patients who underwent CABG surgery and received treatment in the ICU of the Integrated Heart Centre, Dr. Wahidin Sudirohusodo Central General Hospital Makassar, from January 2017 to June 2022, was 16%. Non-surviving patients were more commonly found in men (75.9%). The average age and gender did not differ significantly between non-surviving patients and surviving patients. Disparities in diagnosis are common among patients undergoing CABG surgery. (7)

The mortality risk is heavily contingent upon several interrelated variables, including patient comorbidities and the possibility of complications arising from the procedure itself. (13) Several factors, such as age, gender, left ventricular ejection fraction, cross-clamp time, cardiopulmonary bypass time, and comorbidities, such as PH, influence the mortality risk of people who have undergone CABG surgery. (7)

Methods

The study employed an analytical observational research methodology, utilizing a retrospective approach and a cross-sectional design, conducted at the Integrated Heart Centre ICU of Dr. Wahidin Sudirohusodo Central General Hospital in Makassar, South Sulawesi. The study was carried out between July 1-15, 2023. Patients undergoing adult cardiac surgery for the treatment of PH were the only ones included in the study's sample between January 2017 and May 2023. The sample for this study was data on patients with PH, confirmed by echocardiography assessment and undergoing adult cardiac surgery, who were treated in the ICU, both those who survived (moved to the regular ward) and those who did not survive (died) after surgery. The sampling technique was performed using purposive sampling. Adult cardiac surgery patients over the age of 18 who have been diagnosed with PH by echocardiographic evaluation are eligible for inclusion. Exclusion criteria were patients who died before surgery. The data collected included demographic data (age, gender, diagnosis), heart disease data (degree of PH based on echocardiography examination), and mortality data (data on survivors and non-survivors after surgery, causes of mortality after surgery). Researchers looked at how PH severity correlated with patient death.

Data were analyzed using descriptive statistics in the form of frequency and percentage of mortality after adult cardiac surgery. Chi-square analysis was used to see whether there was a correlation between the severity of PH and mortality. For the chi-square test, no more than 20% of the sample size can have anticipated values lower than 5. The Fisher test is an alternative to the chi-square test that can be performed if the chi-square test cannot be done for whatever reason. It was suggested that a significance threshold (P alpha) of 5% be used for interpreting the data. Note that if the p-value was less than or equal to 0.05, the association between the independent and dependent variables was accepted rather than the null hypothesis (H0). If the p-value was larger than 0.05, on the other hand, the null hypothesis (H0) was accepted, indicating that there was no correlation between the two variables of interest.

To assess the correlation between risk variables and mortality or the severity of PH using continuous data, we employed the independent sample t-test to compare two groups and the ANOVA test to analyze more than two groups. The t-test and ANOVA were employed for datasets that had a normal distribution. In cases where the data deviated from a normal distribution, we utilized the Mann-Whitney test to compare two groups and the Kruskal-Wallis test to compare more than two groups. The Kolmogorov-Smirnov normalcy test was employed to do the normality assessment. The examination of diagnostic tests involved determining the cut-off value for the severity of PH and evaluating the sensitivity and specificity in predicting mortality using the area under the curve (AUC). All data was analyzed using SPSS 23.0 for Windows.

Results

Characteristics of research samples with research variables

The attributes of the research sample are presented in **Table 1**. No significant differences were seen in the mortality groups when analyzing the age and gender factors ($p>0.05$). These results indicated that the two groups had homogeneous data and were suitable for comparison tests.

The study encompassed a cohort of 429 participants from 2017 through 2023. The total number of patients, classified by gender, included 305 men, of which 251 were alive and 54 had passed away. Meanwhile, the total number of females was 124 people, with 95 people alive and 29 people died.

Over 5 years, a total of 158 patients experienced PH, with 114 patients were alive and 44 patients died. Meanwhile, 271 patients did not experience PH (232 patients were alive and 39 patients died after surgery.

Characteristics of mortality in PH patients based on type of adult cardiac surgery

Table 2 shows the mortality characteristics of PH patients according to the kind of adult cardiac surgery. Upon analysis of the three categories of causes for adult heart surgery, it was observed that the valvular heart disease group exhibited the highest mortality rate with 34 cases (35.1%), followed by coronary artery disease with 6 cases (17.2%), and adult congenital heart disease with 15.4%. The differences among the three groups were found to be statistically significant, as shown by a p-value of 0.039. **Figure 1** illustrates the mortality features associated with different types of cardiac surgery done on humans.

Comparison of the mortality rate in each degree of PH

Table 3 displays the correlation between the severity of PH and the corresponding death rate. The analysis revealed significant differences in mortality occurrences between the low-probability and the intermediate- and high-probability groups ($p<0.05$). **Figure 2** illustrates a comparative analysis of the mortality occurrences across three categories of PH severity.

Correlation between PH and Mortality Rates

The relationship between the severity of PH and the mortality rate is seen in **Table 4**.

Based on **Table 4**, there was a clear association between the death rate in the low-probability group and the intermediate and high-probability groups. A connection that was statistically significant ($p<0.05$) was seen among the three groups. The correlation coefficient among the three groups was 17.8%, indicating a correlation that falls inside the first quartile.

Discussion

Characteristics of research samples with research variables

The study encompassed a total of 429 individuals who were observed between 2017 and 2023. The overall patient count, categorized by gender, consisted of 305 males, with 251 individuals still alive and 54 deceased. Meanwhile, the total number of women was 124, with 95 alive and 29 dead. There was a total of 158 patients who experienced PH, with 114 patients alive and 44 patients died. Meanwhile, 271 patients did not experience PH, 232 patients were alive and 39 patients died after surgery. In total, 346 patients lived and 83 died.

From the characteristics of the research sample and the research variables, it can be seen that in the age and gender variables, there were no differences found in the mortality groups ($p>0.05$). These results indicated that the two groups had homogeneous data and were suitable for comparison tests.

Characteristics of mortality and incidence of PH based on the type of adult cardiac surgery

In the three groups of causes of adult cardiac surgery, it was found that in all three groups, the highest mortality was in the valvular heart disease group with 34 cases (35.1%), followed by coronary artery disease with 6 cases (17.2%), and adult congenital heart disease (15.4%). A significant difference in mortality incidence was seen across the three groups, with a p-value of 0.039.

The effects of surgery on the population of individuals with coronary artery disease were consistent with the findings of this study. With an odds ratio of 2.1 and a p-value of 0.029, PH was found to be a significant predictor of mortality in this setting. (14)

This study's results were consistent with those of another that looked at the effect of PH on death rates after mitral valve surgery for patients with mitral regurgitation by the same authors (Ghoreishi et al.). Mortality rates were shown to increase with increasing degrees of perioperative PH. (15) Similar results were shown by Spencer et al., demonstrating that PH prior to aortic valve replacement could increase mortality and impact survival. (16)

This study identified considerable disparities in the occurrence of PH and its impact on mortality in adults with congenital heart disease. According to the study done by Ko Bando et al., it has been found

that the occurrence of perioperative PH and the lack of preventive use of alpha-blockers were important variables that increased the risk of death. (17)

Characteristics of the degree of PH and mortality rate

There were significant changes between the groups over the course of 5 years ($p<0.05$). There were statistically significant differences in the overall death rate ($p<0.05$) between the low- and intermediate-probability groups and the high-probability groups. After adult cardiac surgery, the presence of PH greatly increases the risk of death.

According to a study done by Kennedy et al., the existence of PH was a separate factor that could predict the likelihood of illness and death after adult cardiac surgery. (4) This study's finding was consistent with those of Ramakrishna et al., who found that patients undergoing thoracic surgical operations who also suffered from PH had a greater than 60% chance of experiencing complications during the perioperative period when compared with patients with PH who underwent gynecological-urological surgery, dermatology, plastic surgery, or surgery in the breast area (16.7%). (3)

Correlation between PH and Mortality Rates

Death rates in the low-probability group were significantly associated ($p<0.05$) with those in the intermediate- and high-probability groups. In the three groups, a correlation coefficient of 17.8% was obtained, which means there was a correlation that was included in the first quartile, in the three groups. This shows a strong correlation, suggesting that the risk of death for patients undergoing cardiac surgery increases with the severity of PH.

The correlation coefficient of 17.8% was related to the number of deaths, which was a high figure when viewed from the perspective of human values because it was related to the death rate.

Ghoreishi et al. conducted a study to see if individuals with mitral regurgitation who underwent surgery on their mitral valve had an increased risk of death due to PH. A p-value of less than 0.001 indicated a statistically significant association between mortality and the severity of perioperative PH. (15) This also agrees with the research results by Ko Bando et al., which found that perioperative PH was a significant risk factor for mortality. (17) To be more specific, the results of a research by Reich et al. were consistent with the surgical treatments used to treat individuals with coronary artery disease. With an odds ratio of 2.1 and a p-value of 0.029, PH was shown to be a mortality predictor in this research. (15)

The association between PH and mortality rates, as assessed using the Bradford-Hill criteria for determining causality, is influenced by several factors. One such factor is the strength of the association, which quantifies the magnitude of the effect and has been accurately measured in this study. The stronger the association, the greater the possibility of a relationship causality. In this study, it was found that the correlation strength was 17.8%, which meant there was a correlation between PH and mortality rates. Apart from that, from a theoretical plausibility perspective, it shows that the causal relationship is stronger if it can be explained rationally and based on existing theories or concepts. These results were appropriate and consistent with previous studies. Therefore, they can help explain why PH is linked to higher mortality. (18)

Conclusion

There is a strong association between the occurrence of PH and the mortality rate of post-operative heart surgery patients in the ICU of the Integrated Heart Centre, Dr. Wahidin Sudirohusodo Central General Hospital. There is a need for more studies on the causes of death following adult cardiac surgery of different sorts.

Table 1. Characteristics of the research sample with research variables

		Survive	Non-survive	p-value
Age (mean±SD)		50.4±14.9	48.3±15.2	0.354
Gender	Male, n (%)	251 (72.5)	54 (65.1)	0.177
	Female, n (%)	95 (27.5)	29 (34.9)	
Pulmonary hypertension	Yes, n (%)	114 (72.2)	44 (27.8)	0.009
	No, n (%)	232 (85.6)	39 (14.4)	
Total, n (%)		346 (80.7)	83 (19.3)	

Legend: SD=standard deviation.
Age data was processed using the Mann-Whitney U test, while gender and PH used the chi-square test. p-value<0.05 means significant.

Table 2. Characteristics of mortality in PH patients based on type of adult cardiac surgery

	Survive	Non-survive	p-value
Coronary artery disease, n (%)	29 (82.8)	6 (17.2)	0.039
Valvular heart disease, n (%)	63 (64.9)	34 (35.1)	
Adult congenital heart disease, n (%)	22 (84.6)	4 (15.4)	
Total (n)	114	44	

Legend: PH=pulmonary hypertension.
Data on the characteristics of the type of operation were processed using the Pearson chi-square test. p-value<0.05 means significant.

Table 3. Sample characteristics degree of PH and mortality rate

		Survive (%)	Non-survive (%)	p-value
Degree of PH	Low	32 (76.2)	10 (23.8)	0.002
	Intermediate	31 (79.4)	8 (20.6)	
	High	51 (66.2)	26 (33.8)	

Legend: PH=pulmonary hypertension.
Data on the degree of PH were processed using the Pearson chi-square test. p-value<0.05 means significant.

Table 4. Correlation of degree of PH and mortality rate

		Survive (%)	Non-survive (%)	r-value	p-value
Degree of PH	Low	32 (76.2)	10 (23.8)	17.8%	<0.001*
	Intermediate	31 (79.4)	8 (20.6)		
	High	51 (66.2)	26 (33.8)		

Legend: PH=pulmonary hypertension.
Data on the degree of PH were processed using the Spearman Correlations test. p-value<0.05 means significant.

Figure 1. Characteristics of mortality in pulmonary hypertension patients based on type of adult cardiac surgery

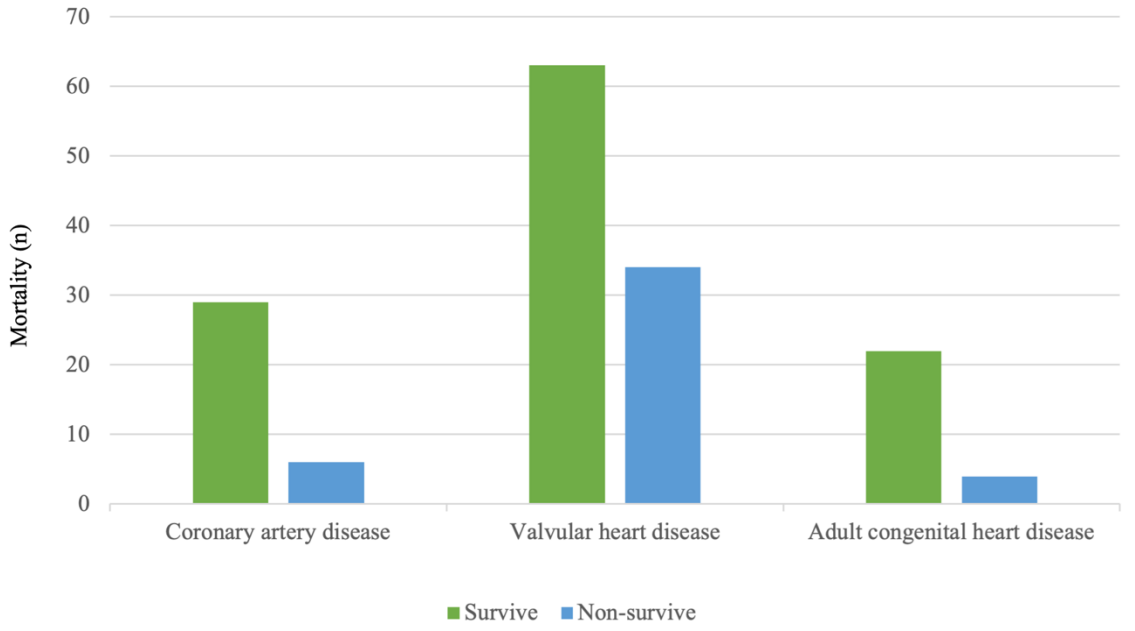
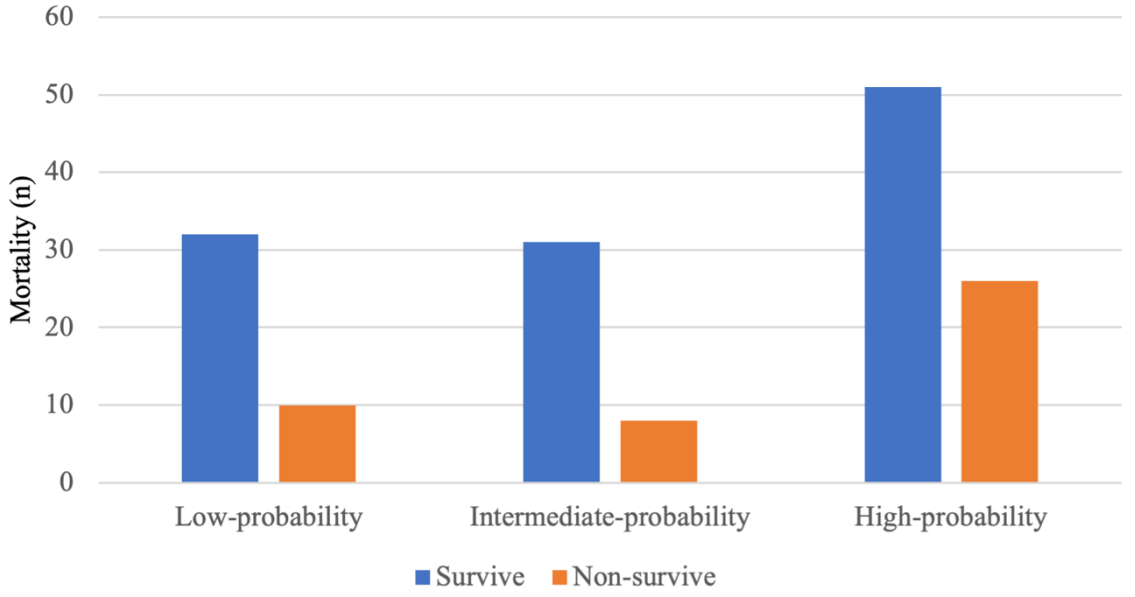


Figure 2. Degree of pulmonary hypertension and mortality incidence



References

1. Peña E, Dennie C, Veinot J, Muñiz SH. Pulmonary hypertension: how the radiologist can help. Radiographics 2012;32:9-32.
2. Lewis G, Hoey ETD, Reynolds JH, Ganeshan A, Ment J. Multi-detector CT assessment in pulmonary hypertension: techniques, systematic approach to interpretation and key findings. Quant Imaging Med Surg 2015;5:423-32.
3. Grosse C, Grosse A. CT findings in diseases associated with pulmonary hypertension: a current review. Radiographics 2010;30:1753-77.
4. Kennedy JLW, LaPar DJ, Kern JA, Kron IL, Bergin JD, Kamath S, et al. Does the Society of Thoracic Surgeons risk score accurately predict operative mortality for patients with pulmonary hypertension? J Thorac Cardiovasc Surg 2013; 146:631-7.
5. Denault A, Deschamps A, Tardif J-C, Lambert J, Perrault L. Pulmonary hypertension in cardiac surgery. Curr Cardiol Rev 2010;6:1-14.
6. Nezic D, Spasic T, Micovic S, Kosevic D, Balevic M, Petrovic I, et al. Clinical performances of the EuroSCORE II in a single-centre, contemporary cardiac surgical cohort. J Cardiothorac Surg 2015;10:A59.
7. Ariaty GM, Sudjud RW, Sitanggang RH. Angka Mortalitas pada Pasien yang Menjalani Bedah Pintas Koroner berdasar Usia, Jenis Kelamin, Left Ventricular Ejection Fraction, Cross Clamp Time, Cardio Pulmonary Bypass Time, dan Penyakit Penyerta. Jurnal Anestesi Perioperatif 2017;5:155-62.
8. Priyantoro K, Soerianata S. Non surgical management of unprotected isolated ostial left main coroner artery disease. Jurnal Kardiologi Indonesia 2012;33:166-73.
9. Melly L, Torregrossa G, Lee T, Jansens J-L, Puskas JD. Fifty years of coronary artery bypass grafting. J Thorac Dis 2018;10:1960-7.
10. Salik I, Lee LS, Widrich J. Mitral Valve Repair. Treasure Island (FL): StatPearls Publishing; 2023 [cited 2023 Aug]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK549879/
11. Gutacker N, Bloor K, Cookson R, Gale CP, Maynard A, Pagano D, et al. Hospital surgical volumes and mortality after coronary artery bypass grafting: using international comparisons to determine a safe threshold. Health Serv Res 2017;52:863-78.
12. Harahap G, Nurcahyo W, Ismail A. Mortalitas operasi jantung coronary artery bypass graft di RSUP Dr Kariadi Semarang periode Januari 2014 - Desember 2014. Jurnal Kedokteran Diponegoro 2016;5:160-6.
13. Farouk Musa A, Cheong XP, Dillon J, Bin Nordin R. Validation of EuroSCORE II in patients undergoing coronary artery bypass grafting (CABG) surgery at the National Heart Institute, Kuala Lumpur: A retrospective review. F1000Res 2019;7:1-18.
14. Reich DL, Bodian CA, Krol M, Kuroda M, Osinski T, Thys DM. Intraoperative hemodynamic predictors of mortality, stroke, and myocardial infarction after coronary artery bypass surgery. Anesth Analg 1999;89:814-22.
15. Ghoreishi M, Evans CF, DeFilippi CR, Hobbs G, Young CA, Griffith BP, et al. Pulmonary hypertension adversely affects short-and long-term survival after mitral valve operation for mitral regurgitation: implications for timing of surgery. J Thorac Cardiovasc Surg 2011;142: 1439-52.
16. Melby SJ, Moon MR, Lindman BR, Bailey MS, Hill LL, Damiano Jr RJ. Impact of pulmonary hypertension on outcomes after aortic valve replacement for aortic valve stenosis. J Thorac Cardiovasc Surg 2011;141:1424-30.
17. Bando K, Turrentine MW, Sharp TG, Sekine Y, Aufiero TX, Sun K, et al. Pulmonary hypertension after operations for congenital heart disease: analysis of risk factors and management. J Thorac Cardiovasc Surg 1996;112:1600-9.
18. Fedak KM, Bernal A, Capshaw ZA, Gross S. Applying the Bradford Hill criteria in the 21st century: how data integration has changed causal inference in molecular epidemiology. Emerg Themes Epidemiol 2015;12:1-9.

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