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Factors Influencing Mortality of Thoracic Aortic Surgery in The Third World Country

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Abstract

Background: A prominent increase in the overall global death rate of aortic disease is seen in developing countries, with Southeast Asia having the highest increase of 41%. Lack of identification and prompt management of the diseases in conjunction with lack of facilities in third world countries that could perform aortic surgery made the procedure more complex when the patients admitted to tertiary hospitals.

Methods: The data was obtained through the medical records of patients who underwent thoracic aortic surgery from 2018 to 2021 at the National Cardiovascular Center Harapan Kita (NCCHK). One-year and 3-year survival analysis was obtained through phone calls and digital messages. Statistical analysis was done to investigate the impact of surgical complexity as the main predictor and other variables on primary (in-hospital mortality) and secondary (mid-term survival) outcomes.

Results: A total of 208 patients were included in the analysis; 157 (75.5%) underwent complex surgery, and 51 (24.5%) underwent non-complex surgery. In-hospital mortality was similar across 2 groups (23.6% vs 13.7%; p = 0.1240). On multivariable analysis, mal perfusion syndrome (OR 3.560; p = 0.002), CPB duration > 180 minutes (OR 4.331; p = 0.001), and surgical priority (urgent OR 4.196; p = 0.003; emergency OR 10.879; p = 0,001) were identified as an independent predictor of in-hospital mortality. Cox regression identified diabetes (HR 4.539; p = 0.025) and emergency procedure (HR 9.561; p = 0.015) as independent predictors for 1-year mortality, and diabetes (HR 3.609; p = 0.004), aortic dissection (HR 2.795; p = 0.029), and maximum aortic diameter (HR 1.034; p = 0.003) for 3-year mortality. Surgical complexity was not associated with early and mid-term mortality.

Conclusion: In patients undergoing thoracic aortic surgery, surgical complexity was not associated with early and mid-term survival. Early and mid-term survival was largely determined by patient comorbidities and intra-surgery factors.

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Keywords: Aorta, complex aortic surgery, in-hospital mortality, mid-term survival.

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Introduction

Thoracic aortic disease encompasses a variety of acute and chronic conditions affecting the aortic root, ascending aorta, aortic arch, descending aorta, and thoracoabdominal aorta. Over the last two decades, the global death rate from aortic disorders has increased from 2.49 per 100,000 in 1990 to 2.78 per 100,000 in 2010, with developing countries experiencing a greater increase, with an average death rate of 0.71 compared to 0.22 in advanced economies. Many patients with aortic disorders presented late in developing countries due to a lack of identification and prompt management of the diseases; not to mention, the lack of facilities in third-world countries that could perform aortic surgery made the procedure more complex when the patients presented to tertiary hospitals.[1,2] This is in contrast to developed countries, where complex surgery is less common than non-complex surgery. According to a study, 3-20% of patients with thoracic aortic disease have concurrent coronary heart disease (CHD) and valve dysfunction. As a result, individuals with aortic disease frequently require coronary artery bypass surgery (CABG) and valve surgery.[3-5]

Because of the absence of early identification of aortic pathology in developing countries, particularly in the periphery, most patients develop severe disease before intervention can be undertaken. Complex aortic pathology necessitates complex aortic surgery, in which aortic surgery is conducted in multiple procedures or conjunction with other cardiac surgical procedures.[6] Therefore, our primary goal was to identify risk indicators for lower long-term survival following complex thoracic aortic surgery in a third world country.

Patients and Methods

Study population

Our center retrospectively collects clinical and procedural data for all patients undergoing thoracic aortic surgery at National Cardiovascular Center Harapan Kita. This database was retrospectively interrogated to identify all adult patients who had undergone emergent or urgent primary open aortic surgery in the cardiac center from 2018 to 2021. Patients were excluded if they had previously undergone cardiac or aortic surgery or hybrid surgery. The cases were linked to the Harapan Kita database to identify all-cause mortality. Complex surgery in our case is defined as thoracic aortic surgery which was performed concomitantly with other cardiac surgery, such as valvular surgery or CABG or aortic surgery which was performed in more than one segment(s).

Statistical analysis

The cohort was stratified by the complexity of the thoracic aortic surgery. Complex surgery included surgery involving the aorta and valvular or coronary surgery, while non-complex surgery involved thoracic aorta surgery only. The baseline characteristics were summarized by group using mean ± standard deviation for age or numbers and percentages for categorical variables. These baseline characteristics were then compared across the groups using analysis of variance for age and the chi-square test for the categorical variables.

Logistic regression analysis was used to identify independent risk factors, such as surgical complexity, malperfusion syndrome, CPB duration > 180 minutes, and surgical priority, and estimate the odds ratio and associated 95% confidence intervals (CIs) for one-year mortality. Next, for those surviving longer than the first year, Cox regression analysis was used to identify the risk factors and estimate their hazard ratios (HRs) and associated 95% CIs for decreased mid-term survival up to 3 years. All baseline characteristics were considered in both multivariate models.

A 2-sided p-value < 0.05 was considered statistically significant. Statistical analyses were performed using IBM SPSS 25.0 for Macintosh (SPSS Inc., Chicago, IL, USA).

Results:

Complex and non-complex surgery

Tn total, 214 patients were treated in our center for the first time with open thoracic aortic surgery. Because four of the 214 instances had thoracoabdominal surgery and two had hybrid surgery, the total number of individuals included in this study was 208. **Table 1** shows

Table 1. Baseline characteristic of subjects underwent thoracic aortic surgery in National Cardiovascular Center Harapan Kita during 2018-2021 according to procedural complexity.

Variables	Thoracic Aortic Surgery		P value
	Non-Complex (n=51)	Complex (n=157)	
Demographic Characteristic			
Age			
Mean ± SD	50.65 ± 10.803	48.81 ± 11.658	0.321
<65 years	45 (88.2%)	142 (90.4%)	0.603
≥65 years	6 (11.8%)	15 (9.6%)	
Gender			
Man	37 (72.5%)	99 (63.1%)	0.239
Woman	14 (27.5%)	58 (36.9%)	
Clinical factors			
Hypertension	41 (80.4%)	127 (80.9%)	1.000
Diabetes Mellitus	5 (9.8%)	25 (15.9%)	0.362
COPD	5 (9.8%)	52 (33.1%)	0.001*
Malperfusion syndrome	6 (11.8%)	47 (29.9%)	0.009*
Amount of malperfused organ			
1 organ	6 (11.8%)	37 (23.6%)	0.006*
≥2 organs	0 (0%)	10 (6.3%)	
Heart failure	48 (94.1%)	143 (91.1%)	0.769
NYHA classification			
I	13 (25.5%)	30 (19.1%)	0.535
II	23 (45.1%)	61 (38.9%)	
III	10 (19.6%)	46 (29.3%)	
IV	2 (3.9%)	6 (3.8%)	
Pre-operative kidney failure	16 (31.4%)	69 (43.9%)	0.140
Aortic dissection	14 (27.5%)	115 (73.2%)	<0.001*
Pre-operative Imaging Parameter			
Left Ventricular Ejection Fraction (LVEF)			
Mean ± SD	54.33 ± 14.03	56.98 ± 13.763	0.239
Good (LVEF > 50%)	31 (60.8%)	113 (72%)	0.354
Moderate (LVEF 31-50%)	18 (35.3%)	38 (24.2%)	
Severe (LVEF 21-30%)	1 (2%)	6 (3.8%)	
LVEDd	65 [40-95.2]	57 [33-119]	0.003*
Maximal aortic diameter	58 [37.3 – 120]	55 [32-105]	0.451
Surgery Parameter			
Post-surgery neurological complication	11 (21.6%)	45 (28,7%)	0.367
CPB duration			
Median [Min-Max]	143.5 [75 – 379]	182.5 [71 – 472]	<0.001*
≤180 mins	44 (88.0%)	76 (49.4%)	<0.001*
>180 mins	6 (12.0%)	78 (50.6%)	
Surgical priority			
Elective	39 (76.5%)	62 (39.5%)	<0.001*
Urgent	11 (21.6%)	83 (52.9%)	
Emergent (salvage procedure)	1 (2%)	12 (7.65%)	
Concomitant surgery			
CABG	0 (0%)	25 (15.9%)	0.001*
Mitral	0 (0%)	17 (10.8%)	0.015*
Tricuspid	0 (0%	12 (7.6)	0.041*
Amount of procedures			
1 procedure	51 (100%)	0 (0%)	<0.001*
2 procedures	0 (0%)	102 (65%)	
≥ 3 procedures	0 (0%)	55 (35%)	
Amount of segments			
Unisegment	51 (100%)	19 (12.1%)	<0.001*
Multisegments	0 (0%)	138 (87.9%)	
Clinical Outcome			
In-hospital mortality	7 (13.7%)	37 (23.6%)	0.194
One year mortality	3 (5.9%)	9 (5.7%)	1.000
Three years	6 (11.8%)	16 (10.2%)	1.000

Notes: Categorical data was stated in amount (n) and %, analysed by chi-square test. Normally distributed numerical data was stated in mean ± SD and analysed by independent t-test, while numerical data that is not normally distributed was stated in median (min-max) and analysed with Mann Whitney test. (*) Variable was significant if P value <0,05. CABG = coronary artery bypass grafting; SD= standard deviation; COPD= chronic obstructive pulmonary disease; NYHA= New York Heart Association; LVEDd= left ventricular end diastolic diameter; CPB= cardiopulmonary bypass time; OR= odds ratio; CI= confidence interval

Table 2. Bivariate analysis in between demographic characteristic, clinical factors, pre-operative imaging parameter, and surgical parameter with in-hospital mortality in subjects underwent thoracic aortic surgery in National Cardiovascular Center Harapan Kita during 2018-2021.

Variables	In-hospital mortality		P value	OR (CI 95%)
	Alive (n=164)	Death (n=44)		
Main Predictor				
Thoracic Aortic Surgery				
Complex	120 (76.4%)	37 (23.6%)	0.140	1.94 (0.81 – 4.66)
Non-complex	44 (86.3%)	7 (13.7%)		
CABG				
Yes	16 (64%)	9 (36%)	0,058	2.38 (0.97 – 5.83)
No	148 (80.9%)	35 (19.1)		
Mitral				
Yes	14 (82.4%)	3 (17.6%)	0.712	0.78 (0.22 – 2.86)
No	150 (78.5%)	41 (21.5%)		
Tricuspid				
Yes	7 (58.3%)	5 (41.7%)	0.085	2.88 (0.87 – 9.55)
No	157 (80.1%)	39 (19.9%)		
The amount of procedure(s)				
1	44 (86.3%)	7 (13.7%)	Ref.	
2	86 (84.3%)	16 (15.7%)	0.749	1.17 (0.45 – 3.05)
≥3	34 (61.8%)	21 (38.2%)	0.002*	3.88 (1.48 – 10.19)
Amount of segment(s)				
Multisegment	102 (73.9%)	36 (26.1%)	0.017*	2.74 (1.19 – 6.26)
Unisegment	62 (88.6%)	8 (11.4%)		
Demographic Characteristic				
Age				
Mean ± SD	48.57 ± 11.742	51.82 ± 10.033	0.097	1.03 (0.99 – 1.06)
≥65 years	15 (71.4%)	6 (28.6%)	0.383	1.57 (0.57 – 4.31)
<65 years	149 (79.7%)	38 (20.3%)		
Gender				
Man	107 (78.7%)	29 (21.3%)	0.934	1.03 (0.51 – 2.08)
Woman	57 (79.2%)	15 (20.8%)		
Clinical Factors				
Hypertension				
Yes	132 (78.6%)	36 (21.4%)	0,842	1.09 (0.46 – 2.57)
No	32 (80.0)	8 (20.0%)		
Diabetes Mellitus				
Yes	24 (80%)	6 (20%)	0.867	0.92 (0.35 – 2.42)
No	140 (78.7%)	38 (21.3%)		
COPD				
Yes	45 (78.9%)	12 (21.1%)	0.982	0.99 (0.47 – 2.09)
No	119 (78.8%)	32 (21.2%)		
Malperfusion syndrome				
Yes	30 (56.6%)	23 (43.4%)	<0.001*	4.89 (2.40 – 9.97)
No	134 (86.5%)	21 (13.5%)		
Amount of malperfused organ(s)				
1	24 (55.8%)	19 (44.2%)	0.810	0.842 (0.20-3.41)
≥ 2	6 (60.0%)	4 (40.0%)		
Heart Failure				
Yes	152 (79.6%)	39 (20.4%)	0.388	0.62 (0.21 – 1.85)
No	12 (70.6%)	5 (29.4%)		
NYHA Classification				
I	35 (81.4%)	8 (18.6%)	Ref.	
II	71 (84.5%)	13 (15.5%)	0.654	0.80 (0.30 – 2.11)
III	44 (78.6%)	12 (21.4%)	0.729	1.19 (0.44 – 3.24)
IV	2 (25%)	6 (75%)	0.004*	13.13 (2,22 – 77.45)
Pre-operative kidney failure				
Yes	63 (74.1%)	22 (25.9%)	0.167	1.60 (0.82 – 3.13)
No	101 (82.1%)	22 (17,9%)		
Thoracic aortic dissection				
Yes	92 (71.3%)	37 (28.7%)	0.001*	4.14 (1.74 – 9.82)
No	72 (91.14)	7 (8.86%)		
Pre-Operative Imaging Parameter				
Left Ventricular Ejection Fraction (LVEF)				
Mean ± SD	56.23 ± 13.72	56.76 ± 14.24	0.825	1.00 (0.07 – 1.02)
Good (> 50%)	114 (79.2%)	30 (20.8%)	Ref.	
Moderate (31-50%)	45 (80.4%)	11 (19.6%)	0.851	0.93 (0.43 – 2.01)
Severe (21-30%)	5 (71.4%)	2 (28.6%)	0.627	1.52 (0.28 – 8.23)
LVEDd	60 [33-119]	53 [33.30-89]	0.041*	0.973 (0.94 – 0.99)
Maximal Aortic Diameter	56 [32.70-105]	56.15 [32 – 120]	0.862	1.002 (0.97 – 1.02)
Surgical Parameter				
Post-surgery neurological complication				
Yes	41 (73.2%)	15 (26.8%)	0.229	1.55 (0.76 – 3.18)
No	123 (80.9%)	29 (19.1%)		
CPB duration				
Median [Min-Max]	164.0 [71 – 472]	193.0 [85 – 382]	<0.001*	1.01 (1.01 – 1.02)
>180 mins	55 (65.5%)	29 (34.5%)	<0.001*	4.03 (1.97 – 8.25)
≤ 180 mins	107 (88.4%)	14 (11.6%)		
Surgery priority				
Elective	93 (92.1%)	8 (7.9%)	Ref.	
Urgent	65 (69.1%)	29 (30.9%)	<0.001*	5.19 (2.23 – 12,07)
Emergensi (termasuk salvage)	6 (46.2%)	7 (58.3%)	<0.001*	13.56 (3.67 – 50.16)

Notes: Categorical data was stated in amount (n) and %. Normally distributed numerical data was stated in mean ± SD, while numerical data that is not normally distributed was stated in median (min-max). Bivariate analysis was performed with logistic regression for bivariate. (*) Variable was significant if P value <0.05.

the baseline characteristics of the total group, stratified by the difficulty of the procedure. The overall mean age was 50.65 10,803 for non-complex surgery and 48.81 11,658 for complex surgery, with men accounting for the majority of patients (65%). Comorbidities before surgery were prevalent, particularly hypertension (80%), diabetes (14%), COPD (27%), and heart failure (91%). Furthermore, more than half of patients undergoing descending or thoracoabominal aorta surgery required complex surgery.

Early- and mid-term survival

The in-hospital mortality rate was 21.6%. Survival at 1 and 3 years was 92.6% (92.5% vs 93.2%) and 80.3% (78.3% vs 84.2%) [complex vs non-complex surgery] in the entire cohort of patients undergoing primary open thoracic aortic surgery in National Cardiovascular Center Harapan Kita from 2018 to 2021. At the end of the one-year survival rate, the average age was 48.74 ± 11.64, and twelve subjects died. In-hospital mortality occurred in 44 participants (21.2%) who were removed from the survival-rate analysis, with complex surgery groups having a higher mortality rate than non-complex surgery groups (23.6% vs 13.7%; p = 0.194).

The complex surgery group had a survival rate of 92.5%, whereas the non-complex surgery group had a survival rate of 93.2%. p = 0.866 for Log Rank (Mantel-Cox) **(Figure 1c)**. The diabetic group had a one-year survival rate of 94.3%, with a Log Rank (Mantel-Cox) p = 0.049. **(Figure 1d)**. The one-year survival rate for elective surgery was 92.47%, 95.38% for urgent surgery, and 66.67% for emergent surgery, Log Rank (Mantel-Cox) p = 0,030. **(Figure 1e)**. The number of individuals included in the three-year survival rate analysis was 112. Because the observation time did not exceed 36 months, 52 patients were removed. The overall survival rate was 80.3%, with complex surgery accounting for 78.3% and non-complex surgery accounting for 84.2%. The average age after the three-year observation period was 50.21± 10.45, with 22 individuals (19.7%) dying.

The effect of the variables such as surgical complexity and the other variables towards the year's survival rate post-thoracic aorta surgery were analyzed bivariate with the *cox regression* method **(Figure 1f)**. Multivariate models for survival rate utilizes multiple *Cox regression*, obtained by inserting the complexity of surgical procedure as the main predictor, and other variable as *stepwise backward* using LR *(likelihood ratio)* **(Table 1)**. The survival rate of the complex surgery group was 78.38% and in non-complex surgery was 84.21%, Log Rank (Mantel-Cox) p = 0,440 **(Figure 1g)**. The survival rate of diabetic patients was 57.89% and in non-diabetic patients was 84.95%, Log Rank (Mantel-Cox) p = 0,005 **(Figure 5.8)**. The survival rate in aortic dissection patients was 76.5% and in groups without aortic dissection was 85.4%, Log Rank (Mantel-Cox) p = 0,020 **(Figure 1h)**.

Discussion:

This study revealed several findings, including (1) in-hospital mortality in 44 patients (21.2%) and

Table 3. Multivariate analysis in between demographic characteristic, clinical factors, pre-operative imaging parameter, and surgical parameter with in-hospital mortality in subjects underwent thoracic aortic surgery in National Cardiovascular Center Harapan Kita during 2018-2021

Variable	B (SE)	Nilai p	OR	CI 95%
Procedural complexity	- 0.775 (0.566)	0.170	0.461	0.15 – 1.39
Malperfusion syndrome	1.270 (0.413)	0.002*	3.560	1.59 – 7.99
CPB duration >180 mins	1.466 (0.427)	0.001*	4.331	1.88 – 10.00
Elective procedure status	Ref.	Ref.	Ref.	Ref.
Urgent procedure status	1.434 (0.479)	0.003*	4.196	1,64 – 10,73
Emergent procedure status (including salvage procedure)	2.387 (0.746)	0.001*	10,879	2.52 – 46.90

Notes: Data was analysed with multiple logistic regression with backward method. (*) Variable was significant if P value <0,05. Nagelkerke R2 = 0.318

Table 4. Bivariate analysis in between demographic characteristic, clinical factors, pre-operative imaging parameter, and surgical parameter with one year survival rate in subjects underwent thoracic aortic surgery in National Cardiovascular Center Harapan Kita during 2018-2021.

Variable	One year survival rate		P value	HR (CI 95%)
	Alive (n=152)	Death (n=12)		
Main predictor				
Thoracic aortic surgery				
Complex	111 (92.5%)	9 (7.5%)	0,867	1.12 (0.30 – 4.13)
Non-complex	41 (93.2%)	3 (6.8%)		
CABG				
Yes	15 (93.8%)	1 (6.2%)	0.863	0.83 (0.11 – 6.46)
No	137 (92.6%)	11 (7,.4%)		
Mitral				
Yes	12 (85.7%)	2 (14.3%)	0.280	2.31 (0.51 – 10.53)
No	140 (93.3%)	10 (6,7%)		
Tricuspid				
Yes	6 (85.7%)	1 (14.3%)	0.458	2.17 (0.28 – 16.8)
No	149 (92.9%)	11 (7.1%)		
Amount of procedure(s)				
1	41 (93.2%)	3 (6.8%)	Ref.	
2	80 (93.1%)	6 (6.9%)	0.961	1.03 (0.26 – 4.14)
≥3	31 (91.2%)	3 (8.8%)	0.724	1.33 (0.27 – 6.61)
Amount of segment(s)				
Multisegment	93 (91.,2%)	9 (8.8%)	0,348	1.87 (0.51 – 6.91)
Unisegment	59 (95.2%)	3 (4.8%)		
Demographic characteristic				
Age				
Mean ± SD	48.74 ± 11.64	46.42 ± 10.45	0.490	0.98 (004 – 1.03)
≥65 years	13 (86.7%)	2 (13.3%)	0.370	2.00 (0.44 – 9.14)
< 65 years	139 (93.3%)	10 (6.7%)		
Gender				
Male	99 (92.5%)	8 (7.5%)	0.898	1.08 (0.33 – 3.59)
Female	53 (93.0%)	4 (7.0%)		
Clinical factor				
Hypertension				
Yes	123 (93.2%)	9 (6.8%)	0.619	0.72 (0.20 – 2.65)
No	29 (90.6%)	3 (9.4%)		
Diabetes Mellitus				
Yes	20 (83.3%)	4 (16.7%)	0.064	3.11 (0,94 – 10.32)
No	132 (94.3%)	8 (5.7%)		
COPD				
Yes	43 (95.6%)	2 (4.4%)	0.412	0.53 (0.12 – 2.42)
No	109 (91.6%)	10 (8,4%)		
Malperfusion syndrome				
Yes	26 (86.7%)	4 (13,3%)	0.172	2.31 (0.69 – 7.67)
No	126 (94.0%)	8 (6.0%)		
Amount of malperfused organ(s)				
1	4 (66.7%)	2 (33.3%)	0.149	4.24 (0.59 – 30.14)
≥ 2	22 (91.7%)	2 (8.3%)		
Heart failure				
Yes	141 (92.8%)	11 (7.2%)	0.874	0.84 (0.11 – 6.56)
No	11 (91.7%)	1 (8.3%)		
NYHA classification				
I	35 (100%)	0 (0%)	Ref.	
II	64 (90.1%)	7 (9.9%)	0.910	1.13 (0.14 – 9.17)
III	40 (90.9%)	4 (9.1%)	0.954	1.07 (0.12 – 9.54)
IV	2 (100%)	0 (0%)	0.991	N/A
Pre-operative kidney failure				
Yes	59 (93.7%)	4 (6.3%)	0.717	0.80 (0.24 – 2.67)
No	93 (92,1%)	8 (7.9%)		
Thoracic aortic dissection				
Yes	82 (89.1%)	10 (10.9%)	0.067	4.13 (0.91 – 18.85)
No	70 (97,2%)	2 (2.8%)		
Pre-operative imaging parameter				
Left ventricular ejection fraction (LVEF)				
Mean ± SD	56.45 ± 13.87	53.44 ± 12.65	0.454	0.98 (0.94 – 1.02)
Good (> 50%)	105 (92.1%)	9 (7.9%)	Ref.	
Moderate (31-50%)	42 (93.3%)	3 (6.7%)	0.812	0.85 (0.23 – 3.15)
Severe (21-30%)	5 (100%)	0 (0%)	N/A	N/A
LVEDd	60 [33-119]	57.4 [41.2– 88.2]	0.833	1.00 (0.96 – 1.04)
Maximal aortic diameter	56.1 [32.7 – 105]	56.0 [39.2 – 96]	0,174	1.03 (0.99 – 1.07)
Surgical parameter				
Post-surgery neurological complication				
Yes	37 (90.2%)	4 (9.8%)	0.509	1.49 (0.45 – 4.97)
No	115 (93.5%)	8 (6.5%)		
CPB duration				
Median [Min-Max]	163.5 [71 – 472]	186 [123 – 264]	0.693	1.00 (0.99 – 1.01)
>180 mins	49 (89.1%)	6 (10.9%)	0.146	2.41 (0.73 – 7.90)
≤180 mins	102 (95.3%)	5 (4.7%)		
Surgical priority				
Elective	86 (92.5%)	7 (7.5%)	Ref.	
Urgent	62 (95.4%)	3 (4.6%)	0.472	0.61 (0.16 – 2.32)
Emergent (tincluding salvage)	4 (66.7%)	2 (33.3%)	0.051	4.78 (0.99 – 23.03)

Notes: Categorical data was stated in amount (n) and %. Normally distributed numerical data was stated in mean ± SD, while numerical data that is not normally distributed was stated in median (min-max). Bivariate analysis was performed with cox regression for bivariate. (*) Variable was significant if P value <0,05. HR= hazard ratio

Table 5. Multivariate analysis in between demographic characteristic, clinical factors, pre-operative imaging parameter, and surgical parameter with one year survival rate in subjects underwent thoracic aortic surgery in National Cardiovascular Center Harapan Kita during 2018-2021.

Variable	ß (SE)	P value	HR	CI 95%
Procedural complexity	-0.604 (0.836)	0.470	0.546	0.10 – 2.81
Diabetes	1.513 (0.674)	0.025*	4.539	1.21 – 17.02
CPB duration > 180 mins	0.779 (0.741)	0.294	2.179	0.51 – 9.37
Maximal aortic diameter	0.038 (0.020)	0.058	1.039	0.99 – 1.08
Elective procedure status	Ref.	Ref.	Ref.	Ref.
Urgent procedure status	-0.188 (0.722)	0.795	0.829	0.20 – 3.41
Emergent procedure status and salvage procedure	2.258 (0.932)	0.015*	9.561	1.53 – 59.42

Notes: Data was analysed with multiple cox regression with backward method. (*) Variable was significant if P value <0.05.

Table 7. Multivariate analysis in between demographic characteristic, clinical factors, pre-operative imaging parameter, and surgical parameter with three years survival rate in subjects underwent thoracic aortic surgery in National Cardiovascular Center Harapan Kita during 2018-2021.

Variable	ß (SE)	P value	HR	CI 95%
Procedural complexity	- 0.713 (0.588)	0.226	0.490	0.15 – 1.55
Diabetes	1.283 (0.440)	0.004*	3.609	1.52 – 8.54
Aortic dissection	1.028 (0.469)	0.029*	2.795	1.11 – 7.01
Maximal aortic dissection	0.033 (0.011)	0.003*	1.034	1.01 – 1.06
CPB duration > 180 mins	0.182 (0.332)	0.583	1.200	0.63 – 2.30

Notes: Data was analysed with multiple cox regression with backward method. (*) Variable was significant if P value <0,05..

no significant difference in in-hospital mortality in complex and non-complex thoracic aorta surgery (23.6% vs 13.7%, p = 0.194), (2) one-year and three-year survival rates of 92.5% and 80.3%, respectively, and no significant difference in complex and non-complex thoracic aorta surgery, (3) With a CPB duration of more than 180 minutes, surgery priority was an independent predictor of in-hospital mortality. (4) Diabetes and emergency procedure status were linked with a one-year survival rate after thoracic aorta surgery, whereas diabetes, aortic dissection, and maximal aortic diameter were associated with a three-year survival rate. (5) There is no significant link between procedural complexity and a higher risk of in-hospital mortality in thoracic aorta surgery with mid-term follow-up. Patients with increased in-hospital mortality were older, had a higher prevalence of malperfusion syndrome, were in a higher NYHA functional class IV, had a higher proportion of dissection and multisegment illnesses, required more urgent and emergent treatments, and were older. Patients who underwent thoracic aortic surgery in our facility had advanced aortic illnesses, based on these parameters.

Complex and non-complex surgery

Apaydin et al. (2007) define complexity in terms of procedure risk rather than patient or disease risk. Robinson et al found that CABG performed concurrently with thoracic aortic surgery had a similar intra-operative mortality rate (1.8% vs 0.8%, p =0.4). The CABG operation was not associated with an increased risk of death (OR 1.9; CI 95% 0.67- 5.33; P = 0.23).[6,7] Although the mortality rate in complex surgery is higher (23.6% vs 13.7%; p = 0.140), our study found no statistically significant association in bivariate and multivariate analyses. Even though the difference was

Table 6. Bivariate analysis in between demographic characteristic, clinical factors, pre-operative imaging parameter, and surgical parameter with three year survival rate in subjects underwent thoracic aortic surgery in National Cardiovascular Center Harapan Kita during 2018-2021.

Variable	Three years survival rate		P value	HR (CI 95%)
	Alive (n=90)	Death (n=22)		
Main predictor				
Thoracic aortic surgery				
Complex	58 (78.4%)	16 (21.6%)	0.446	1.44 (0.56 – 3,68)
Non-complex	32 (84.2%)	6 (15.8%)		
CABG				
Yes	12 (92.3%)	1 (7.7%)	0.199	1.80 (0.73 – 4.41)
No	78 (78.8%)	21 (21.2%)		
Mitral				
Yes	4 (66.7%)	2 (33.3%)	0.289	2.19 (0.51 – 9.41)
No	86 (81.1%)	20 (18.9%)		
Tricuspid				
Yes	1 (50%)	1 (50%)	0.179	3.96 (0.53 – 29.55)
No	89 (20.9%)	21 (19.1%)		
Amount of procedure				
1	32 (84.2%)	6 (15.8%)	Ref.	
2	48 (82.8%)	10 (17.2%)	0.828	1.11 (0.40 – 3.07)
≥3	10 (62.5%)	6 (37.5%)	0.078	2.77 (0.89 – 8.60)
Amount of segment(s)				
Multisegment	48 (76.2%)	15 (23.8%)	0.199	1.80 (0.73 – 4.41)
Unisegment	42 (85.7%)	7 (14.3%)		
Demographic characteristic				
Age				
Mean ± SD	50.21 ± 10.45	47.45 ± 12.83	0.251	0.97 (0.94 – 1.01)
≥ 65	10 (83.3%)	2 (16.7%)	0.817	0.84 (0.19 – 3.60)
< 65	80 (80%)	20 (20%)		
Gender				
Male	60 (81.1%)	14 (18.9%)	0.835	0.91 (0.38 – 2.17)
Female	30 (78.9%)	8 (21.1%)		
Clinical factor				
Hypertension				
Yes	78 (83.0%)	16 (17.0%)	0.111	0.46 (0.18 – 1.19)
No	12 (66.7%)	6 (33.3%)		
Diabetes Mellitus				
Yes	11 (57.9%)	8 (42.1%)	0.009*	3.20 (1.34 – 7.64)
No	79 (84.9%)	14 (15.1%)		
COPD				
Yes	22 (88%)	3 (12%)	0.313	0.53 (0.15 – 1.80)
No	68 (78.2%)	19 (21.8%)		
Malperfusion syndrome				
Yes	14 (70%)	6 (30%)	0.203	1.83 (0.71 – 4.69)
No	76 (82.6%)	16 (17.4%)		
Amount of malperfusion organ(s)				
1	11 (73.3%)	4 (26.7%)	0.526	1.73 (0.31 – 9.50)
≥ 2	3 (60%)	2 (40%)		
Heart failure				
Yes	89 (80.91%)	21 (19.09%)	0.179	0.25 (0.03 – 1.88)
No	1 (50%)	1 (50%)		
NYHA classification				
I	25 (92.59%)	2 (7.41%)	Ref.	
II	39 (75%)	13 (25%)	0.719	0.64 (0.06 – 7.10)
III	24 (80%)	6 (20%)	0.437	2.24 (0.29 – 17.14)
IV	1 (100%)	0 (0%)	0.643	1.65 (0.20 – 13.71)
Pre-operative kidney failure				
Yes	36 (81.8%)	8 (18.1%)	0.738	0.86 (0.36 – 2.05)
No	54 (79.4%)	14 (20.5%)		
Thoracic aortic dissection				
Yes	49 (76.5%)	15 (23.5%)	0.207	1.78 (0.73 – 4.37)
No	41 (85.4%)	7 (14.6%)		
Pre-operative imaging parameter				
Left ventricular ejection fraction (LVEF)				
Mean ± SD	57.65 ± 13.78	55.45 ± 12.75	0.449	0.98 (0.95 – 1.01)
Good (> 50%)	64 (80%)	16 (20 %)	Ref.	
Moderate (31-50%)	24 (80%)	6 (20%)	0.975	1.01 (0.39 – 2.59)
Severe (21-30%)	2 (100%)	0 (0%)	NA	NA
LVEDd	60 [37-119]	58.8 [41.2-88.2]	0,609	0.99 (0.96 – 1.02)
Maximal aortic dissection	55 [33-105]	62 [39-96]	0.012*	1.03 (1.01 – 1.06)
Thoracic surgery				
Post-surgery neurological surgery				
Yes	22 (78.6%)	6 (21.43%)	0.750	1.16 (0.45 – 2.97)
No	68 (80.9%)	16 (19.1%)		
CPB duration				
Median [Min-Max]	153 [71-350]	181 [108-264]	0.157	1.00 (0.99 – 1.01)
>180 mins	24 (68.6%)	11 (31.4%)	0.026*	2.64 (1.12 – 6.21)
≤180 mins	65 (86.7%)	10 (13.3%)		
Surgical priority				
Elective	56 (81.2%)	13 (18.8%)	Ref	
Urgent	31 (81.6%)	7 (18.4%)	0.948	0.97 (0.38 – 2.43)
Emergent including salvage procedure	3 (60%)	2 (40.0%)	0.209	2.59 (0.58 – 11.52)

Notes: Categorical data was stated in amount (n) and %. Normally distributed numerical data was stated in mean ± SD, while numerical data that is not normally distributed was stated in median (min-max). Bivariate analysis was performed with cox regression for bivariate. (*) Variable was significant if P value <0,05. HR= hazard ratio

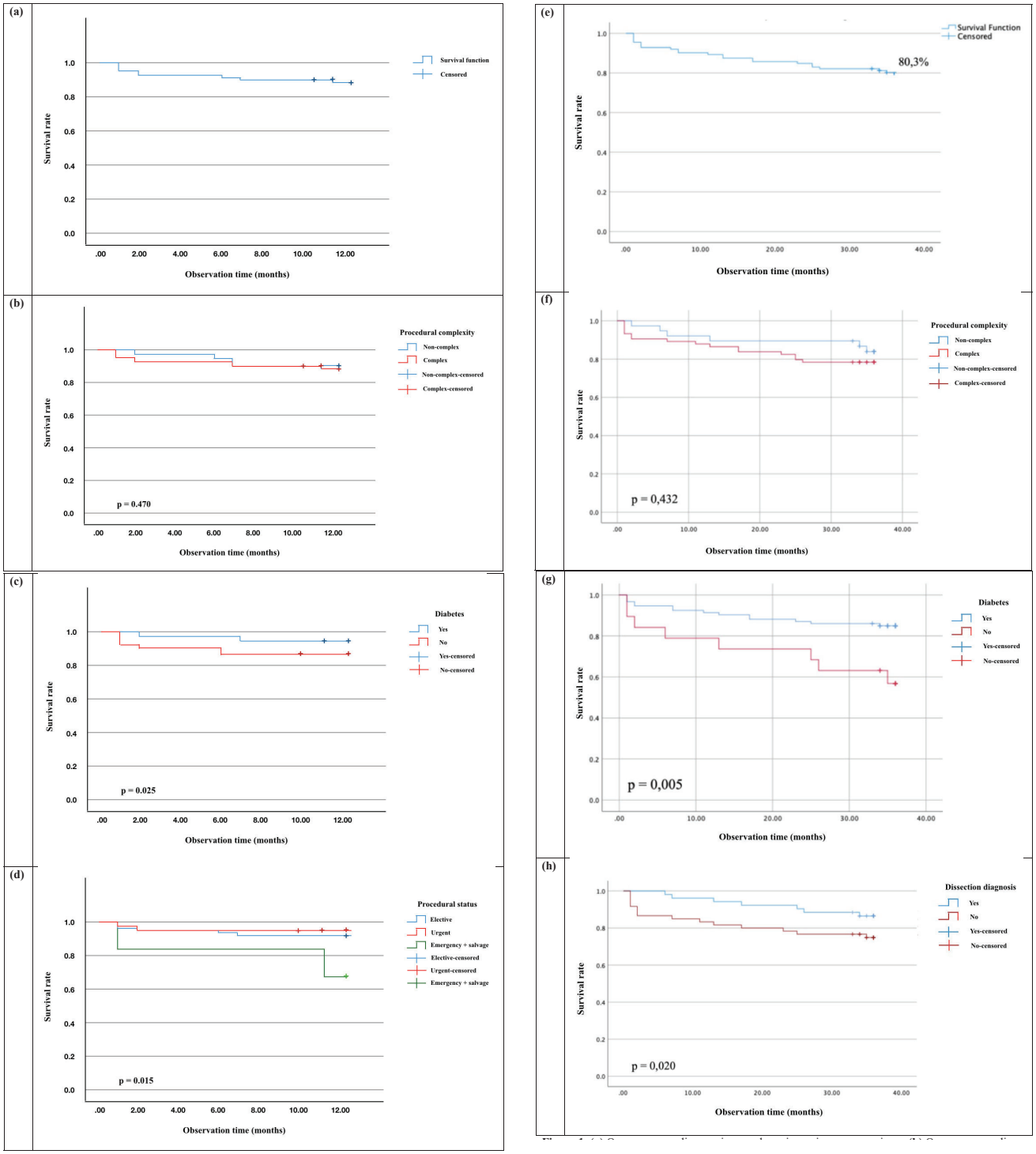

Figure 1. (a) One-year mortality rate in post-thoracic aortic surgery patients. (b) One-year mortality rate in complex and non-complex surgery. (c) One-year mortality rate in diabetic and non-diabetic patients. (d) One-year survival-rate in elective, urgent, and emergent procedure. (e) Three-year survival rate in post-thoracic aortic surgery. (f) Three-year survival rate in complex and non-complex surgery. (g) Three-year survival rate in diabetic and non-diabetic patients. (h) Three-year survival rate in dissecting and non-dissecting patients..

statistically insignificant, complex surgery had a higher proportion of in-hospital mortality than non-complex surgery. The intricacy of the technique was not linked to increased in-hospital mortality in this study. As a result, if required, multi-procedure CABG, valve surgery, and thoracic aortic surgery should be undertaken.[8-10]

Malperfusion syndrome

Signs and symptoms of malperfusion were described in 20-30% of patients in the International Registry of Acute Aortic Dissection (IRAD) study cohort and were associated with poorer outcomes. When compared to survivors, patients who died during hospitalization had a higher rate of malperfusion consequences such as neurological impairments (24% vs 15%), myocardial ischemia (15% vs 9%), visceral ischemia (6% vs 2%), renal failure (11% vs 3%), and limb ischemia (14% vs 7%). According to Conzelmann et al, the greater the number of organs damaged by malperfusion syndrome, the greater the risk of post-thoracic aortic surgery (adjusted OR one organ = 1.651, two organs = 2.440, three or more organs = 3.393, P 0.0001). In our study, 43.4% of patients with malperfusion syndrome died in the hospital. Early revascularization of malperfused organs before open thoracic surgery may result in a decreased post-surgical mortality rate.[11,12]

Duration of cardiopulmonary bypass

Cardiopulmonary bypass (CPB) is required during thoracic aortic surgery. However, it can cause considerable inflammation and oxidative stress, which can lead to multi-organ dysfunction. Xu et colleagues (2019) discovered that CPB duration was an independent predictor of postoperative AKI in 115 patients undergoing emergent thoracic aortic surgery (OR=1.171; 95% CI:1.002-1.368; P=0.047). A 10-minute increase in CPB time was linked to a 17.1% increased incidence of postoperative AKI. Mamikonian et al. (2014) discovered considerable hemolysis during CPB, which was linked to the development of postoperative AKI. Decreasing CPB-induced hemolysis or attenuating the effects of CPB-induced hemolysis by augmenting endogenous mechanisms that exist to scavenge and remove free hemoglobin may provide a way to clear excess plasma free hemoglobin more quickly, reduce oxidant injury, minimize the toxic effects of acute hemolysis, and reduce the incidence of AKI. In our analysis, patients with in-hospital mortality had a longer median CPB time (193 [85 - 382] vs 164 [71-472]; p 0.001).[13-15]

Surgical priority

In emergencies, open surgical repair of the thoracic aorta involves a very significant surgical risk. The reported mortality rate is 45%, with paraplegia, respiratory problems, or renal failure occurring in 12-45% of patients. The mortality rate associated with urgent and emergent surgery is higher than that of elective surgery. Priority of non-elective surgery, according to Harky et al, is a predictor of in-hospital mortality in patients undergoing open thoracic and thoracoabdominal aorta surgery (OR 2.72, IK 95% 1.44-5.12; P = 0.002). In a tertiary hospital, such as ours, emergency surgery settings could not be avoided because many patients were referred with hemodynamic instability and various problems. Experienced teams, modern surgical tools, and high-quality imaging are necessary.[16,17]

Early- and mid-term survival

In our study, mid-term survival after thoracic aortic surgery was calculated using the Kaplan-Meier method to be 92.6% in one year and 80.3% in three years. The Kaplan-Meier approach predicted the mid-survival rate after thoracic aortic surgery to be 92.6% in one year and 80.3% in three years. Di Eunasio et al found a one-year survival rate of 92.1% and a three-year survival rate of 87.3% after aortic arch surgery. This demonstrated that our center's post-thoracic aortic surgery survival rate is equivalent to that of industrialized countries. Our research also found that the complexity of the process is not a risk factor over the course of a year. Diabetes mellitus and emergent operation are independent predictors of one-year mortality in our final multivariate analysis model. Diabetes raises the one-year death rate after thoracic aortic surgery (HR 4.539, CI 95% 1.210 – 17.023; p = 0.025). The three-year survival rate after thoracic aortic surgery was 78.3% for complex surgery and 84.2% for non-complex surgery, according to Log Rank (Mantel-Cox) p = 0.440. In three and one year, our study found that procedural complexity did not affect survival rate. Diabetes mellitus, aortic dissection, and maximal aortic diameter were found

to be independent predictors of the three-year survival rate in our multivariate analytic model. Diabetes was previously recognized as a chronic disease that causes cardiovascular disease and may increase the mid-term death rate. Aortic dissection also increased the risk of death three years after thoracic aortic surgery (HR 2.796; CI 95% 1.11 – 7.01; p = 0.029). When compared to non-dissecting aneurysms, aortic dissection had a worse result. When dissection occurred, propagation to multisegment or dissection acceleration occurred more quickly, as evidenced by the three-year survival rate. Furthermore, in aortic dissection, persistent pathology was assumed to occur in other segments after final treatment in sick parts. This study's findings have crucial implications for developing a surveillance system in aortic dissection patients to decide whether to execute aggressive treatment in distal parts early.

Our study also found that maximal aortic diameter was a significant variable in our final multivariate model in terms of a three-year survival rate. This finding shows that maximal aortic diameter is an independent predictor of a three-year mortality rate, but not of a one-year mortality rate. When the ascending aorta diameter increased just before the surgical surgery, the proportion of aortic disease in other proportions besides the ascending aorta increased as well. The greater an aneurysm, the faster it dilates, and these symptoms may occur concurrently, especially if the diameter has reached the ascending aorta hinge point of 6 cm. When a dissection process occurs in the ascending aorta, a pathological process occurs in the descending aorta; therefore, the aortic diameter must be evaluated comprehensively and regularly (especially when the aortic diameter has surpassed the hinge point), not just in the diseased segments where the surgical procedure was performed.

Conclusions:

Procedural complexity was not associated with an increased risk of in-hospital mortality or a lower probability of mid-term survival in patients undergoing open thoracic aortic surgery. In-hospital mortality is predicted by malperfusion syndrome, CPB duration greater than 180 minutes, and surgical priority. We advocate a multicenter study for more varied participants to provide us with more prognostic factors that may alter mortality and survival rates following thoracic aortic surgery.

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