

Impact of hypertension on short- and long-term survival of Patients Who Underwent Emergency Surgery for Type A Acute Aortic Dissection

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Research article

Keywords: Type A acute aortic dissection, Hypertension, Early outcomes, Propensity score matching, Long-term outcomes, Mortality

Posted Date: April 17th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-22302/v1>

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Version of Record: A version of this preprint was published at Journal of Thoracic Disease on November 1st, 2020. See the published version at <https://doi.org/10.21037/jtd-20-2336>.

Abstract

Objective

To explore the clinical characteristics and prognosis of patients with hypertension underwent emergency surgery for type A acute aortic dissection (TA-AAD).

Methods

The present study enrolled 712 consecutive patients diagnosed with TA-AAD who were admitted to our hospital between January 2014 to December 2018. All patients accepted aortic repair surgery during hospitalization. The cohort was separated into two groups based on if they were diagnosed with hypertension upon administration. Before analyzing the short-term outcomes, baseline characteristics were matched for propensity scores. Patients' clinical characteristics were compared and analyzed before and after propensity scoring. To identify predictors for long-term mortality rate, Kaplan-Meier survival estimation and Cox proportional hazard analysis were performed.

Results

The 492 patients (69.1% of all patients in the cohort) included in the hypertensive group were generally older and heavier than patients in the non-hypertensive group. Between two groups, preoperative leukocyte count and serum creatinine level were found significant different ($P < 0.05$). After propensity scoring, 128 pairs (256 patients) were successfully matched. Our analysis showed that there was no significant difference of ventilation duration, 30-day mortality rate, intensive care unit (ICU) stay time and hospitalization time between these patients. However, our observation from surgeries suggested that hypertensive patients presented with less intraoperative aortic valve involvement. There was a significant difference in long-term survival rate ($P = 0.037$) between two groups and Cox regression analysis demonstrated that hypertension was an independent risk factor (hazard ratio [HR], 2.290; 95% confidence interval [CI], 1.013-5.178; $P = 0.046$).

Conclusions

Our data suggested that TA-AAD patients complicated with hypertension were generally older and heavier compared to non-hypertensive patients. The hypertension diagnosed upon hospital administration was an independent risk factors for long-term survival in TA-AAD patients but did not influence the 30-day mortality rate.

Introduction

Type A acute aortic dissection (TA-AAD) is a life-threatening disease, characterized by abrupt onset and catastrophic outcomes. The mortality rate of acute aortic dissection increases by 1–2% per hour after the first 24 to 48 h of symptom onset [1] and ranges from 8–34% even after prompt surgeries [2]. Several risk factors associated with spontaneous dissection have been identified and hypertension is considered the most important one and presented in about 65%-75% of all patients [3]. In general population, hypertension accounts for 54% of the population-attributable risk of developing acute aortic dissection [4].

Surgical repair is the 1st line treatment for patients presenting with TA-AAD. Repair of TA-AAD can be restrained to replacement of the proximal arch sparing the aortic arch branch vessels or total arch replacement (TAR). Study showed that the prevalence of hypertension in thoracic aortic dissection patients increased in the past few years [5]. However, even though the importance of hypertension in preoperative risk evaluation has been well examined, whether hypertension could influence short- and long-term survival rates after surgery has not been well studied. Therefore, the present study aimed to investigate the impact of pre-existing hypertension on short- and long-term mortality rates in patients with TA-AAD after emergency surgery.

Methods And Materials

Patients

This retrospective study was reviewed and approved by the institutional research ethics committee. Informed written consent was waived owing to the retrospective nature of the study. The data of all TA-AAD patients who underwent surgical repair between January 2014 and December 2018 was collected and retrospectively analyzed. The diagnosis of aortic dissection was made using computed tomography angiography (CTA) upon admission to the hospital.

Exclusion criteria included a history of preoperative renal replacement therapy or death occurred within 24 hours postoperatively. All patients were assigned to two groups based on if they were also diagnosed with hypertension: a hypertensive group and a normotensive group.

Date collection

A standardized form was used to collect clinical information. Data included patient demographics, history of the disease, aortic dissection features (blood supply of renal artery), operation parameters, peri-operational parameters including preoperative pericardial effusion and postoperative parameters like drainage volume 24 hours after surgery, mechanical ventilation time, 30-day mortality, length of intensive care unit (ICU) stay, and hospitalization time were collected.

Outcome variables

The primary endpoint was long-term survival rates with patients followed up to 6-year post surgery. Secondary endpoints were early postoperative clinical characteristics and surgery complications.

Surgical techniques

A standard median sternotomy was routinely performed on patients with TA-AAD. After systemic heparinization, cardiopulmonary bypass (CPB) was established by arterial cannulation of the right axillary or femoral artery or the ascending aorta and venous cannulation of the right atrium. When patients were cooled to 18 °C – 20 °C (nasopharyngeal temperature) or 22 °C – 24 °C (bladder temperature), the blood circulation was stopped, and the flow rate was reduced to 3–5 ml/kg/min. After clamping of the ascending aorta, cardiac arrest was accomplished with cold cardioplegic solution. Bentall procedure or ascending aorta replacement was performed depending on the conditions of aortic regurgitation. TAR method was traditionally selected in the following scenarios: major dissection tear around the aortic arch or proximal descending aorta, or diameter of the aortic arch is greater than 4 cm on contrast computed tomography. Once the distal and transverse anastomoses were completed, antegrade perfusion was reinitiated. Systemic warming was then initiated, and the proximal

reconstruction marked the completion of a standard CPB surgery. All patients were then transferred to ICU for routine monitoring.

Follow-up

Routine evaluation of enrolled patients' general health status was obtained through contacting with patients and their relatives through phone calls which was conducted every 3 months after discharging from the hospital. The follow-up information included blood pressure (BP), current medication and deaths (if any, cause of death and date were recorded). All follow-up data was collected. The median follow-up period was 29 months, and follow-up information was obtained in 86.8% (618 of 712) of all enrolled patients.

Diagnosis of hypertension

For TA-AAD patients, the diagnosis of hypertension was made if the patient was diagnosed with hypertension by a physician previously or presented with at least 3 times of elevated BP (systolic BP greater than 140 mmHg and diastolic BP greater than 90mmHg) on different days during hospitalization [6].

Statistical analysis

Data was analyzed with SPSS software (version 25.0, IBM Corp, Armonk, NY). Continuous and categorical variables were expressed as mean \pm standard deviation (SD). The student *t*-test was used for Gaussian distributed continuous variables and the Mann-Whitney *U* test for non-Gaussian distributed variables. Categorical variables were compared with the χ^2 test or Fisher exact test.

To reduce selection bias, a one-to-one propensity score matching (PSM) method was applied to analyze the short-term outcomes, with hypertension as the dependent variable. And it was conducted between groups highlighted in the univariate analysis (preoperative characteristics that showed significant differences between two groups). PSM was based on one-to-one nearest neighbor matching method with a tolerance level on the maximum propensity score distance (calipers of width 0.1 standard deviations of the logit of the propensity score).

Kaplan-Meier survival estimation was applied for long-term survival analysis, whereas the Log-Rank test was applied for the calculation of significances for follow-up period. Univariate and multivariate Cox proportional hazard analysis (stepwise forward LR method) were performed to determine independent predictors for late mortality, variables with a *P* value less than 0.1 on univariate analyses were included in the multivariate model. All analyses were two-sided, and any *p* < 0.05 was considered statistically significant.

Results

Demographic and clinical features

During the survey period, 730 patients underwent surgeries for TA-AAD. Of these patients, 3 patients were excluded for the need of dialysis, 15 patients were excluded because of death within 24 hours after the operation. Eventually, a total of 712 patients were included in this study. Among these patients, 694 patients (97.5%) received emergency operation and 492 patients (69.1%) were diagnosed with hypertension. Patients' preoperative characteristics were presented in Table 1. Compared to normotensive patients, patients with hypertension were

elder and heavier ($P < 0.001$) and presented with elevated preoperative leucocyte and serum creatinine (sCr) levels.

Table 1
Comparison of preoperative variables before and after matching

Characteristics	Overall Cohort			PSM Cohort		
	Normotension (n = 220)	Hypertension (n = 492)	<i>P</i> Value	Normotension (n = 128)	Hypertension (n = 128)	<i>P</i> Value
Demographics						
Age (year)	49.6 ± 14.6	53.8 ± 12.3	< 0.001	51.0 ± 15.0	52.1 ± 12.0	0.497
Male (%)	160(72.7)	362(73.6)	0.813	93(72.7)	96(75.0)	0.670
BMI (kg/m ²)	23.9 ± 4.3	25.9 ± 5.1	< 0.001	24.1 ± 4.3	25.0 ± 5.4	0.129
Medical history						
Diabetes mellitus (%)	3(1.4)	9(1.8)	0.763	0(0)	5(3.9)	0.060
Previous cardiac surgery (%)	9(4.1)	27(5.5)	0.432	8(6.3)	10(7.8)	0.625
Previous Coronary artery disease (%)	4(1.8)	23(4.7)	0.065	4(3.1)	4(3.1)	1.000
Cerebrovascular disease (%)	6(2.7)	18(3.7)	0.525	3(2.3)	3(2.3)	1.000
LVEF (%)	54.4 ± 8.0	55.5 ± 5.7	0.440	53.3 ± 8.8	52.7 ± 7.8	0.813
Pericardial effusion (%)	10(4.5)	18(3.7)	0.574	4(3.1)	5(3.9)	1.000
Preoperative laboratory data						
WBC (10 ⁹ /L)	10.5 ± 4.1	11.2 ± 4.2	0.041	10.5 ± 4.1	10.9 ± 4.1	0.396
sCr (μmol/L)	90.1 ± 53.8	110.5 ± 90.9	< 0.001	89.0 ± 60.0	102.6 ± 82.6	0.132
PLT (10 ⁹ /L)	151.6 ± 72.6	142.0 ± 64.3	0.093	155.0 ± 72.2	154.2 ± 65.5	0.926
Fibrinogen (g/L)	2.6 ± 1.3	2.6 ± 1.3	0.453	2.6 ± 1.2	2.6 ± 1.3	0.977
Triglyceride (mmol/L)	1.1 ± 1.0	1.3 ± 1.1	0.057	1.1 ± 1.1	1.2 ± 0.9	0.439
Preoperative CTA						
Left renal artery: true lumen (%)	121(65.4)	243(63.3)	0.621	76(70.4)	66(63.5)	0.285
Notes: Data presented as n (%); mean ± standard deviation.						
Abbreviations: PSM, propensity score matching; BMI, body mass index; LVEF, left ventricular ejection fraction; WBC, white blood cell;						
SCr, serum creatinine; PLT, platelet; CTA, computed tomography angiography;						

	Overall Cohort			PSM Cohort		
Right renal artery: true lumen (%)	139(75.1)	292(76.0)	0.813	80(74.1)	78(75.0)	0.877
Notes: Data presented as n (%); mean ± standard deviation.						
Abbreviations: PSM, propensity score matching; BMI, body mass index; LVEF, left ventricular ejection fraction; WBC, white blood cell;						
SCr, serum creatinine; PLT, platelet; CTA, computed tomography angiography;						

In terms of operative variables, hypertensive patients required less intraoperative aortic valve management and experienced shorter aortic cross-clamp (ACC) duration. While the extracorporeal circulation assist time and the deep hypothermic circulatory arrest (DHCA) duration were significantly longer in the hypertensive group, as shown in Table 2. In addition, normotensive patients were more likely to receive aortic valve management ($P < 0.001$).

Table 2
Comparison of operative variables before and after matching

	Overall Cohort			PSM Cohort		
Characteristics	Normotension (n = 220)	Hypertension (n = 492)	<i>P</i> Value	Normotension (n = 128)	Hypertension (n = 128)	<i>P</i> Value
TAR (%)	117(53.2)	254(51.6)	0.701	63(49.2)	72(56.3)	0.260
CABG/MVR/MVP/TVP (%)	26(11.8)	42(8.5)	0.169	17(13.3)	13(10.2)	0.437
Aortic valve (%)	108(49.1)	108(22.0)	< 0.001	58(45.3)	29(22.7)	< 0.001
CPB time (min)	245.3 ± 66.5	239.5 ± 68.9	0.296	238.0 ± 62.7	243.7 ± 79.0	0.522
Extracorporeal circulation assist time (min)	51.4 ± 28.4	58.1 ± 34.4	0.008	48.5 ± 21.1	54.2 ± 25.1	0.055
Aortic cross-clamp time (min)	176.0 ± 56.7	165.1 ± 58.6	0.021	171.4 ± 55.7	171.2 ± 66.6	0.976
DHCA time (min)	26.9 ± 13.4	29.0 ± 12.4	0.046	26.9 ± 13.4	28.7 ± 12.6	0.286
Notes: Data presented as n (%); mean ± standard deviation.						
Abbreviations: PSM, propensity score matching; TAR, total arch replacement; CABG, coronary artery bypass graft;						
MVR, mitral valve replacement; MVP, mitral valvuloplasty; TVP, tricuspid valvuloplasty; CPB, cardiopulmonary bypass;						
DHCA, hypothermic circulatory arrest.						

In order to better compare patients with similar baseline characteristics, propensity matching was performed in the entire cohort based on age, body mass index (BMI), preoperative leucocyte count and preoperative sCr. After matching, a total of 256 patients (128 pairs) remained for further analysis.

Short-term outcome

As indicated in Table 3, hypertensive patients had a significantly higher incidence of developing in-hospital complications compared to patients without hypertension. The 30-day mortality rate before propensity matching was 14.4% in the hypertension group and 8.6% in the normotensive patients ($P = 0.032$). Other parameters, such as mean ICU stay and hospital stay showed no significant differences between two groups.

Table 3
Comparison of postoperative variables before and after matching.

Characteristics	Overall Cohort			PSM Cohort		
	Normotension (n = 220)	Hypertension (n = 492)	<i>P</i> Value	Normotension (n = 128)	Hypertension (n = 128)	<i>P</i> Value
Drainage volume 24 hours after surgery (ml)	808.6 ± 833.9	721.8 ± 607.0	0.182	828.1 ± 935.0	696.9 ± 547.2	0.184
Ventilation time (hour)	33.5 ± 49.3	35.5 ± 53.5	0.704	36.4 ± 56.7	33.1 ± 45.0	0.656
30-day mortality (%)	19(8.6)	71(14.4)	0.032	14(10.9)	12(9.4)	0.697
ICU Stay time (day)	6.1 ± 5.4	7.3 ± 12.8	0.212	5.7 ± 5.2	5.6 ± 4.6	0.770
Hospital stay time (day)	21.6 ± 11.1	22.7 ± 13.2	0.301	21.3 ± 13.2	23.9 ± 13.7	0.128
Notes: Data presented as n (%); mean ± standard deviation.						
Abbreviations: PSM, propensity score matching; ICU, intensive care unit.						

However, there was no significant differences discovered between hypertensive and normotensive patients regarding 30-day mortality (9.4% vs 10.9%, $p = 0.697$) after propensity-matching suggested that the increased mortality observed in hypertensive group previously was largely due to the patients' baseline differences. Furthermore, our data suggested that there was no difference in variables like ventilation duration, ICU and hospital stay time between two matched groups.

Long-term outcome

73 patients (14.8%) in the hypertensive group and 21 patients (9.5%) in the normotensive group died during the hospitalization period. As a result, a total of 419 hypertensive patients and 199 normotensive patients were included in the follow-up. Period. We identified 32 (6.5%) deaths that occurred in the hypertension group and 9 (4.1%) in the normotensive group. The causes of late death are presented in Table 4. It is important to point out that 1 normotensive patient committed suicide six months after discharge and was excluded from the study. 48 (7.8%) patients were lost to follow-up after hospital discharge, and these patients were excluded from the subsequent long-term survival analysis. The 5-year survival rate was 84.4%±3.0% in the hypertensive group and

94.4%±2.1% in the normotensive group. The significant difference of long-term survival rate was discovered by Kaplan-Meier test between hypertensive and normotensive two groups ($P= 0.037$) (Fig. 1).

Table 4
Causes of late mortality (n = 41)

Overall cohort		
Cause of late mortality	Normotension (n = 9)	Hypertension (n = 32)
Aortic rupture	2	7
Cardiac failure	2	4
Neurological	1	3
Respiratory failure		1
Malignancy	1	1
Suicide	1	
Unknown	2	16

Following univariate analysis, parameters including age above 65 years ($P= 0.050$), female gender ($P= 0.095$), hypertension ($P= 0.044$), overweight (BMI greater than 24) [7] ($P= 0.096$) and TAR ($P= 0.088$) were selected for further multivariate analysis. Multivariable Cox regression analysis showed that only hypertension (hazard ratio [HR], 2.290; 95% confidence interval [CI], 1.013–5.178; $P= 0.046$) was proved to be an independent predictor for long-term survival (Table 5).

Table 5
Univariable and multivariable analysis on factors for late mortality in hospital survivors

Characteristics	Univariable analysis			Multivariate analysis
	HR	95% CI	<i>P</i> value	<i>P</i> value
Age(≥ 65y)	2.051	1.001–4.203	0.050	0.061
Female gender	1.727	0.910–3.275	0.095	0.103
Hypertension	2.317	1.025–5.238	0.044	0.046 (HR:2.290, 95%CI: 1.013–5.178)
BMI ≥ 24	1.738	0.906–3.333	0.096	0.189
TAR	0.572	0.302–1.086	0.088	0.073
Previous Coronary artery disease	1.514	0.365–6.238	0.567	NI
Cerebrovascular disease	2.537	0.782–8.231	0.121	NI
sCr	1.001	0.998–1.003	0.559	NI
WBC	0.944	0.868–1.027	0.182	NI
PLT	0.998	0.993–1.003	0.458	NI
Triglyceride	0.806	0.527–1.232	0.319	NI
LVEF	0.987	0.905–1.077	0.768	NI
Pericardial effusion	2.523	0.777–8.189	0.123	NI
CPB time	1.000	0.995–1.004	0.923	NI
Aortic valve	1.009	0.520–1.955	0.980	NI
DHCA time	0.980	0.957–1.004	0.105	NI
Drainage volume 24 hours after surgery	1.000	0.999–1.001	0.901	NI
Ventilation time	1.000	0.992–1.007	0.971	NI
ICU Stay time	1.003	0.986–1.019	0.761	NI
Hospital stay time	1.000	0.973–1.028	0.994	NI
Abbreviations: HR, hazard ratio; CI, confidence interval; BMI, body mass index; TAR, total arch replacement; SCr, serum creatinine;				
WBC, white blood cell; PLT, platelet; LVEF, left ventricular ejection fraction; CPB, cardiopulmonary bypass;				
DHCA, hypothermic circulatory arrest; ICU, intensive care unit; NI, not included in the multivariate model.				

Discussion

It has been known that hypertension is one of the most important risk factors for aortic dissection [4]. However, the predictive value of hypertension in patients of TA-AAD underwent cardiac surgeries remained understudied. Therefore, we examined the association between preexisting hypertension and patients' short- and long-term mortality rates in our hospital. In this study, we demonstrated that complicating with hypertension did not increase patients' mortality rate within 30 days after surgery. However, the long-term survival rate of hypertensive patients was significantly lower than that of normotensive patients. In addition, hypertension was identified as an independent predictor for increased long-term mortality rate.

Compared to previous studies that trying to decipher the influence of blood pressure on patients with TA-AAD [8, 9], one of the strengths of this study was that we applied PSM methods on the cohort before further analysis. As a result, confounders that might bias the results were excluded between two groups. The patient cohort analyzed in our study comprised of consecutively enrolled patients who underwent surgical repair of TA-AAD. In our cohort, 492 patients (69.1%) were complicated with hypertension, a percentage that is consistent with previous studies [5, 10–13]. Our clinical profile depictions suggested that hypertensive patients were older and heavier than normotensive patients, similar to previous reports [8, 9, 14]. Unsurprisingly, hypertensive patients were associated with significantly elevated preoperative sCr, which was also consistent with other reports [9, 15]. Most studies started their survival analysis on hospital day 1 thereby included in-hospital deaths. It is important to notice that we only count deaths that happened after hospital discharge in this study which might give us an underestimated mortality rate when comparing to other studies.

Another important finding in our study was that hypertensive patients received less aortic valve management. However, normotensive patients tend to be younger in our study and we could not rule out the influence of age on disease manifestations and procedure selections. As a matter of fact, reports from IRAD investigators suggested that younger patients more often underwent root surgeries [16].

In the present study, we found that hypertension was not associated with increasing peri-operative mortality rate. Several reports analyzing the influence of preoperative factors on the survival of patients with TA-AAD found a similar result that hypertension was not an independent predictor of higher operative mortality [8, 17–19]. One reason might be that the patients' BP was closely monitored and proper antihypertensive medications were prescribed during hospitalization period. Another reason might be that the area of greatest aortic shear stress was surgically repaired and the risk of developing a new separation of the aortic vessel layers was minimized.

Our findings suggested that after aortic repair surgeries, hypertension was associated with patient's long-term survival. Similar to other studies, main reasons for late death in our cohort were cardiac failure and aortic rupture [19]. Strict BP control after discharge is pivotal in the management of patients experienced aortic dissection. Unfortunately, it is difficult to achieve in some patients. From a nationwide database of 276,197 subjects (aged 40–75 years), there were 123,063 hypertensive patients, and only 77,379 (63%) received proper anti-hypertensive drugs. Another research found that only 598 out of 848 (70.5%) hypertensive patients received regular medication in China [9]. Poor medication adherence and BP control contribute to the developing of TA-AAD in vulnerable population. A previous report demonstrated that an increase in BP of 26 mm Hg was equivalent to an increase of the aortic diameter of 1 centimeter [20]. A 25 years follow-up study of 252 patients who underwent repair of TA-AAD suggested that the reoperation probability was markedly decreased with improved systolic BP control [11]. Tsai and associates examined 303 consecutive patients with TA-AAD concluded that patients who

died within 3 years of surgery had increased systolic BP compared with those who survived (130 vs 122, $P < 0.01$) [13].

Contrary to our conclusions, Merkle and colleagues [8] demonstrated that hypertensive patients were not associated with worse long-term survival compared to normotensive patients. However, compared to their study, we involved more cases and more sophisticated statistical analysis like PSM and Cox regression analysis to eliminate potential bias in baseline characteristics, which might render us a better strength. And it is important to point out that ethnics might also play an important role. In addition, the observation in a cohort consisted of 232 consecutive patients treated surgically for TA-AAD followed up to 4 years supported our findings [19]. Numerous studies, including us, proved that in order to prevent late adverse events, frequent follow-up and appropriate medication are essential for patients who have undergone aortic repair for TA-AAD.

In the present study, our data showed a clear trend, though did not reach statistical significance, that age predicted a worse prognosis in long term while TAR procedure was associated with a better long-term mortality, suggested by Cox regression analysis ($P = 0.061$, $P = 0.073$; Respectively). Previous studies demonstrated that age was an independent predictor of late mortality for TA-AAD patients [19, 21]. Improvement of long-term prognosis after surgical repair of TA-AAD mainly depends on the reduction of complications related to the distal false lumen. It has been known that TAR procedure could diminished the tear and accelerated thrombosis rates of the residual false lumen and led to excellent late results [22]. Heo et al. [23] reported that an entry resection was important to prevent aortic events during the late phase. Thus, in order to reduce severe aortic events in the long term, it is advisable to replace the aortic arch during the surgery.

Study Limitations

Our research presented with several limitations. Firstly, our study was a retrospective study conducted in a single center, with a cohort that might not necessarily representable for the general population. In addition, our study had a median follow-up period of 29 months. A longer follow-up period might provide additional insights into the impact of hypertension on disease's long-term outcome. Another points that worth mentioning are that the survival analysis excluded patients lost to follow-up and PSM method was not applied to the long-term follow-up analysis. Moreover, during the follow-up, the exact cause of death in some patients could not be verified, which also might affect our analysis.

Conclusions

Hypertensive patients who underwent surgeries for TA-AAD presented with similar perioperative outcomes but increased long-term mortality rate compared to normotensive patients. Hypertension was identified as an independent risk factor for late mortality. Our study provided insights in re-evaluating the importance of hypertension in TA-AAD patients. Future studies included more patients with prolonged follow-up period are needed to verify our findings.

Abbreviations

TA-AAD: Type A acute aortic dissection; ICU: Intensive care unit; HR: Hazard ratio; CI: Confidence interval; TAR: Total arch replacement; CTA: Computed tomography angiography; CPB: Cardiopulmonary bypass; BP: Blood

pressure; SD: Standard deviation; PSM: Propensity score matching; SCr: Serum creatinine; ACC: Aortic cross-clamp; DHCA: Deep hypothermic circulatory arrest; BMI: Body mass index; LVEF: Left ventricular ejection fraction; WBC: White blood cell; PLT: Platelet; CABG: Coronary artery bypass graft; MVR: Mitral valve replacement; MVP: Mitral valvuloplasty; TVP: Tricuspid valvuloplasty; NI: Not included in the multivariate model

Declarations

Acknowledgements

Not applicable.

Authors' contributions

DJW, MG, ZGW designed the study; ZGW, TC, CC collected the data; ZGW, LCL analyzed the data; ZGW, QYZ analyzed and interpreted the results; DJW support and encourage the study; ZGW wrote this article; All the authors have read and reviewed this manuscript.

Funding

The authors received no internal or external funding from their institution or department.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Ethics approval and consent to participate

The study protocol was approved by the ethics committee at Nanjing Drum Tower Hospital, and all experimental methods were performed in accordance with the relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors have declared they have no interest.

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Figures

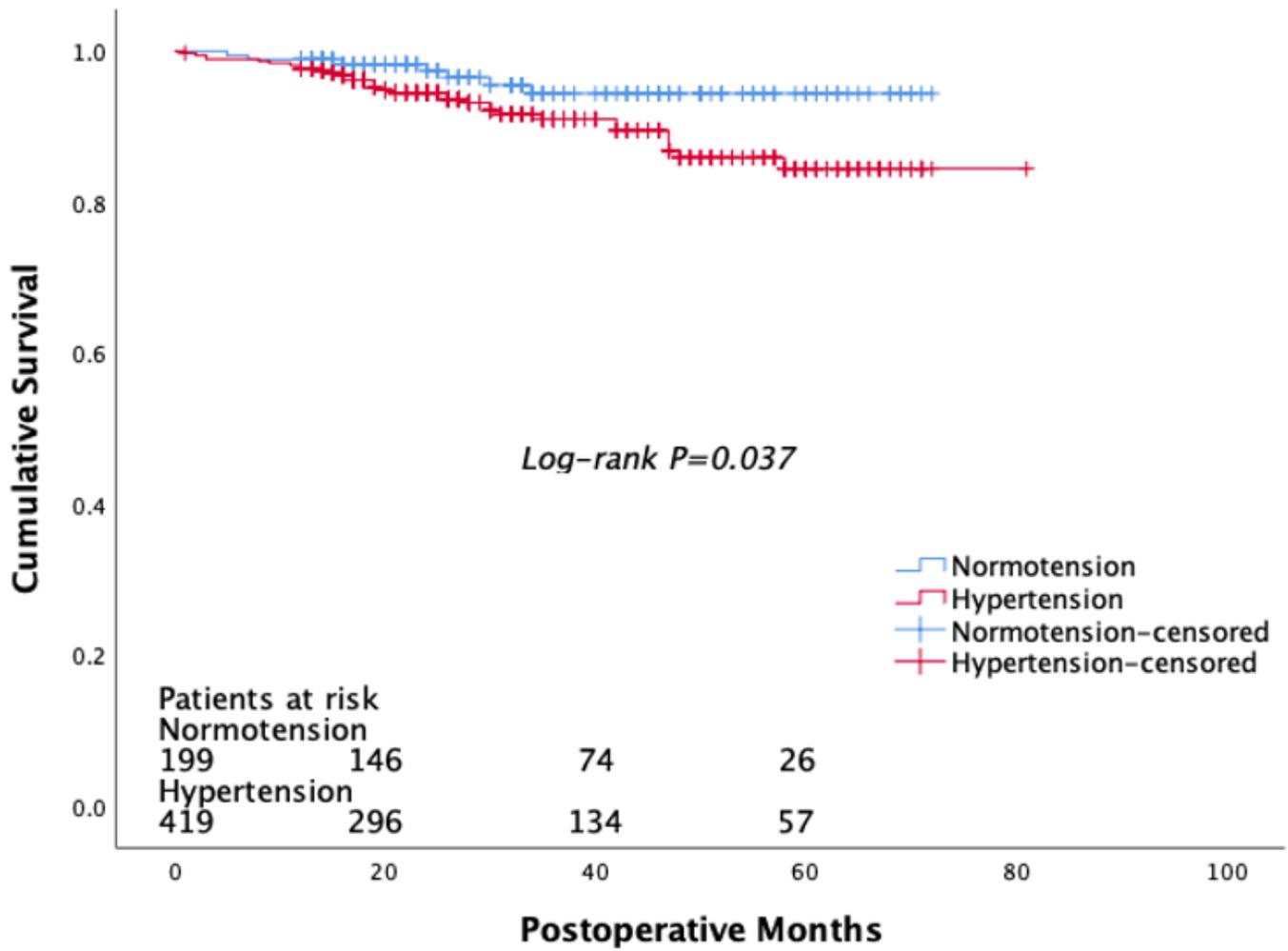


Figure 1

Kaplan-Meier estimate for late survival of patients operated on for type A acute aortic dissection according to the presence of hypertension.