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Article

Mid-to-Long-Term Outcomes of Acute Type A Aortic Dissection Complicated by Preoperative Shock

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Abstract

Background: Acute type A aortic dissection (ATAAD) complicated by preoperative shock is associated with fatal outcomes. Preoperative shock is caused by coronary malperfusion, cardiac tamponade, and aortic rupture. However, there were few reports about mid-to-long-term outcomes in patients with ATAAD complicated by preoperative shock. **Methods**: Between October 2013 and November 2024, 181 patients with ATAAD underwent emergent aortic repair, including 44 (24.3%) with preoperative shock. Preoperative shock included cardiac tamponade, cardiopulmonary arrest, aortic rupture and coronary malperfusion. The mean age of patients was 60.4 ± 14.0 years. We analyzed postoperative outcomes in patients with ATAAD complicated by preoperative shock (shock group) compared to patients without shock (non-shock group). **Results**: Early mortality of the shock group was 43.2% (19/44), and 17.5% (24/137) in the non-shock group. There was a significant difference in early mortality between the two groups ($p < 0.01$). Logistic regression analysis demonstrated that older age and preoperative shock were significant predictors for early mortality ($p < 0.01$ and 0.02). The follow-up period was 34.0 ± 36.6 months. The cumulative survival rate in 10 years was 54.5% in the shock group, and 65.8% in the non-shock group. A significant difference was noted between the two groups ($p < 0.01$). On Cox proportional hazards regression analysis, preoperative shock was not an independent risk factor for cumulative survival. **Conclusions**: The mid-to-long-term survival rate of acute type A aortic dissection patients with preoperative shock was not inferior to that of patients without shock if they survived after the first aortic repair. Preoperative shock was a risk factor for early mortality in this patient cohort.

Keywords: acute type A aortic dissection; preoperative shock; long-term outcome

1. Introduction

Extensive research has recently been done on the association between shock and the risk of acute type A aortic dissection (ATAAD) [1]. It has been shown that the presence of preoperative shock increases mortality in ATAAD [2,3]. Much has been documented about early, short-term, and perioperative mortality for ATAAD [4–6]. Previous studies reported that advanced age, preoperative shock, including cardiopulmonary arrest (CPA) were significant predictors for the early mortality [7,8]. However, in short- and long-term outcomes, the effect of shock in the mid to long-term has been poorly documented particularly with follow-up past 5 years [9]. We sought to focus on early and mid-term outcomes in patients with ATAAD complicated by preoperative shock evaluating predictors for mid to long-term mortality.

2. Patients and Methods

From October 2013 to November 2024, 181 patients with ATAAD underwent emergent aortic repair at Albany Medical Center, including 44 (24.3%) with preoperative shock (Fig. 1). We analyzed postoperative outcomes in patients with ATAAD complicated by preoperative shock (shock group) compared to patients without shock (non-shock group). Shock was defined as systolic pressure less than 90 mmHg, including preoperative CPA. The primary endpoint was early mortality and the cumulative survival rate at 10 years between the shock group and the non-shock group. Early mortality was defined as death within 30 days of the initial aortic repair. Predictors for early and mid-to-long-term mortality were evaluated in patients with preoperative shock. In a sub-analysis, each component of preoperative shock including cardiac tamponade, aortic rupture, and coronary malperfusion was analyzed for early and mid-term mortality. A survivor was defined as a patient who survived for at least 30 days from the initial aortic repair for ATAAD, and the mid-term outcome was assessed. A secondary endpoint was the need for an aortic reintervention after the initial aortic repair. An aortic reintervention included thoracic endovascular aortic repair and open descending repair, and thoracoabdominal aortic repair. All patients were annually followed as outpatients at cardiothoracic surgery and cardiology offices.

2.1 Operative Procedure

The aortic repairs were conducted via a median sternotomy using full heparinization and cardiopulmonary by-

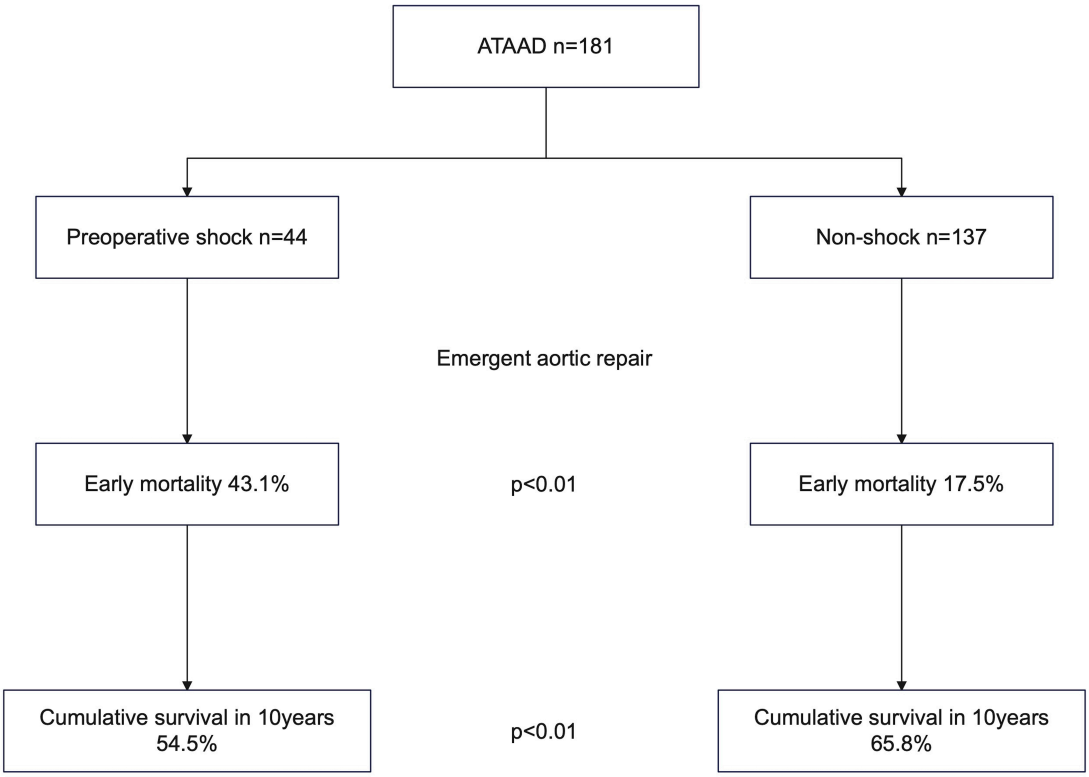

Fig. 1. 181 patients with ATAAD underwent emergent aortic repair. Of 181 patients, 44 presented with preoperative shock. There was a significant difference in the early mortality and mid to long-term survival between the shock and non-shock groups ($p < 0.01$). ATAAD, acute type A aortic dissection.

pass. Arterial cannulation was accessed via the femoral artery, right axillary artery, innominate artery or the ascending aorta. The arterial cannulation site was selected by each surgeon according to the clinical situation and the presence of malperfusion. Once the patient was cooled down for 45 minutes and reached out to a bladder temperature of 22 °C, cardiopulmonary bypass was discontinued, and circulatory arrest was initiated with or without antegrade cerebral perfusion. The intimal tear was resected, and a hemiarch/total arch replacement was performed. After reconstruction of the distal ascending aorta or distal arch, cardiopulmonary bypass was resumed with systemic warming until the body temperature reached 36 °C. 32 patients required aortic root replacement.

2.2 Statistical Analysis

Categorical variables were described as numbers and percentages, while continuous variables were presented as mean $\pm$ SD. For data that does not follow a normal distribution, the median and quartiles were used. Student's *t*-test was performed for continuous variables that have a normal distribution and the Mann-Whitney U test was used for those that did not have a normal distribution. Categorical variables were assessed by the Chi-squared test and Fisher's exact test. A $p < 0.05$ was considered statistically significant. Seven factors previously shown to be determinants of mortality (age, sex, preoperative shock, transfer time from diagnosis to operating room (OR), axillary/innominate artery cannulation, femoral artery cannulation, ascending aorta cannulation) of early mortality were evaluated. Logistic regression analysis was used to evaluate the risk factors for the early mortality. Model fitting was confirmed by area under the curve (AUC) (0.798) and receiver operating characteristic (ROC) curves. A second logistic regression analysis was performed with components of preoperative shock (cardiac tamponade, CPA, aortic rupture, and coronary malperfusion). The Kaplan-Meier method was used to evaluate the cumulative survival rate and requirement of aortic reintervention after initial aortic repair. Statistical differences were analyzed using the log-rank test. Cox proportional hazard analysis was conducted to evaluate the predictors for mid-term mortality. Four factors (age, sex, preoperative shock, and transfer time from diagnosis to OR) were selected for the Cox hazard proportional analysis. A second Cox hazard proportional analysis was done using the components of preoperative shock. The proportional hazard assumption was verified by stratified log minus log plots, and independent of time in covariables. Data analyses were performed by SPSS version 29.0.0.0 (IBM Corp., Armonk, NY, USA) and GraphPad Prism version 10.6.1 (GraphPad Software, Boston, MA, USA).

Table 1. Preoperative characteristics.

Characteristic	Shock n = 44	Non-shock n = 137	*p*
Age, y	66.6 ± 13.0	58.2 ± 14.0	<0.01
Male, n (%)	30 (68.2)	94 (68.6)	0.96
Hypertension, n (%)	27 (61.4)	103 (75.2)	0.08
Diabetes, n (%)	3 (6.8)	4 (2.9)	0.36
Dialysis, n (%)	1 (2.3)	1 (0.7)	0.43
Smoking history, n (%)	21 (47.7)	80 (58.4)	0.22
Stroke, n (%)	5 (11.4)	9 (6.6)	0.33
Previous open heart surgery, n (%)	0 (0)	6 (4.4)	0.34
Intimal tear at ascending aorta or aortic root, n (%)	44 (100)	133 (97.1)	0.57
Intimal tear at aortic arch	0 (0)	3 (2.2)	0.43
Retrograde type A dissection, n (%)	0 (0)	1 (0.7)	0.76
Cardiac tamponade, n (%)	40 (90.9)	0 (0)	<0.01
Cardiopulmonary arrest, n (%)	6 (13.6)	0 (0)	<0.01
Aortic rupture, n (%)	3 (6.8)	1 (0.7)	0.04
Coronary malperfusion, n (%)	3 (6.8)	3 (2.2)	0.16
Preoperative disturbed consciousness, n (%)	23 (52.3)	17 (12.4)	<0.01
Transfer time from diagnosis to OR, min	128.5 (98.3–166.8)	137.0 (87.8–223.8)	0.21

OR, operation room.

Table 2. Procedural characteristics.

Characteristic	Shock n = 44	Non-shock n = 137	*p*
Hemiarch replacement, n (%)	40 (90.9)	106 (77.4)	0.04
Total arch replacement, n (%)	0 (0)	3 (2.2)	0.43
Aortic root replacement, n (%)	4 (9.1)	27 (19.7)	0.11
Total arch replacement + aortic root replacement, n (%)	0 (0)	1 (0.7)	0.76
Coronary artery bypass grafting, n (%)	4 (9.1)	13 (9.5)	0.60
Cardiopulmonary bypass time, minutes	216.2 ± 88.8	221.4 ± 87.9	0.74
Aortic cross clamp time, minutes	132.0 ± 53.7	134.7 ± 64.1	0.82
Circulatory arrest time, minutes	37.1 ± 17.2	34.3 ± 22.0	0.48

3. Results

Patient characteristics are listed in Table 1, and intraoperative data in Table 2. The mean age of all subjects was 60.4 ± 14.0 years old. When compared with the non-shock group, the mean age was higher in the shock group (66.6 ± 13.0 years old vs 58.2 ± 14.0 years old, $p < 0.01$). In 44 patients in the shock group, the prevalence of cardiac tamponade, CPA, aortic rupture, and coronary malperfusion was 90.9% (40/44), 13.6% (6/44), 6.8% (3/44), and 6.8% (3/44), respectively. The incidence of preoperative altered consciousness was significantly higher in the shock group (52.3% vs 12.5%, $p < 0.01$). Transfer time from diagnosis to OR did not differ between the two groups. Intraoperative procedures, cardiopulmonary bypass time, aortic cross clamp time, and circulatory arrest time were similar between the two groups except for the rate of hemiarch replacement (Table 2). A hemiarch procedure was performed more frequently in the shock group (90.9% vs 77.4%, p = 0.04) (Table 2).

3.1 Early Surgical Outcomes

Postoperative outcomes are shown in Table 3. Postoperative complications and length of hospital stay did not differ statistically between the shock and non-shock groups although postoperative stroke, new dialysis, and tracheostomy requirements tended to be higher in the shock group (Table 3). The early mortality rate was 43.2% (19/44) in the shock group, and 17.5% (24/137) in the non-shock group. There was a significant difference in the early mortality between the two groups ($p < 0.01$). In 6 patients with preoperative CPA, 5 expired within 10 days of undergoing the aortic repair and there was only one survivor. Among the shock group, 19 patients died within 30 days of undergoing the aortic repair from multiple organ failure in 11 patients, heart failure in 4 patients, stroke in 2 patients, mesenteric ischemia in 1 patient, and exsanguination in 1 patient. Among the non-shock group, 24 patients died within 30 days of undergoing the aortic repair. The cause of death included multiple organ failure in 7 patients, heart failure in 5 patients, stroke in 4 patients, sepsis in 3 patients, limb ischemia in 2 patients, exsanguination in 2 patients and rup-

Table 3. Postoperative outcomes.

Characteristic	Shock n = 44	Non-shock n = 137	p
Stroke, n (%)	5 (11.4)	13 (9.5)	0.77
New dialysis requirement, n (%)	7 (15.9)	13 (9.5)	0.24
Tracheostomy, n (%)	3 (6.8)	3 (2.2)	0.16
Length of hospital stay, days	8.5 (1.5–16.8)	10.0 (7.0–17.5)	0.99
Early mortality, n (%)	19 (43.2)	24 (17.5)	<0.01
Follow-up term, months	23.6 ± 35.6	36.1 ± 36.6	0.04
Cumulative survival in 10 years, %	54.5	65.8	<0.01
Aortic reintervention in 5 years, %	25.0	10.7	0.85

Table 4. Multivariable analysis for early and mid to long-term mortality in patients with ATAAD.

Logistic regression analysis			
Risk factors	Adjusted Odds Ratio	95% Confidence Interval	p
Age	1.05	1.01–1.09	<0.01
Male	0.39	0.15–0.99	0.05
Preoperative shock	2.86	1.15–7.10	0.02
Transfer time from diagnosis to OR	1.00	0.998–1.001	0.69
Axillary/Innominate artery cannulation	0.33	0.05–2.23	0.25
Femoral artery cannulation	0.42	0.06–3.08	0.39
Ascending aorta cannulation	0.19	0.02–2.25	0.19
Cox hazard proportional analysis			
Risk factors	Adjusted Hazard Ratio	95% Confidence Interval	p
Age	1.03	1.004–1.06	0.02
Male	0.60	0.31–1.16	0.13
Preoperative shock	1.89	0.99–3.58	0.05
Transfer time from diagnosis to OR	0.90	0.99–1.001	0.90

ture of the pulmonary artery in 1 patient. In the logistic regression analysis, older age and preoperative shock were significant risk factors for the early mortality ($p < 0.01$, and $p = 0.02$) whereas male sex was associated with decreased early death ($p = 0.047$) (Table 4). Transfer time from diagnosis to OR and each cannulation site did not predict the early mortality (Table 4). Multivariable analysis with components of preoperative shock revealed that older age and preoperative CPA were predictors for early mortality ($p < 0.01$, $p = 0.02$) (Table 5).

3.2 Mid to Long-Term Outcomes

The mean follow-up period was 34.0 ± 36.6 months and 21 patients were lost. During this period, 3 patients in the shock group died due to heart failure in 2 patients, and the cause was unknown in 1 patient. Among the non-shock group, 10 patients expired during the follow-up period. The cause of death included heart failure in 3 patients, sudden cardiac death in 1 patient, sepsis in 1 patient, endocarditis in 1 patient, intracranial hemorrhage in 2 patients, and unknown in 2 patients. The cumulative survival rate including early mortalities in 10 years in the shock and non-shock groups was 54.5% and 65.8%, respectively (Table 3). A significant difference was noted between the two groups ($p < 0.01$) (Fig. 2). The Cox hazard proportional analysis demonstrated that only older age was associated with mid-term mortality ($p < 0.01$) while preoperative shock and transfer time from diagnosis to OR were not predictors (Table 4). In the sub-analysis with each component of preoperative shock, older age and preoperative CPA were significant predictors for the mid-term outcome ($p < 0.01$) (Table 5). During the follow-up period, 14 patients required thoracic endovascular aortic repair, 1 patient with aortic valve replacement, 1 patient with redo aortic root replacement, and 1 patient with open thoracoabdominal aortic repair. The rate of aortic reintervention at 5 years was 25.0% in the shock group and 10.7% in the non-shock group (Table 3). There was no significant difference in the requirement for aortic reintervention between the two groups ($p = 0.85$) (Fig. 3).

3.3 Survivors From Initial Aortic Repair for ATAAD

The survivor's preoperative and postoperative data are summarized in Table 6. The cumulative survival rate in the shock group was 96.0% while that of the non-shock group was 79.8%. The cumulative survival rates were comparable between the two groups ($p = 0.52$) (Fig. 4). Older age and preoperative shock were not related to the mid-term outcome in the survivor group (Table 7).

Table 5. Multivariable analysis for early and mid to long-term mortality with components of preoperative shock.

Logistic regression analysis			
Risk factors	Adjusted Odds Ratio	95% Confidence Interval	*p*
Age	1.05	1.02–1.09	<0.01
Male	0.46	0.20–1.04	0.06
Cardiac tamponade	2.22	0.92–5.37	0.08
Cardiopulmonary arrest	26.51	1.77–398.08	0.02
Aortic rupture	0.21	0.01–3.51	0.28
Coronary malperfusion	1.76	0.19–16.77	0.62
Cox hazard proportional analysis			
Risk factors	Adjusted Hazard Ratio	95% Confidence Interval	*p*
Age	1.03	1.01–1.05	<0.01
Male	0.63	0.35–1.14	0.11
Cardiac tamponade	1.60	0.85–3.01	0.15
Cardiopulmonary arrest	5.28	1.70–16.37	<0.01
Aortic rupture	0.49	0.07–3.65	0.49
Coronary malperfusion	1.13	0.28–4.50	0.87

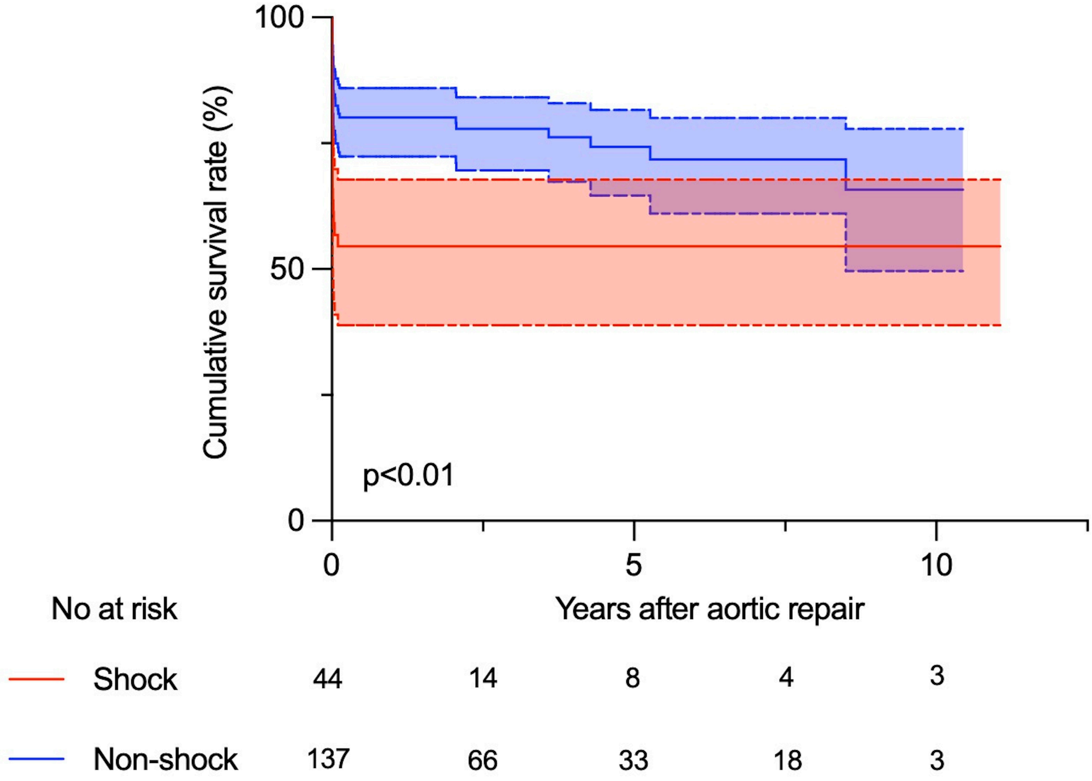

Fig. 2. Cumulative survival rates of patients with preoperative shock and non-shock. The cumulative survival rate at 10 years in the shock and non-shock group was 54.5% and 65.8%. There was a significant difference in the mid to long-term survival between the two groups ($p < 0.01$).

4. Discussion

Our study evaluated postoperative outcomes in patients with ATAAD comparing shock with non-shock patients. The results demonstrated that there was a higher incidence of adverse postoperative events in patients complicated by preoperative shock for ATAAD versus patients without preoperative shock. The cumulative survival rate at 10 years was 54.5% in the shock and 65.8% in the non-shock group. The mid to long-term outcomes might be acceptable given the disease severity in patients with ATAAD. While many reports and registries documented the correlation between preoperative shock and mortality for ATAAD, some lack documented follow-up periods after discharge [10,11], while others reported mortality only for inpatient

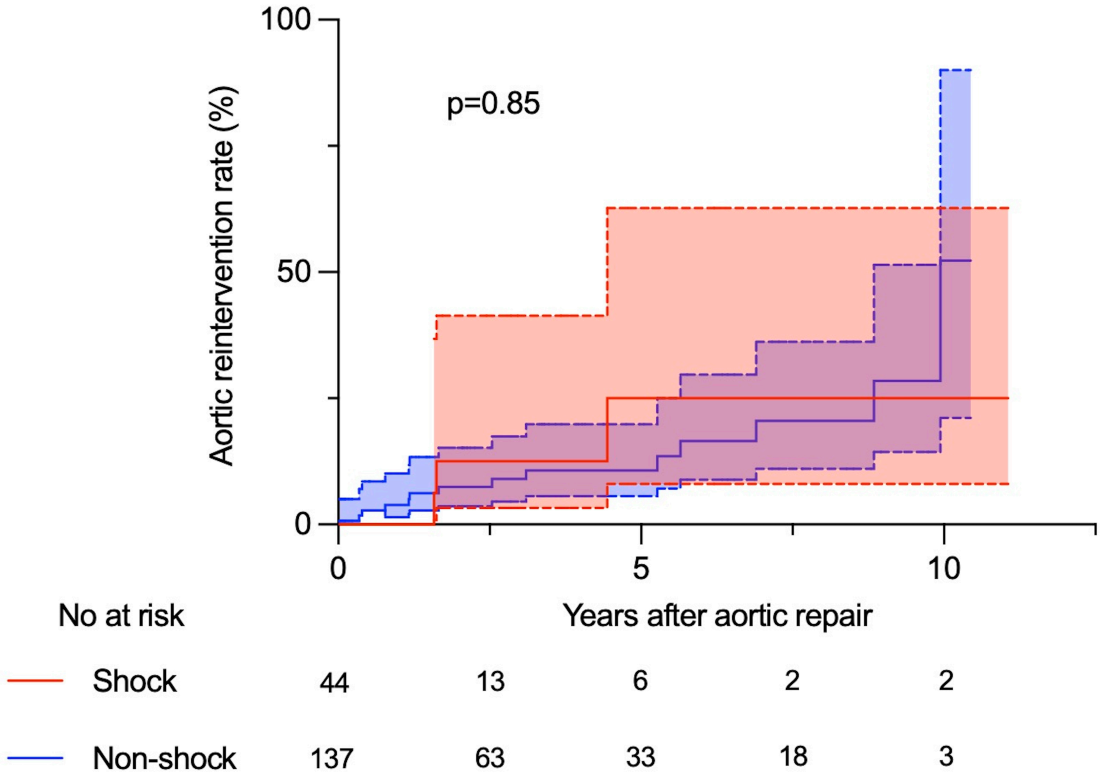

Fig. 3. Requirement of aortic reintervention after initial aortic repair. The rate of aortic reintervention in 5 years was 25.0% in the shock group and 10.7% in the non-shock group. There was no significant difference in the requirement of aortic reintervention between the two groups (p = 0.85).

Table 6. Survivor's characteristics.

Characteristic	Shock n = 25	Non-shock n = 113	p
Age, y	63.3 ± 15.0	56.5 ± 13.6	0.03
Male, n (%)	19 (76.0)	83 (73.5)	0.79
Cardiac tamponade, n (%)	24 (96.0)	0 (0)	<0.01
Cardiopulmonary arrest, n (%)	1 (4.0)	0 (0)	0.18
Aortic rupture, n (%)	2 (8.0)	1 (0.9)	0.08
Coronary malperfusion, n (%)	1 (4.0)	2 (1.8)	0.45
Postoperative stroke, n (%)	7 (28.0)	11 (9.7)	0.01
Postoperative new dialysis requirement, n (%)	4 (16.0)	9 (8.0)	0.25
Follow-up term, months	41.5 ± 38.2	43.8 ± 35.9	0.77
Cumulative survival in 10 years, %	96.0	79.8	0.52

Table 7. Multivariable analysis for mid-term mortality in survivors after the first aortic repair.

Risk factors	Adjusted hazard ratio	95% confidence interval	p
Age	1.01	0.96–1.06	0.63
Male	1.80	0.31–10.44	0.51
Preoperative shock	1.60	0.38–6.67	0.52
Time from diagnosis to OR	1.00	0.998–1.004	0.43

hospital stays rather than recording mid-to-long-term mortality after discharge [12]. Long *et al*. [2] reported preoperative shock to be associated with operative mortality during hospitalization or within 30 days with follow-up for survivors averaging 46 months [5], but did not report data for long-term mortality or preoperative CPA. Our study provided a ten-year follow-up and examined preoperative CPA. Bossone *et al*. [3] reported on survivors with cardiogenic shock on admission with follow-up to 5 years and reported that patients discharged alive after shock had similar mor-

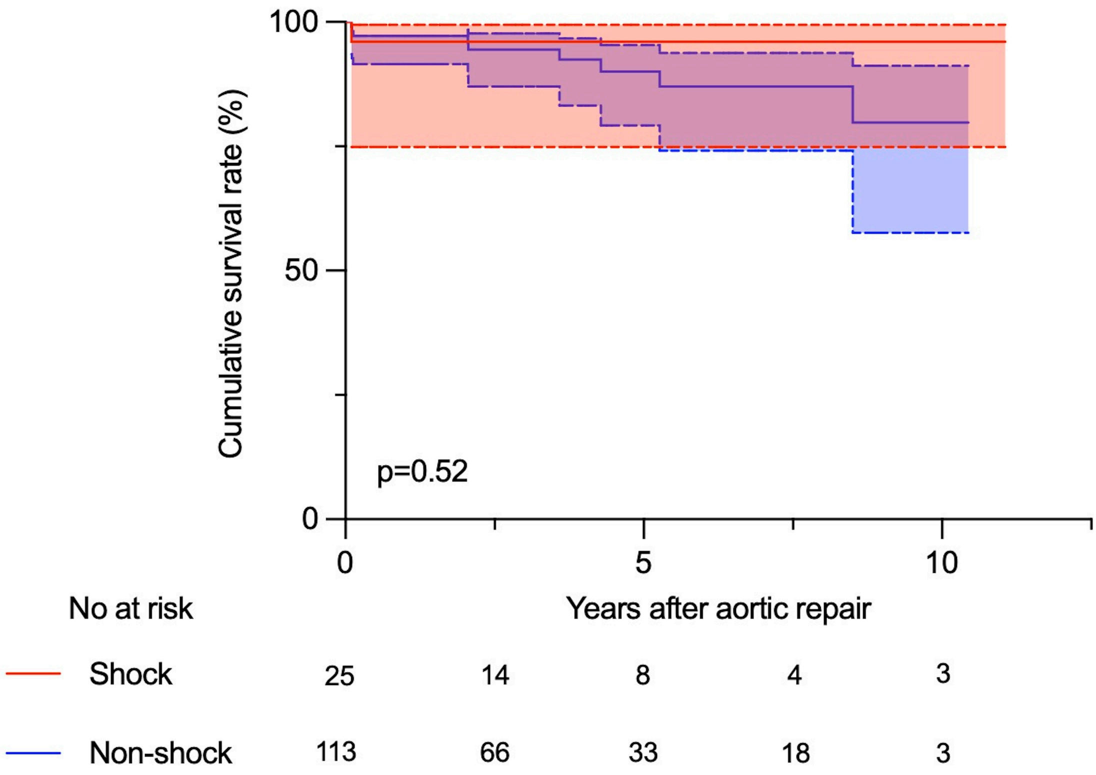

Fig. 4. Cumulative survival rates of patients who survived for 30 days from the initial aortic repair. The cumulative survival rate in 10 years in the shock and non-shock group was 96.0% and 79.8%. There was no significant difference in the mid to long-term survival between the two groups (p = 0.52).

tality rates as those without cardiogenic shock on admission [6], and did not report the incidence of CPA. Our study differs, however, from Bossone's study in that our study followed up on patients for up to 10 years including preoperative CPA, as well as showing that cardiopulmonary arrest predicted mid-term outcomes.

Previous studies on aortic dissections, which followed outcomes out to 15 years, found unfavorable aortic dissection outcomes associated specifically with preoperative need for cardiopulmonary resuscitation and failed to find significance with cardiogenic shock [13]. To the best of our knowledge, limited data exist for mid to long-term outcomes for preoperative shock in ATAAD. In our study, preoperative shock was an independent risk factor for early mortality although it did not predict the mid-to-long-term mortality. In the sub-analysis, preoperative CPA was a significant predictor for both short and mid-to-long-term mortality. However, in our Cox hazard proportional analysis, the early mortality events with preoperative CPA were included. Only one patient with preoperative CPA could survive for the mid-to-long-term outcomes while most patients after emergent aortic repair died within the admission. The result was consistent with the previous report [14].

To improve outcomes in patients with preoperative shock, prompt transfer from onset to the OR and preoperative management for cardiac tamponade, and CPA would be critical factors in addition to intraprocedural management in the OR [14,15]. Most patients in our study were transferred from outside hospitals after the diagnosis was confirmed. As a result, there was a lot of missing data regarding time from onset to diagnosis. We could evaluate only transfer time from diagnosis to OR, which was not a predictor for postoperative outcome. At some outside hospitals, computed tomography to confirm ATAAD was delayed due to the facility's capacity or staff shortages which required transfer to another hospital to obtain computed tomography. If we could assess transfer time from onset to diagnosis, the results have had different outcomes. In addition to the prompt transfer to OR, there was a point the management of preoperative cardiac tamponade was also important [16]. Controlled pericardial drainage was one of the options for patients with ATAAD complicated by cardiac tamponade and the procedure could be performed safely to stabilize those patients [16]. Most shock patients (89%) who were discharged alive from the hospital could survive for 5 years and the cumulative survival rate was similar to that of patients without shock (82%) [3]. Some patients underwent pericardial drainage before they were transferred to the OR at our facility. Most drainage procedures were successful in stabilizing the patients with cardiac tamponade. However, the drainage procedure was an isolated pericardiocentesis and not controlled pericardial drainage as reported. These results favor controlled pericardial drainage for patients with cardiac tamponade preoperatively when necessary.

Our study is unique in that the mid-to-long-term outcomes among the survivors after the first aortic repair were evaluated comparing the shock to non-shock group and there were no preoperative predictors for the mid-to-long-term survival including preoperative shock (Tables 6,7). One of possible reasons was the incidence of aortic reintervention during the follow-up period. Table 3 shows that the incidence of aortic intervention at 5 years was similar between the two groups (25.0% vs 10.7%, p = 0.85). Given the high mortality in patients with ATAAD complicated by preoperative shock, further studies should be performed to elucidate the difference between the survivors and non-survivors.

There were several limitations in our study. First, it was a retrospective single-center study. A multicenter study is needed in the future since the surgical management might differ at each facility. Second, some patients died or were lost during the follow-up periods. As a result, the number of remaining patients decreased and the analyses at 10-year follow-up were underpowered. Third, the mean age in the shock group was significantly higher than that of the non-shock group. Fourth, there was missing data on time from onset to diagnosis. Time from onset to diagnosis might be a critical factor in patients with shock.

5. Conclusions

The mid-to-long-term survival rate of acute type A aortic dissection patients with preoperative shock was not inferior to that of patients without shock if they survived after the first aortic repair. Preoperative shock was a risk factor for early mortality. Older age and cardiopulmonary arrest were significant predictors for mid-to-long-term mortality. Preoperative shock was not related to aortic reintervention after the initial aortic repair.

Availability of Data and Materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

CN and SS designed the study design. AK, YHW, JL, ST, and NA collected the data. CN and ED analyzed statistically. CN, ED and ST drafted the manuscript. All authors contributed to critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was carried out in accordance with the Declaration of Helsinki and approved by Albany Medical Center Institutional Review Board (Protocol No. 7051, November 15, 2024). This study would not adversely affect the rights and welfare of subjects. The procedure for ATAAD was clinically indicated; therefore would be done regardless of the research. The informed consent was waived by Institutional Review Boards at Albany Medical Center.

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Conflict of Interest

The authors declare no conflict of interest.

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