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Risk Factors for Postoperative Prolonged Ventilation Time in Acute Type A Aortic Dissection Patients Received Modified Aortic Root Procedure

Yanjing Chen, BN, Ning Li, MD, Yang Li, MD, Zhigang Song, MD, Zhao An, MD

Department of Cardiovascular Surgery, Changhai Hospital, Shanghai, China

ABSTRACT

Background: Postoperative prolonged ventilation time (PPVT) is associated with increased mortality in acute type A aortic dissection (ATAAD). The aim of this study is to investigate risk factors for PPVT in ATAAD patients.

Methods: We retrospectively collected ATAAD patient data for those who received modified aortic root procedure and extensive arch repair between June 2017 and June 2018 at our institution. Patients were included in PPVT (N = 30) and No-PPVT (N = 72) groups, according to whether postoperative ventilation time > 72 hours. Univariate and multivariate logistic regression analysis were adopted to determine the independent risk factors for PPVT.

Results: More female in the PPVT Group (56.67% versus 23.61%, $P < .05$). Max diameter (MD) of ascending aorta was wider in the PPVT Group (4.71 ± 1.02 versus 4.30 ± 0.61, $P < .05$). Postoperative data showed a higher in-hospital mortality in the PPVT Group (26.67% versus 5.56%, $P < .05$). There were more patients in the PPVT Group who experienced postoperative acute renal failure (ARF) (36.67% versus 5.56%, $P < .05$). Multivariable logistic regression analysis showed female gender, MD of ascending aorta > 4.05 cm, and postoperative ARF were independent risk factors for PPVT with the OR of 3.55 (1.13 – 11.20, $P < .05$), 2.89 (1.02 – 8.22, $P < .05$), and 4.31 (1.03 – 18.02, $P < .05$), respectively.

Conclusions: In the present study, we determined female gender, MD of ascending aorta > 4.05 cm, and postoperative ARF within 72 hours were independent risk factors for PPVT in ATAAD patients received modified root procedure and extensive arch repair.

INTRODUCTION

Surgical treatment of acute type A aortic dissection (ATAAD) is effective, however, its in-hospital mortality is still very high. Previous studies have shown that postoperative prolonged ventilation time (PPVT) was associated with higher mortality in ATAAD patients who received extensive arch procedure [Jin 2017].

We adopted modified aortic root repair procedure in ATAAD surgical repair and got satisfactory clinical results [Tang 2017]. According to the previous studies, we realized PPVT might be associated with in-hospital mortality in ATAAD patients who received this modified procedure. In

Table 1. Preoperative patient details

	No-PPVT (N = 72)	PPVT (N = 30)	*P*
Gender (female)	17 (23.61%)	19 (63.33%)	<.05
Age	50.94 ± 10.84	58.33 ± 10.92	.05
BMI	26.58 ± 3.15	26.15 ± 3.99	.56
Marfan (N)	0 (0.00%)	1 (3.33%)	.29
BAV (N)	1 (1.39%)	0 (0%)	1.00
Pre-PLR	222.95 ± 131.59	195.69 ± 129.21	.22
Pre-NLR	13.65 ± 9.07	14.11 ± 10.50	.97
Pre-RDW	13.10 ± 1.56	13.18 ± 1.22	.89
Smoker (N)	17 (23.61%)	11 (36.67%)	.18
Hypertension (N)	54 (75.00%)	21 (70.00%)	.60
Diabetes (N)	3 (4.17%)	1 (3.33%)	1.00
LVEF (%)	60.86 ± 6.64	61.33 ± 6.87	.51
Pericardial tamponade (N)	22 (30.56%)	17 (56.67%)	<.05
Aortic regurgitation			
Mild (N)	22 (30.56%)	7 (23.33%)	.46
Moderate (N)	5 (6.94%)	2 (6.67%)	1.00
Severe (N)	5 (6.94%)	3 (10.00%)	.91
MD of ascending aorta (cm)	4.30 ± 0.61	4.71 ± 1.02	<.05
Coronary rupture (N)	10 (13.89%)	3 (10.00%)	.83

PPVT, postoperative prolonged ventilation time; BMI, body mass index; BAV, bicuspid aortic valve; Pre-PLR, preoperative platelet-to-lymphocytes ratio; Pre-NLR, preoperative neutrophil-to-lymphocyte ratio; Pre-RDW, preoperative red blood cell distribution width; LVEF, left ventricular ejection fraction; MD, maximal diameter. Data presented as mean ± standard deviation or N (%).

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Zhao An, MD, Department of Cardiovascular Surgery, Changhai Hospital, Changhai road No.168, Shanghai 200433, China; Tel +86 021 3116 1765 (email: anzhao1@yeah.net).

Table 2. Intraoperative details

	No-PPVT (N = 72)	PPVT (N = 30)	*P*
CPB time (min)	135.51 ± 27.62	144.23 ± 34.95	.11
SCP time (min)	22.81 ± 6.03	22.70 ± 6.45	.48
Cross-clamp time (min)	80.74 ± 21.78	80.87 ± 23.29	.37
Concomitant CABG (N)	8 (11.11%)	4 (13.33%)	1.00
RBC (ml)	530.56 ± 526.65	633.33 ± 596.73	.43
PLT (unit)	9.86 ± 2.05	11.33 ± 3.46	<.05

PPVT, postoperative prolonged ventilation time; CPB, cardiopulmonary bypass; SCP, selective cerebral perfusion; CABG, coronary artery bypass grafting; RBC, Red blood cell; PLT, Platelet. Data presented as mean ± standard deviation or n (%).

Table 3. Postoperative in-hospital details

	No-PPVT (N = 72)	PPVT (N = 30)	P
PLR	267.45 ± 209.19	193.84 ± 157.60	.07
NLR	24.90 ± 13.59	20.98 ± 14.98	.08
RDW	13.62 ± 2.00	13.68 ± 1.13	.38
24 hours chest drainage (mL)	447.85 ± 300.64	510.10 ± 347.90	.46
Reoperation (N)	1 (1.39%)	3 (10.00%)	.14
Complication within 72 hours			
ARF (N)	4 (5.56%)	11 (36.67%)	<.05
Stroke (N)	1 (1.39%)	1 (3.33%)	.50
Paraparesis (N)	2 (2.78%)	1 (3.33%)	1.00
Hospital time (days)	18.64 ± 7.95	23.90 ± 19.13	.26
ICU time (days)	6.93 ± 5.50	15.17 ± 16.97	<.05
In-hospital death (N)	4 (5.56%)	8 (26.67%)	<.05

PPVT, postoperative prolonged ventilation time; PLR, platelet-to-lymphocytes ratio; NLR, neutrophil-to-lymphocyte ratio; RDW, red blood cell distribution width; ARF, acute renal failure; ICU, intensive care unit. Data presented as mean ± standard deviation or n (%).

addition, risk factors for PPVT in these patients were also still unknown.

In the present study, we compared in-hospital mortality between patients with and without PPVT and analyzed risk factors for PPVT in ATAAD patients who received modified aortic root procedure.

METHODS

Patients data collection: We retrospectively collected ATAAD patient in-hospital data from June 2017 to June 2018 at our institution. All patients received emergency surgical repair with modified aortic root procedure and extensive arch repair using a stented elephant trunk. In this study, informed consent was obtained from patients or their relatives, and our study was approved by the Institutional Review Board of Changhai hospital.

Surgical procedures: Surgical procedures were under general anesthesia, median sternotomy, and deep hypothermic circulatory arrest. Cardiopulmonary bypass (CPB) was established with femoral artery and right axillary artery cannulation. We adopted antegrade selected cerebral perfusion (SCP) to provide cerebral protection during operation. After cross-clamp, intermittent antegrade cold blood cardioplegia was adopted for myocardial protection. During cooling, aortic root procedure was performed, which included aortic valve resuspension, reinforce non-coronary sinus of Valsalva wall and sinotubular junction with two modified Teflon strips. When rectal temperature reached 25°, CPB was arrested and total arch replacement with a stented elephant trunk (MicroPort Medical Co Ltd, Shanghai, China) was done. Details of the modified aortic root repair procedure was described in our previous study [Tang 2017].

Statistical analysis: Student t test and Mann-Whitney U test was adopted for statistical comparison in continuous variables when distribution was normal and not normal, respectively. Chi-square test was adopted for two groups statistical comparison in categorical variables. We used receiver operating characteristic (ROC) curve analysis to determine the optimal cut-off value of continuous variables, which had statistical differences between the PPVT and No-PPVT group, area under the curve (AUC) was adopted to evaluate the efficacy of the cut-off value. In this study, we used univariate logistic regression analysis to detect the risk factors for PPVT and factors with $P < 0.05$ in the univariate logistic regression analysis were involved in the multivariate logistic regression analysis to determine the independent risk factors for PPVT. We adopted Odds ratio (OR) and 95% confidence index (CI) to evaluate risk factors` effect on PPVT. All statistical analyses were completed in SPSS (Chicago, Ill), data were presented as mean ± standard deviation or N (%), and $P < 0.05$ was considered statistically significant.

RESULTS

Patient information: In this study, PPVT was defined as postoperative mechanical ventilation time more than 72 hours. A total of 102 patients were included in this study. Among these patients, 72 were included in the No-PPVT Group, and 30 were included in the PPVT Group. There were more females in the PPVT Group (56.67% versus 23.61%, $P < .05$). Patients in the PPVT Group were older compared with the No-PPVT Group (58.33 ± 10.92 versus 50.94 ± 10.84, $P < .05$). Preoperative pericardial tamponade incidence was higher in the PPVT Group compared with the No-PPVT Group (56.67% versus 30.56%, $P < .05$). Max diameter (MD) of ascending aorta was wider in the PPVT Group (4.71 ± 1.02 versus 4.30 ± 0.61, $P < .05$). Patient details are shown in Table 1.

Table 4. ROC curve analysis

	AUC	*P*	Cut-off value
Age (years)	0.69	<.05	59.00
MD of ascending aorta (cm)	0.67	<.05	4.05
PLT	0.57	.26	-

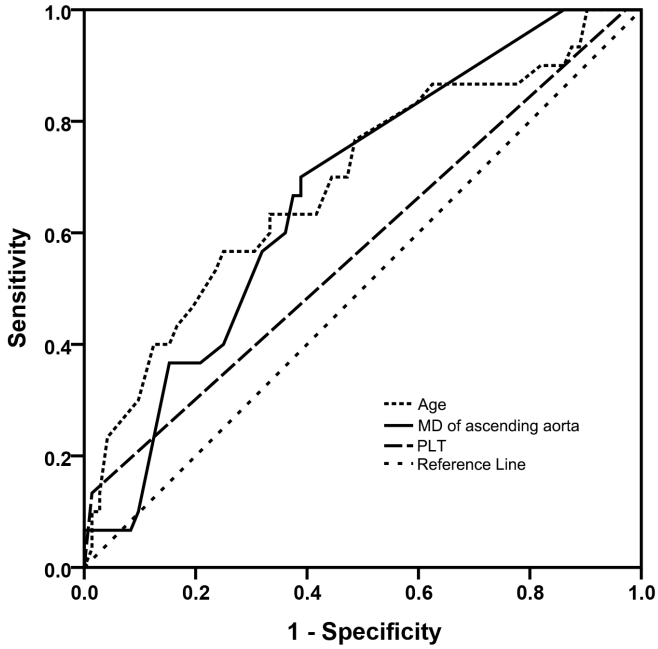
ROC, receiver operating characteristic; AUC, area under the curve; MD, maximal diameter; PLT, platelet.

Intraoperative results: Operation was successful with all patients and no intraoperative death occurred. Patients in the PPVT Group received more intraoperative PLT transfusion (11.33 ± 3.46 versus 9.86 ± 2.05, $P < .05$). No differences were detected in CPB, SCP and cross-clamp time between the PPVT and No-PPVT groups. No differences were found in concomitant coronary artery bypass grafting (CABG) procedure and intraoperative red blood cell (RBC) transfusion between these two groups. Intraoperative details are shown in Table 2.

Postoperative in-hospital results: Postoperative data showed a higher in-hospital mortality in the PPVT Group compared with the No-PPVT Group (26.67% versus 5.56%, $P < .05$). Compared with the No-PPVT Group, ICU time in the PPVT Group was longer (15.17 ± 16.97 versus 6.93 ± 5.50, $P < .05$). There were more patients in the PPVT Group experienced postoperative acute renal failure (ARF) compared with No-PPVT Group (36.67% versus 5.56%, $P < .05$). ARF was defined as dialysis requirements. Details of the postoperative in-hospital results are shown in Table 3.

ROC curve analysis results: We adopted ROC curve analysis to find the optimal cut-off value in the present study. Results showed the optimal cut-off value of age was 59.00 years with the AUC of 0.69 ($P < .05$). The optimal cut-off value of ascending aorta max diameter was 4.05 cm with the AUC of 0.67 ($P < .05$). Details of the ROC curve analysis are shown in Table 4 and Figure 1.

Univariate and multivariable logistic regression analysis results: We brought gender (female), age > 59, pericardial tamponade, MD of ascending aorta > 4.05 and ARF into the univariate logistic regression analysis. Results showed all these 5 factors were risk factors for PPVT. Further analysis with these 5 factors in multivariable logistic regression analysis showed female gender, MD of ascending aorta > 4.05 and ARF were independent risk factors for PPVT with the OR of 3.55 (1.13 – 11.20, $P < .05$), 2.89 (1.02 – 8.22, $P < .05$), and 4.31 (1.03 – 18.02, $P < .05$), respectively. Details of univariate and multivariable logistic regression analysis results are shown in Table 5.



ROC analysis based on age, MD of ascending aorta and PLT. ROC, receiver operating characteristic; MD, maximal diameter; PLT, platelet.

DISCUSSION

ATAAD is a deadly aortic emergency, and PPVT always occurred in patients who experienced surgical treatment. In the present study, we determined in-hospital risk factors for PPVT in ATAAD patients, who received modified aortic root procedure and extensive arch repair.

In this study, we found female gender was an independent risk factor for PPVT. Wang et al found female gender was associated with longer ventilation time after liver transplantation surgery; their study also showed female gender prolonged hospital stay [Wang 2016]. Totonchi et al reported female experienced open heart surgery was more likely to get PPVT [Totonchi 2014]. Blankstein et al reported female gender was an independent risk factor for worse outcomes [Blankenstein 2005]. These findings were in accordance with ours and showed female gender with ATAAD tended to get PPVT.

We identified preoperative MD of ascending aorta > 4.05 cm was another independent risk factor for PPVT. We reviewed studies in this field and did not find research on the relationship between aortic diameter and PPVT. In this study, the aortic diameter of patients in the PPVT Group significantly was wider compared with the No-PPVT Group. Logistic regression analysis confirmed MD of ascending aorta > 4.05 cm promoted PPVT in ATAAD patients who received modified aortic root procedure and extensive arch repair.

Postoperative ARF was found as another independent risk factor for PPVT in the present study. Studies have shown preoperative renal dysfunction was associated with PPVT. Schechter et al reported preoperative high creatinine was an independent predictor for PPVT in patients received deep hypothermic circulatory arrest surgery [Schechter 2016]. It was reported preoperative chronic renal disease was also a risk factor for PPVT in patients experienced open heart surgery [Totonchi 2014]. In the present study, we detected ARF occurred within 72 hours after operation indicated PPVT in ATAAD patients.

Table 5. Logistic regression analysis for PPVT risk factors in ATAAD patients

	Univariate			Multivariate		
Variables	OR	95% CI	*P*	OR	95% CI	*P*
Gender (Female)	5.59	2.23 – 14.03	<.05	3.55	1.13 – 11.20	<.05
Age > 59	3.92	1.60 – 9.63	<.05	2.38	0.79 – 7.15	.12
Pericardial tamponade	2.97	1.23 – 7.16	<.05	2.00	0.68 – 5.90	.21
MD of ascending aorta > 4.05 cm	3.67	1.47 – 9.14	<.05	3.36	1.12 – 10.07	<.05
ARF	11.33	3.26 – 39.37	<.05	5.19	1.23 – 21.81	<.05

PPVT, postoperative prolonged ventilation time; ATAAD, acute type A aortic dissection; MD, maximal diameter; ARF, acute renal failure; OR, odds ratio; CI, confidence interval.

It was reported PPVT was a relatively common complication in ATAAD repair surgery and was associated with postoperative oxygenation impairment, which significantly increased the in-hospital death [Shen 2018]. Chen et al reported PPVT induced postoperative neurodysfunction, and they detected cognitive decline and increased inflammation factors in mice PPVT model [Chen 2015]. We also found a postoperative stroke rate in our study, however, the differences between the PPVT and No-PPVT groups had no statistical means.

Sharma et al reported low left ventricular ejection fraction (LVEF) was associated with PPVT in patients received cardiac surgery [Sharma 2017]. Hsu et al also reported LVEF was a predictor for postoperative prolonged mechanical ventilation time in patients received robot-assisted coronary artery bypass graft surgery [Hsu 2019]. In the present study, we found there was no statistical differences in preoperative LVEF between the PPVT and No-PPVT groups in ATAAD patients who received surgical repair.

Previous study showed CPB time > 180 minutes was a risk factor for PPVT in patients who received CABG surgery [Madhavan 2018]. Suematsu et al reported prolonged CPB time promoted delayed extubation in patients who received coronary artery bypass grafting surgery [Suematsu 2000]. However, in our study, we did not find significant differences between the PPVT and No-PPVT groups in patients who experienced ATAAD repair surgery. Jin et al reported low preoperative platelet count was an independent risk factor for PPVT in patients who received ATAAD repair surgery [Jin 2017], but our results did not find statistical differences in preoperative platelet count between the PPVT and No-PPVT groups.

Previous study showed PPVT patients after cardiac surgery had a significantly higher postoperative mortality. Fernandez-Zamora et al reported PPVT was a postoperative mortality predictor in patients experienced cardiac surgery. They found patients with PPVT had a postoperative 44.3% ICU mortality, while the ICU mortality was only 3.1% in patients without PPVT [Fernandez-Zamora 2018]. A study by Cislaghi et al included 5,123 patients who experienced cardiac surgery and results showed in-hospital mortality in PPVT patients was significantly higher compared with no-PPVT patients [Cislaghi 2009]. In our study, we found in-hospital mortality was significantly higher in the PPVT Group compared with No-PPVT Group.

Our study has several limitations. First, this is a retrospective study and a further prospective study is needed to verify these findings. Second, this study was based on a single center data and a study based on multiple centers is needed to further clarify risk factors for PPVT.

CONCLUSION

In the present study, we compared patient characters between PPVT and No-PPVT groups and found female gender, MD of ascending aorta > 4.05 cm, and postoperative ARF within 72 hours were independent risk factors for PPVT in ATAAD patients who received modified root procedure and extensive arch repair.

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