Body Mass Index is an Independent Predictor of Acute Kidney Injury After Urgent Aortic Arch Surgery for Acute DeBakey Type I Aortic Dissection

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Abstract

Background: Aortic arch surgery and obesity are both related to risk of acute kidney injury. Our hypothesis was the risk of postoperative acute kidney injury increases when the body mass index increases in patients underwent urgent aortic total arch replacement surgery for acute Debakey Type I aortic dissection.

Methods: We conducted a retrospective cohort study in Beijing Anzhen hospital from December 2015 to April 2017. All patients receiving urgent aortic total arch replacement surgery with a frozen elephant trunk implant for acute Debakey Type I aortic dissection were included. Body mass index was calculated based on height and weight. Acute kidney injury was diagnosed depended on the Kidney Disease Improving Global Outcomes standards.

Results: We included 115 consecutive patients in this timeframe. There were 53.0% (n=61) patients had acute kidney injury. Mean age was 47.8 ± 10.7 years; 25.2% were women. Mean body mass index was 26.2 ± 3.9 kg/m². In-hospital mortality was obvious increased in the acute kidney injury group (13.1% vs 1.9%; P=0.025). Multivariate logistic regression showed that body mass index was associated with postoperative acute kidney injury after adjust other confounding factors (odds ratio=1.18; 95% confidence interval: 1.04-1.34; P =0.012).

Conclusions: Body mass index was an independent predictor of acute kidney injury after urgent aortic total arch replacement surgery with a frozen elephant trunk implant.

Background

Acute kidney injury (AKI) was not an uncommon complication following cardiovascular surgery. The incidence was roughly 30%, and markedly increases their mortality and morbidity [1–4]. Occurrence of AKI following cardiac surgery is influenced by many factors, involving perioperative red blood cell transfusions, preoperative anemia, increased age, and intraoperative cardiopulmonary bypass (CPB) time [5–7]. However, AKI after aortic surgery has not been extensively studied. This kind of operation will increase the incidence of AKI, due to the complexity of this operation, including CPB time longer and circulatory arrest.

Currently, obesity is a worldwide public health issue. It is correlated with a broad range of cardiovascular disorders [8], including hypertension, insulin resistance, and diabetes mellitus [9]. Obese patients in general are prone to AKI owing to the higher burden of accompanying diseases and potential structural changes that appear in their kidneys, even the serum biochemistry was normal [10, 11]. There were limited studies to examine the effect of obesity on AKI in patients underwent urgent aortic total arch replacement (TAR) surgery with a frozen elephant trunk implant (FET) for acute Debakey Type I aortic dissection (ADTIAD).

Therefore, our objective was to investigate the effect of body mass index (BMI) on AKI in patients underwent urgent TAR + FET after adjust for all known confounding factors. Our hypothesis was that the risk of AKI would increase as BMI increased.

Methods

Participants

The retrospective cohort study was conducted at Beijing Anzhen hospital in China from December 2015 to April 2017. This study was allowed by the human research and development committees of this hospital and was adhered to the rules of the Declaration of Helsinki and principles of Good Clinical Practice. Individual consent was waived for the retrospective study. All patients with ADTIAD who underwent urgent TAR + FET surgery in this timeframe were included. All surgical treatments were operated by the same surgical team.

A total of 137 patients with ADTIAD undergoing urgent TAR + FET with CPB were admitted. A total of 18 patients were excluded because they underwent renal replacement therapy (RRT) before the operation. Three patients were excluded for they died intraoperatively or within 24 hours after surgery. One patient who lack of serum creatinine (sCr) was also excluded. Consequently, 115 consecutive patients were involved in the ultimate analysis. A flow chart of the screening and registration of study patients was shown in Fig. 1.

Data collection

Trained staff collected detailed data of patients from electronic medical records of this hospital. Baseline characteristics involved age, gender, height, weight, BMI (calculated based on height and weight), drinking history, smoking history; Comorbidities: diabetes mellitus, hypertension, previous cerebrovascular disease, left ventricular ejection fraction (LVEF), coronary artery disease, hematocrit, preoperative blood urea nitrogen (BUN); sCr, preoperative hemoglobin, hemopericardium, eGFR (estimated glomerular filtration rate, calculated based on Epidemiology Collaboration equation), renal artery dissection, Penn class (Class Aa and Non class Aa), kidney malperfusion, acute myocardial infarction (AMI), preoperative shock; Intraoperative data: intraoperative packed red blood cells (PRBCs), intraoperative amount of plasma, intraoperative blood loss, CPB time, aortic occlusion clamp time, time of circulatory arrest, rectal temperature and nasopharyngeal temperature at circulatory arrest, the type of surgery (Bentall + TAR + FET or ascending aorta replacement + TAR + FET), combined with coronary artery bypass grafting (CABG) and combined with ascending aorta to femoral artery bypass surgery (aortic bypass surgery); Postoperative data: reoperation for bleeding, postoperative dialysis, intensive care unit (ICU) stays, hospital stays, in-hospital death. Primary indications for renal replacement therapy were uraemia, anuresis, volume overload and obviously biochemical abnormalities.

Outcome variables

The main endpoint event was the occurrence of AKI following urgent TAR + FET operation. Recently, KDIGO proposed a new range of guidelines for the characterization of AKI based on two previous classifications, RIFLE and AKIN [12, 13]. In this study, AKI was diagnosed based on KDIGO criteria: the postoperative sCr levels increased greater than 50% within 7 days or 0.3 mg/dL within two days by baseline after operation. Preoperative sCr values which recorded the last measurement before operation were regarded as baseline sCr.

Assessment of covariates

Our covariates were selected based on our prior work and studies and from others examining risk factors for postoperative AKI. Hypertension, DM, preoperative hemoglobin, hematocrit, preoperative baseline sCr, preoperative BUN, CPB time, intraoperative blood loss, and intraoperative amount of PRBCs were recorded in all participants. Preoperative hemoglobin, hematocrit, preoperative baseline creatinine, and preoperative BUN were recorded as the results of the laboratory test after hospital admission before surgery.

Surgical technique

All patients received TAR with FET. This method has been reported at great length by our research team [14]. Briefly, we used right axillary artery and atrium dextrum to perform CPB following heparinization [maintaining the activated clotting time exceed 480s]. The flow rates of CPB were 2.5 L/(min·m²). We kept the mean arterial pressure between 50 and 70 mmHg. Whether to perform an aortic valve replacement depended on the condition of the aortic valve. If the classification of aortic regurgitation was moderate or severe, we preferred to perform Bentall procedure (aortic valve replacement combined with ascending aorta replacement). If there was only mild regurgitation, we preferred to perform ascending aorta replacement only. A frozen elephant stent (MicroPort Medical Company Limited, Shanghai, China) and a four branched artificial vessel (Maquet Cardiovascular, Wayne, NJ) were employed in this implantation. We usually performed the surgery with moderate hypothermic circulatory arrest and antegrade cerebral perfusion.

Data analysis

Mean or median were used to express continuous variables according to data dispersion. Categorical variables were present with percentages (%). If continuous variables were normally distributed, t-tests were used to compare and if the data was skewed, non-parametric Mann–Whitney U tests were applied. The predictors of AKI were recognized by univariate regression analysis. Multiple regression models were used to evaluate the effect of BMI on postoperative AKI. Both non-adjusted and adjusted models (gender; age; previous cerebrovascular disease; smoking history; renal artery dissection; eGFR; AMI) were applied. Whether the concomitant variable was adjusted according to the following principle: if the matched odds ratio was changed at least 10% [15] by the variable when added to this model, then an adjustment was made. A generalized additive model (GAM) was also applied to discover linear relationships. BMI was analyzed as a continuous variant in multivariable logistic models. Further analysis was performed using 24 kg/m² as cut-off values based on the Chinese population BMI classification criteria [16]. Interaction

and stratified analysis were performed based on age (< 60 and ≥ 60 years), gender, hypertension, smoking history, drinking history, coronary artery disease, previous cerebrovascular disease, CPB time (< 204 or ≥ 204 min), aortic cross clamp time (< 115 or ≥ 115 min), circulation arrest time (< 27 or ≥ 27 min), operation time (< 8 or ≥ 8 h), Intraoperative blood loss (< 1500 or ≥ 1500 mL), Intraoperative amount of PRBCs (< 2 or ≥ 2 U), Intraoperative amount of plasma (< 400 or ≥ 400 mL) and hemoglobin (< 135 or ≥ 135 g/L). All of the analysis was conducted by the statistical software packages R and EmpowerStats.

Results

Baseline characteristics

After the exclusion criteria were applied, 115 consecutive patients were admitted in this cohort, with a median age of 47.8 ± 10.7 years; 29 (25.2%) were female. There were 61 patients (53%) with AKI. The average BMI was 26.2 ± 3.9 kg/m². The average preoperative BUN was 7.2 ± 2.5 mmol/L and preoperative sCr was 86.2 ± 29.1 umol/L. Comorbidities included hypertension (80%), diabetes mellitus (6.1%), previous cerebrovascular disease (5.2%), and coronary artery disease (5.2%). In total, 20% of patients required RRT. The baseline characteristics of the 115 study patients between AKI and non-AKI were given in Table 1.

Table 1
Characteristics of the study patients between AKI and No-AKI

Variable	No-AKI (n = 54)	AKI (n = 61)	P value
Age	46.8 ± 11.0	48.7 ± 10.4	0.342
Gender			0.486
male	42 (77.8%)	44 (72.1%)	
female	12 (22.2%)	17 (27.9%)	
BMI (kg/m²)	25.0 ± 3.8	27.2 ± 3.7	0.002
Diabetes mellitus	1 (1.9%)	6 (9.8%)	0.074
Hypertension	42 (77.8%)	50 (82.0%)	0.575
Previous cerebrovascular disease	4 (7.4%)	2 (3.3%)	0.320
Coronary artery disease	3 (5.6%)	3 (4.9%)	0.878
Smoking history	22 (40.7%)	34 (55.7%)	0.108
Drinking history	11 (20.4%)	12 (19.7%)	0.926
Renal artery dissection	10 (18.5%)	7 (11.5%)	0.288
Hemopericardium	9 (16.7%)	10 (16.4%)	0.969
Penn class			0.665
Class Aa	34 (63.0%)	36 (59.0%)	
Non class Aa	20 (37.0%)	25 (41.0%)	
Kindey malperfusion	3 (5.6%)	4 (6.6%)	0.823
AMI	2 (3.7%)	7 (11.5%)	0.121
Preoperative shock	9 (16.7%)	10 (16.4%)	0.969
Preoperative sCr (umol/L)	82.0 ± 30.0	90.0 ± 27.9	0.141
BUN (mmol/L)	7.1 ± 2.7	7.3 ± 2.4	0.724
Hemoglobin (g/L)	137.2 ± 18.6	135.9 ± 16.3	0.689
Bold value indicates significance at p < 0.05. Results are expressed as n (%) or mean ± SD or median [IQR].			
AKI Acute Kidney Injury, AMI Acute Myocardial Infarction, BMI Body Mass Index, BUN Blood Urea Nitrogen, CPB Cardiopulmonary Bypass, CABG Coronary Artery Bypass Grafting, eGFR estimated Glomerular Filtration Rate, FET Frozen Elephant Trunk, ICU Intensive Care Unit, PRBCs Packed Red Blood Cells, sCr serum Creatinine, SD Standard Deviation, TAR Total Arch Replacement, IQR Interquartile Range			

Variable	No-AKI (n = 54)	AKI (n = 61)	<i>P</i> value
Hematocrit (%)	39.7 ± 5.0	39.1 ± 4.2	0.443
eGFR mL/(min·1.73 ^m)	94.2 ± 21.2	83.5 ± 22.8	0.011
CPB time (min)	199.1 ± 45.6	222.0 ± 62.0	0.027
Aortic cross clamp time (min)	120.2 ± 49.0	127.0 ± 36.1	0.400
Circulatory arrest time (min)	27.4 ± 9.6	27.5 ± 7.6	0.914
Operation time (h)	23.1 ± 1.6	22.7 ± 1.5	0.142
Nasopharyngeal temperature at circulatory arrest (°C)	25.5 ± 2.3	25.1 ± 2.0	0.358
Rectal temperature at circulatory arrest (°C)	7.9 ± 1.6	8.8 ± 2.0	0.007
Intraoperative amount of PRBCs (mL)	300.0 (0.0-600.0)	600.0 (0.0-600.0)	0.043
Intraoperative blood loss (mL)	1300.0 (1000.0-1575.0)	1500.0 (1200.0-2000.0)	0.024
Intraoperative amount of plasma (mL)	400.0 (0.0-550.0)	400.0 (0.0-800.0)	0.102
Combined with CABG	3 (5.6%)	5 (8.2%)	0.578
Combined with aortic bypass surgery	0 (0.0%)	1 (1.6%)	0.345
Bentall + TAR + FET	22 (40.7%)	25 (41.0%)	0.979
Length of ICU	1.9 (1.0–3.0)	4.0 (2.0–9.0)	< 0.001
Length of in hospital	1 (1.9%)	8 (13.1%)	0.025
Reoperation for bleeding	1 (1.9%)	8 (13.1%)	0.025
In-hospital mortality	1 (1.9%)	8 (13.1%)	0.025
Bold value indicates significance at $p < 0.05$. Results are expressed as n (%) or mean ± SD or median [IQR].			
AKI Acute Kidney Injury, AMI Acute Myocardial Infarction, BMI Body Mass Index, BUN Blood Urea Nitrogen, CPB Cardiopulmonary Bypass, CABG Coronary Artery Bypass Grafting, eGFR estimated Glomerular Filtration Rate, FET Frozen Elephant Trunk, ICU Intensive Care Unit, PRBCs Packed Red Blood Cells, sCr serum Creatinine, SD Standard Deviation, TAR Total Arch Replacement, IQR Interquartile Range			

Univariate analysis of predictors for AKI

The consequences of a univariate analysis showed that BMI, eGFR, CPB time, operative time, intraoperative blood loss and intraoperative amount of PRBCs were significantly correlated with AKI. Smoking, hemoglobin levels, hypertension, hematocrit, preoperative sCr, BUN, aortic cross clamp time,

intraoperative amounts of plasma and circulatory arrest time were not significantly associated with AKI. The results were given in Table 2.

Table 2
Univariate analysis of risk factors associated with postoperative AKI in patients with ADTIAD

Variable	Statistics	OR (95%CI)	P-value
Age	47.81 + 10.70	1.02 (0.98, 1.05)	0.339
Gender			
male	86 (74.78%)	1.0	
female	29 (25.22%)	1.35 (0.58, 3.17)	0.487
BMI (kg/m²)	26.2 + 3.9	1.18 (1.06, 1.33)	0.003
Diabetes mellitus	7 (6.09%)	5.78 (0.67, 49.62)	0.110
Hypertension	92 (80.00%)	1.30 (0.52, 3.24)	0.576
Previous cerebrovascular disease	6 (5.22%)	0.42 (0.07, 2.41)	0.333
Coronary artery disease	6 (5.22%)	0.88 (0.17, 4.55)	0.878
Smoking history	56 (48.70%)	1.83 (0.87, 3.85)	0.110
Drinking history	23 (20.00%)	0.96 (0.38, 2.39)	0.926
Renal artery dissection	17 (14.78%)	0.57 (0.20, 1.62)	0.292
Hemopericardium	19 (16.52%)	0.98 (0.37, 2.63)	0.969
Penn class			
Class Aa	70 (60.87%)	1.0	
Non class Aa	45 (39.13%)	1.18 (0.56, 2.50)	0.665
Kidney malperfusion	7 (6.09%)	1.19 (0.25, 5.59)	0.823
AMI	9 (7.83%)	3.37 (0.67, 16.98)	0.141
Preoperative shock	19 (16.52%)	0.98 (0.37, 2.63)	0.969
Preoperative sCr (umol/L)	86.22 + 29.07	1.01 (1.00, 1.02)	0.147

Bold value indicates significance at $p < 0.05$. §=The result failed because of the small sample size.

Results are expressed as n (%) or mean $\pm$ SD or median [IQR].

AKI Acute Kidney Injury, AMI Acute Myocardial Infarction, BMI Body Mass Index, BUN Blood Urea Nitrogen, CPB Cardiopulmonary Bypass, CABG Coronary Artery Bypass Grafting, eGFR estimated Glomerular Filtration Rate, FET Frozen Elephant Trunk, ICU Intensive Care Unit, PRBCs Packed Red Blood Cells, sCr serum Creatinine, SD Standard Deviation, TAR Total Arch Replacement, IQR Interquartile Range

Variable	Statistics	OR (95%CI)	P-value
BUN (mmol/L)	7.21 + 2.51	1.03 (0.89, 1.19)	0.722
Hemoglobin (g/L)	136.53 + 17.32	1.00 (0.97, 1.02)	0.686
Hematocrit (%)	39.38 + 4.61	0.97 (0.89, 1.05)	0.440
eGFR mL/(min·1.73 m ²)	88.55 + 22.64	0.98 (0.96, 1.00)	0.013
CPB time (min)	211.25 + 55.90	1.01 (1.00, 1.02)	0.032
Aortic cross clamp time (min)	123.81 + 42.57	1.00 (0.99, 1.01)	0.401
Circulatory arrest time (min)	27.44 + 8.54	1.00 (0.96, 1.05)	0.913
Operation time (h)	8.36 + 1.89	1.33 (1.07, 1.65)	0.009
Nasopharyngeal temperature at circulatory arrest (°C)	22.86 + 1.55	0.83 (0.65, 1.06)	0.143
Rectal temperature at circulatory arrest (°C)	25.29 + 2.13	0.92 (0.77, 1.10)	0.356
Combined with CABG	8 (6.96%)	1.52 (0.35, 6.67)	0.581
Combined with aortic bypass surgery	1 (0.87%)	§	0.992
Bentall + TAR + FET	47 (40.87%)	1.01 (0.48, 2.13)	0.979
Intraoperative amount of PRBCs(mL)	393.91 + 413.17	1.00 (1.00, 1.00)	0.048
Intraoperative blood loss(mL)	1487.8 ± 710.5	1.00 (1.00, 1.00)	0.032
Intraoperative amount of plasma(mL)	400 (0-600)	1.00 (1.00, 1.00)	0.104
Reoperation for bleeding	9 (7.83%)	8.00 (0.97, 66.21)	0.054
Bold value indicates significance at p < 0.05. §=The result failed because of the small sample size.			
Results are expressed as n (%) or mean ± SD or median [IQR].			
AKI Acute Kidney Injury, AMI Acute Myocardial Infarction, BMI Body Mass Index, BUN Blood Urea Nitrogen, CPB Cardiopulmonary Bypass, CABG Coronary Artery Bypass Grafting, eGFR estimated Glomerular Filtration Rate, FET Frozen Elephant Trunk, ICU Intensive Care Unit, PRBCs Packed Red Blood Cells, sCr serum Creatinine, SD Standard Deviation, TAR Total Arch Replacement, IQR Interquartile Range			

The linear relationship between BMI and AKI after adjusting for covariates

Spline smoothing was implemented using GAM to identify the linear relationship between BMI and AKI after adjusting for age; gender; previous cerebrovascular disease; smoking history; renal artery dissection;

eGFR; AMI. The red line represents the fitting spline. The blue points represent the 95% confidence intervals. The result was shown in Fig. 2.

Multivariate analysis: independent predictor of AKI

Table 3 revealed the consequences of multivariate regression analysis. We constructed three models: (I) unadjusted; (II) adjusted for demographics: age; gender; (III) adjusted for age; gender; previous cerebrovascular disease; smoking history; renal artery dissection; eGFR; AMI. The model I showed a significant association between BMI and AKI [odds ratio (OR) = 1.18; 95% confidence interval (CI): 1.06 – 1.33; p = 0.003]. In model II (adjusted for age and gender), the results were significant (OR = 1.21, 95% CI: 1.08–1.36; p = 0.002). Furthermore, in model III (adjusted for age; gender; previous cerebrovascular disease; smoking history; renal artery dissection; eGFR; AMI), the results still were significant (OR = 1.18, 95% CI: 1.04–1.34; p = 0.012).

Table 3

Multivariable analysis to assess the independent impact of BMI on postoperative AKI in patients with ADTIAD using non-adjusted and adjusted logistic regression model.

Variable	Model I		Model II		Model III	
	OR (95%CI)	P-value	OR (95%CI)	P-value	OR (95%CI)	P-value
BMI (kg/m ²)	1.18 (1.06, 1.33)	0.003	1.21(1.08, 1.36)	0.002	1.18 (1.04, 1.34)	0.012
BMI groups (kg/m ²)						
< 24	1.0		1.0		1.0	
≥ 24	3.27 (1.43, 7.48)	0.005	4.02 (1.64, 9.89)	0.002	3.45 (1.29, 9.23)	0.014
ADTIAD Acute DeBakey Type I Aortic Dissection, AKI Acute Kidney Injury, AMI Acute Myocardial Infarction, BMI Body Mass Index, eGFR estimated Glomerular Filtration Rate, OR Odd Ratio,95% CI 95% Confidence Interval						
Model I: adjust for none.						
Model II: adjust for age; gender;						
Model III: adjust for age; gender; previous cerebrovascular disease; smoking history; renal artery dissection; eGFR; AMI						

Secondary analyses were performed using 24 kg/m² as cut-off values based on the Chinese BMI classification reference standard. In the non-adjusted model, BMI < 24 kg/m² was taken as a reference. The risk of postoperative AKI in the BMI ≥ 24 kg/m² groups increased by 2.27 times (OR = 3.27, 95% CI:

1.43–7.48; $p = 0.005$). After adjusting for other confounding factors, the results were still statistically significant; the risk of AKI increased by 2.45 (OR = 3.45, 95% CI: 1.29–9.23; $p = 0.014$).

Stratified analysis

Stratified analysis was performed in patients separated by age (age < 60 years and age $\geq$ 60 years), diabetes mellitus, hypertension, previous cerebrovascular disease, coronary artery disease, smoking history, drinking history, coronary artery disease, previous cerebrovascular disease, CPB time (< 204 or $\geq$ 204 min), aortic cross clamp time (< 115 or $\geq$ 115 min), circulation arrest time (< 27 or $\geq$ 27 min), operation time (< 8 or $\geq$ 8 h), Intraoperative blood loss (< 1500 or $\geq$ 1500 mL), Intraoperative amount of PRBCs (< 2 or $\geq$ 2 U), Intraoperative amount of plasma (< 400 or $\geq$ 400 mL) and hemoglobin (< 135 or $\geq$ 135 g/L). BMI was still an independent predictor of AKI in these high-risk subgroups. The results of stratified analysis are given in Fig. 3.

Discussion

In this cohort study of 115 patients underwent urgent TAR + FET for ADTIAD, we found BMI was positively correlated with postoperative AKI. A 1-kg/m² increase of BMI was correlated with a 18% higher risk of postoperative AKI. Taking BMI < 24 kg/m² as reference, the risk of AKI in BMI $\geq$ 24 kg/m² group increased by 2.45 times. This confirms the relationship between BMI and postoperative AKI and verifies our hypothesis.

The finding was same with results of Kumar et al. [17], who identified a obviously increase in incidence of postoperative AKI in patients with a BMI greater than 40 kg/m². Certainly, there were some obvious differences between their study and this study. First, lots of patients were obese (46% vs 13%) in their study cohort. Second, there were no patients in our study with BMI equal or exceed 40 kg/m². Third, they didn't examine the impact of baseline hemoglobin and hematocrit on AKI, which was a risk factor associated with AKI [18]. O'Sullivan et al. [19] analyzed 432 consecutive patients received cardiovascular surgery with CPB and they found a BMI of 30 kg/m² or greater was an independent predictor of AKI (OR = 2.12, 95% CI: 1.27–3.54; $p = 0.004$). This finding was consistent with the results of our study. Moreover, several other studies [20–24] have found that BMI was an independent predictor of development of AKI in patients received cardiovascular surgery, which further confirmed our findings.

There were some studies showed various results. Roh et al. [25] analyzed 98 patients underwent thoracic aorta replacement due to AD and found that BMI was not correlated with AKI (OR = 1.04, 95% CI: 0.93–1.16; $p = 0.54$). However, as the authors acknowledged, the smaller number of participants might have led to insufficient statistical validity. Vellinga et al. [26] analyzed 565 consecutive patients undergoing CABG with the employment of cardiopulmonary bypass and did not find that BMI was associated with postoperative AKI. This could be due to the fact that the study population was different.

The potential molecular mechanisms for the connection between BMI and AKI remain unclear. Billings et al. [27] explored the connection in 445 consecutive patients underwent cardiac surgery. The results

showed BMI was independently associated with AKI. Additionally, baseline F2-isoprostane, intraoperative F2-isoprostane, and intraoperative plasminogen activator inhibitor-1 concentrations were also independent predictors of AKI. But, after adjusting for these variables, BMI was no longer associated with AKI, indicating that the influence may be interrupted by oxidative stress.

This study has several strengths. First, the patients selected for this study comprised a homogeneous population of patients with ADTIAD, underwent urgent TAR + FET. Second, we adopted the KDIGO guidelines for AKI instead of the previous 2 classifications, as the KDIGO guidelines have been revised more recently and offer clarity and simplicity for clinical use. Third, although the study was an observational research and impressionable to possible confounder, we performed rigorous statistical methods to minimize remaining confounders. Finally, we handled target independent variable as both continuous variable and categorical variable. Such an approach can reduce the contingency in the data analysis and enhance the robustness of results.

It was very vital to explore the predictors related to AKI. Emphasis on obesity as a problem may be helpful for clinicians to deal with patients pre- and postoperatively. For elective surgical patients, weight-loss may be a useful method to reduce the risk of AKI preoperatively. However, it may not be effective for the emergent surgery on various occasions. Furthermore, we should pay more attention to patients with higher BMIs who are undergoing urgent TAR + FET in case the occurrence of postoperative AKI.

There were also some limitations in the present study: (1) in this study, our research subjects were patients who received aortic surgery for ADTIAD. Therefore, there was a certain deficiency in the universality and extrapolation of research. (2) because we exclude patients requiring RRT before surgery, therefore, the findings of this study cannot be used for these people. (3) it was a retrospective cohort study, which may have limited the observational study design.

Conclusion

BMI was an independent predictor of AKI in patients underwent urgent TAR + FET surgery for ADTIAD. It was crucial to explore the molecular mechanisms for perform preventative therapies.

Abbreviations

ADTIAD

acute DeBakey Type I aortic dissection; AKI:acute kidney injury; AKIN:Acute Kidney Injury Network; AMI:acute myocardial infarction; BMI:body mass index; BUN:blood urea nitrogen; CABG:coronary artery bypass grafting; CI:confidence interval; CPB:cardiopulmonary bypass; GAM:generalized additive model; ICU:intensive care unit; KDIGO:Kidney Disease Improving Global Outcomes; LVEF:left ventricular ejection fraction;OR:odds ratioPRBCs:packed red blood cellsRIFLE:Risk, Injury, Failure, Loss and End-stageRRT:renal replacement therapySCP:selective cerebral perfusion sCr:serum creatinine

Declarations

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Authors' Contributions

Taoshuai Liu, Yuwei Fu Shijun Xu, Ming Gong, Hongjia Zhang designed the study; Taoshuai Liu, Yuwei Fu Xinliang Guan, Jiachen Li, Zining Wu, Lei Li collected the data; Shijun Xu, Jie Liu analysed the data; Taoshuai Liu, Yuwei Fu, Shijun Xu analysed and interpreted the results; Shijun Xu wrote this article. All authors read and approved the final manuscript.

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Availability of data and materials

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

Ethics approval and consent to participate

The study protocol was approved by Ethics Committee of Beijing Anzhen Hospital (2014019).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

Flow diagram of the screening and enrollment of study patients.

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Figure 2

A linear relationship between BMI and postoperative AKI was observed after adjusting for age; gender; previous cerebrovascular disease; smoking history; renal artery dissection; eGFR; AMI In the figure, the red line indicates the estimated risk of acute kidney injury, and the blue points represent pointwise 95% confidence interval.

Figure 2

A linear relationship between BMI and postoperative AKI was observed after adjusting for age; gender; previous cerebrovascular disease; smoking history; renal artery dissection; eGFR; AMI In the figure, the red line indicates the estimated risk of acute kidney injury, and the blue points represent pointwise 95% confidence interval.

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Figure 3

Subgroup analysis of the association between BMI and AKI in patients with ADTIAD. Each stratification adjusted for all the factors: (age, diabetes mellitus, hypertension, previous cerebrovascular disease, coronary artery disease, smoking history, drinking history, coronary artery disease, previous cerebrovascular disease, CPB time, aortic cross clamp time, circulation arrest time, operation time,

Intraoperative blood loss, Intraoperative amount of PRBCs , Intraoperative amount of plasma and hemoglobin). except the stratification factor itself.

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