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Article

Elevated AST/ALT (De Ritis) Ratio is a Risk Factor of Drainage Volume after Aortic Arch Surgery

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Abstract

Background: To examine the correlation between the preoperative elevated aspartate aminotransferase (AST)/alanine transaminase (ALT) (De Ritis) ratio and the drainage volume in patients after aortic arch surgery. **Methods**: This retrospective cohort study was conducted from January 2017 to December 2018. The exposure factor was the preoperative AST/ALT ratio and the primary outcome was the total amount of the drainage volume. The optimal AST/ALT ratio cutoff value was determined by the maximum Youden index. Accordingly, we defined the ratio $\geq$0.92 as a high AST/ALT ratio and $<$0.92 as a low AST/ALT ratio. Based on the median drainage volume of all participants, we dichotomized the study population: patients with a total drainage volume of 1670 mL or more were classified into high-output group (HOPG) and the remaining patients were classified into the low-output group (LOPG). Univariable and multivariable logistic regression analyses were conducted to investigate the correlation between the elevated AST/ALT ratio and drainage volume. **Results**: 425 participants were enrolled. 213 participants were divided into the LOPG and the others were in the HOPG. 244 participants were divided into the low AST/ALT ratio group. In the univariable logistic regression analysis, the odds ratio (OR) and 95% condifence interval (CI) for the large drainage volume in participants with elevated AST/ALT ratio were 1.810 and 1.226–2.670 (p = 0.003). After adjustments with the confounders, multivariable logistic regression analysis showed an elevated AST/ALT ratio was significantly associated with the total amount of drainage volume (OR = 1.725, 95% CI 1.115–2.669, p = 0.014). **Conclusions**: Preoperative elevated AST/ALT ratio is an independent risk factor for the pericardial and mediastinal drainage volume in patients undergoing aortic arch surgery. It might represent a novel marker for individual risk assessment for cardiac surgery.

Keywords

AST/ALT ratio; De Ritis ratio; drainage; aortic arch surgery

Introduction

Pericardial and mediastinal drains are routinely inserted in patients after cardiovascular surgery postoperatively in order to avoid developing cardiac tamponade. Postoperative chest drainage is associated with operative deaths following pericardiectomy [1]. Prolonged drainage may increase the risk of infection and the use of analgesic agents [2]. The drainage volume determines the time to remove the drains. A higher drainage volume is associated with higher 30-day mortality and other postoperative complications [3]. A postoperative drainage volume higher than 100–150 mL/h, is a cause for concern [4]. It had been shown that the structure and material of the drains may reduce the amount and duration of drainage [5–7]. However, few studies have investigated the correlation between preoperative status and the total drainage volume. Identification of the potential risk factors for increased drainage volume is helpful to avoid postoperative complications.

In patients with acute type A aortic dissection, coagulation and fibrinolysis factors may be altered prior to surgery due to changes in liver function [8]. Hepatic dysfunction is a common concomitant symptom in patients with cardiovascular disease (CVD). Transaminases such as aspartate aminotransferase (AST) and alanine transaminase (ALT) can reflect hepatocellular damage and are routinely available in clinical practice. The AST/ALT ratio (De Ritis) is a predictor of chronic liver disease and can predict clinical outcomes in patients with CVD [9], digestive disease [10], and urinary tract disease [11,12]. A study has shown that the AST/ALT ratio may be used as an independent predictor of postoperative mortality in patients with cardiovascular surgery [13]. As AST/ALT may provide more information on the risk assessment of CVD, we hypothesized that the preoperative De Ritis ratio is associated with the total drainage volume. The purpose of this study was to examine the relationships between the preoperative elevated AST/ALT ratio and the increased drainage volume in patients after aortic arch surgery.

Patients and Methods

Study Design and Patients

Patients requiring aortic arch surgery were selected for this study and were excluded if they (1) had missing data on the preoperative AST or ALT; (2) were treated with anticoagulants preoperatively; (3) needed extracorporeal membrane oxygenation (ECMO) support postoperatively; (4) underwent minimally access surgery. Patients younger than 18 years old were also excluded. The indications for total arch replacement were type I and type II aortic dissection. The indications for hemiarch reconstruction were the presence of an ascending aortic aneurysm and type II thoracic aortic dissection, limited to the ascending aorta.

Exposures and Primary Endpoint

The exposure factor was the preoperative AST/ALT ratio. To calculate the optimal AST/ALT ratio cutoff to differentiate the level of postoperative drainage, the maximum Youden index based on the receiver operating characteristic curve (ROC) analysis was calculated. Accordingly, we defined the ratio $\geq$0.92 as a high AST/ALT ratio and $<$0.92 as a low AST/ALT ratio. The primary endpoint was the level of the total amount drainage volume. Based on the median drainage volume of all participants, we dichotomized the study population: patients with a total drainage volume of 1670 mL or more were classified into high-output group (HOPG) and the remaining patients were classified into the low-output group (LOPG).

Postoperative Drain Management

Patients will be transferred to the cardiac intensive care unit (ICU) after surgery, and the postoperative management of patients will not be very different due to the differences between the two types of surgery, and in general, the patient will regain consciousness and get off the ventilator as soon as possible while maintaining stable circulatory function, so as to promote early recovery. Drains were routinely inserted in all patients undergoing aortic arch surgery. One drain was placed at the anteroinferior sinus of pericardium, one was placed behind the sternum. All drains were placed on negative pressure suction. Nurses would disinfect the edge of the drains regularly and record the drainage volume continuously. The decision to remove the drains was usually made by attending doctors. In general, the drains would be removed when the drainage volume was less than 150 mL within 24 hours.

Data Collection

The following information on preoperative characteristics was retrieved from the hospital's electronic medical records system, which was the source of this database: demographics, smoking history, preoperative ejection fraction (EF) and preoperative comorbidities. Preoperative laboratory test results routinely performed 1 to 3 days before surgery were collected. The type of surgery, postoperative complications and special postoperative treatment were also retrieved. The total volume of the pericardial and mediastinal drainage was collected from the nursing record sheet. The length of ICU stay and hospital stay and the in-hospital death were also recorded. All of these data were obtained from our Department of Information.

Statistical Analysis

The normality of continuous variables was tested using the Shapiro-Wilk test. Normally distributed continuous variables are shown as mean $\pm$ standard deviation (M $\pm$ SD) and were compared using the Student *t* test. Non-normally distributed continuous variables are shown as medians (25th and 75th percentiles) and were compared using the Wilcoxon Mann-Whitney test. Categorical variables are expressed as frequency with percentages and were compared using the chi-squared test or Fisher's exact test. The drainage volume was dichotomized into a binary variable using its median. The AST/ALT ratio was dichotomized into a binary variable using a cutoff suggested by the Youden index. We classified patients as having an elevated AST/ALT ratio if it was larger than that with the highest Youden index. The univariable logistic regression analysis was conducted to explore the correlation between the AST/ALT ratio level and the drainage volume. Results are presented as odds ratios (OR) with 95% confidence interval (CI). In order to identify the potential confounders, potential risk factors were compared between the HOPG and the LOPG. Factors with a p-value < 0.1 in the univariable analysis were considered candidates for multivariable logistic regression analysis which was used to determine the risk factors influencing the volume of drainage volume. All statistical analysis was performed with SPSS®, version 23.0 (SPSS Inc., Chicago, IL, USA) with 2-sided $p < 0.05$ considered statistically significant.

Results

Baseline Characteristics

510 consecutive patients were screened, 425 patients fulfilled the criteria and were included in the final analysis (Fig. 1). They consisted of 181 participants whose AST/ALT ratio was $<$0.92 and 244 participants with the AST/ALT ratio $\geq$0.92. Perioperative characteristics of the

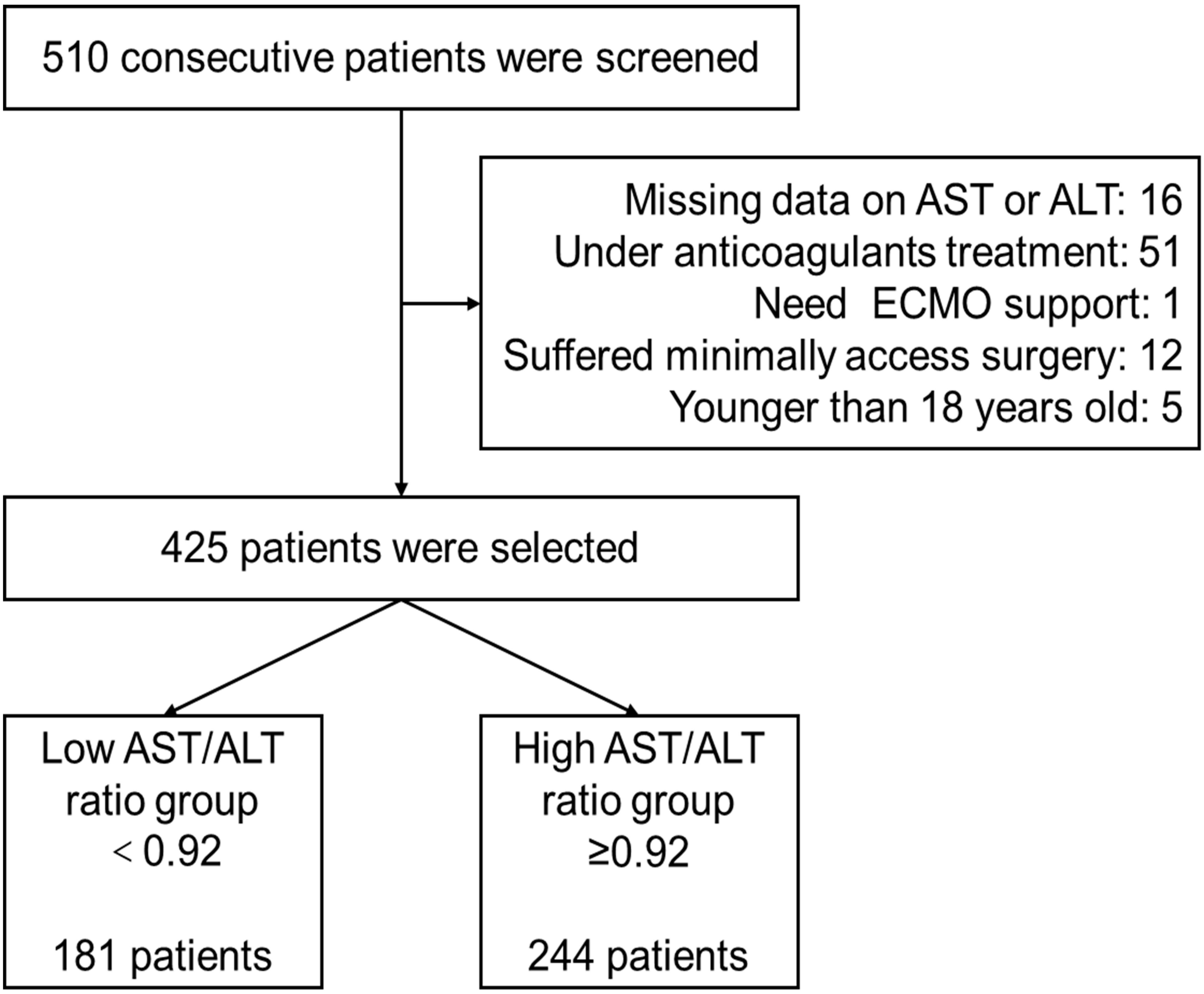

Fig. 1. Flow chart. ALT, alanine transaminase; AST, aspartate aminotransferase; ECMO, extracorporeal membrane oxygenation.

study population are presented in Table 1. Preoperative information of the low AST/ALT ratio and high AST/ALT ratio groups are presented in Table 2. Total drainage volume in the high AST/ALT ratio group was significantly greater than in the low AST/ALT ratio group (p = 0.002). The preoperative ALT level in the low ratio group was much higher than that in the high ratio group ($p < 0.001$). There were also significant differences between the groups regarding age, gender, body mass index (BMI), and smoking history.

Postoperative Drainage Volume

Of the 425 patients, the median of the total amount of drainage volume was 1670 (1030, 2655) mL. There were 213 participants in the LOPG with a median total drainage volume of 1030 (715, 1335) mL and 212 participants in the HOPG with a median total drainage volume of 2657.5 (2070, 3610) mL, in which 15 participants had more than 1000 mL of drainage on the first day after surgery. Differences between the two groups are presented in Table 3. Participants in the HOPG were older than the LOPG (p = 0.070). In the LOPG, 106 participants (49.77%) had a low AST/ALT ratio, compared to 77 (36.32%) in the HOPG (p = 0.003). The serum total protein (TP) level and the prothrombin temporal activity (PTA) were higher in the LOPG. While participants in the HOPG had a higher concentration of serum creatinine (p = 0.005) and blood urea nitrogen (BUN) (p = 0.001) and an increased prothrombin time (PT) (p = 0.008). The international normalized ratio (INR) value was slightly higher in the HOPG (p = 0.015). Postoperatively, patients, who developed acute kidney injury (AKI) and required continuous renal replacement therapy (CRRT), re-intubation, had an increased amount of the drainage volume. There were also significant differences between the two groups regarding the surgical type, hospital and ICU stay.

Risk Factors Analysis

In the univariable logistic regression analysis, compared with patients whose AST/ALT ratio <0.92, the OR for the large drainage volume in patients with an elevated

Table 1. Demographics and perioperative data of patients in this cohort.

Variable	Median (IQR)/Mean ± SD/n (%)
Age (year)	52.4 (44.4, 63.3)
Gender	
Male	288 (67.80)
Female	137 (32.20)
BMI (kg/m^2)	26.00 (24.0, 29.0)
Preoperative comorbidities	
Hypertension	324 (76.20)
Diabetes	14 (3.30)
Hyperlipemia	239 (56.20)
COPD	3 (0.70)
CKD	8 (1.90)
Cerebral vascular disease	30 (7.10)
Peripheral vessel disease	19 (4.50)
Smoking history	175 (41.20)
EF value	60 (59.0, 63.0)
Surgical treatment	
Total arch replacement	371 (87.30)
Hemiarch reconstruction	54 (12.70)
Preoperative Laboratory test	
Albumin (g/L)	40.00 (36.00, 42.70)
TP (g/L)	66.66 ± 36.54
ALT (U/L)	21.00 (14.00, 33.00)
AST (U/L)	21.00 (16.00, 27.00)
AST/ALT	1 (0.72, 1.44)
Creatinine (mg/dL)	82.17 (67.07, 102.71)
BUN (mmol/L)	5.65 (4.53, 7.14)
PT (s)	14.10 (13.40, 14.80)
PTA	86.68 ± 13.15
INR	1.10 (1.03, 1.17)
APTT (s)	36.80 (34.40, 40.80)
Hospital stay (d)	13.35 (9.59, 17.41)
ICU stay (d)	4.00 (2.00, 5.00)
In-hospital Mortality	12 (2.80)
Postoperative complications	
MI	7 (1.60)
AKI	98 (23.10)
Special postoperative treatment	
CRRT	28 (6.60)
Tracheotomy	3 (0.70)
IABP	3 (0.70)
Re-open cheat surgery	18 (4.20)
Re-ICU	4 (0.90)
Re-intubation	15 (3.50)

IQR, interquartile range; SD, standard deviation; BMI, body mass index; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; EF, ejection fraction; TP, total protein; ALT, alanine transaminase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; PT, prothrombin time; PTA, prothrombin temporal activity; INR, international normalized ratio; APTT, activated partial thromboplastin time; ICU, intensive care unit; MI, myocardial infarction; AKI, acute kidney injury; CRRT, continuous renal replacement therapy; IABP, intra-aortic balloon pump; y, year; d, day; s, second.

AST/ALT ratio ($\geq$0.92) was 1.810 (95% CI 1.226–2.670, p = 0.003). After identifying the potential confounders using a less stringent cut-off of 0.1 for the p value, the multivariable logistic regression analysis was conducted with adjustments for age, surgical type, AKI, CRRT, re-intubation, and preoperative laboratory tests (TP, serum creatinine, BUN, PT, PTA, INR). Variables following the multivariable analysis are presented in Table 4. A preoperative elevated AST/ALT ratio ($\geq$0.92) was significantly associated with the total amount of drainage volume (OR = 1.725, 95% CI 1.115–2.669, p = 0.014). In the ROC, the area under the curve was 0.571 (95% CI 0.517–0.626, p = 0.011). Compared with total arch replacement, hemiarch reconstruction may be a potential protective factor for drainage volume (OR = 0.242, 95% CI 0.111–0.526, $p < 0.001$). Participants who developed AKI postoperatively may have a higher drainage volume (OR = 3.148, 95% CI 1.748–5.669, $p <$ 0.001). After excluding 15 patients with a drainage volume greater than 1000 mL on the first day after surgery, we performed a sensitivity analysis and the results remained stable (OR = 1.738, 95% CI 1.116–2.706, p = 0.014), see details at Table 5.

Discussion

The present study used retrospectively collected data from patients undergoing aortic arch surgery in order to investigate the predictive impact of the serum AST/ALT ratio on the total amount of drainage volume. We found that a preoperative elevated AST/ALT ratio is significantly associated with drainage volume and is an independent risk factor for the total drainage volume. These findings indicated that the AST/ALT ratio might represent a novel marker for individual risk assessment for cardiac surgery.

The leading cause of increased postoperative drainage volume is bleeding, which may require a re-exploration to stop the bleeding. In addition, primary or secondary coagulation abnormalities, surgery types, age, and use of preop anticogulants are the reasons for the increased drainage volume. The structure and material of the drains may reduce the amount and duration of drainage [5–7]. In this study, we sought to identify potential risk factors for increased drainage volume and focused on preoperative risk factors.

The AST/ALT (De Ritis) ratio was initially described in 1957 and was found to be a useful indicator of structural liver cell damage when the ratio was elevated [14]. An elevated AST/ALT ratio is also associated with nonalcoholic fatty liver disease which has been shown to increase cardiovascular morbidity [15]. A recent study had shown that the elevated AST/ALT ratio was a strong predictor for long-term mortality after acute myocardial infarction (AMI), which was associated with systemic hypoperfusion and end-organ damage [16]. It was also associated with higher mortality after cardiac arrest which may cause ischaemic-reperfusion injury of hepatocytes [17]. Patients

Table 2. Preoperative information of the low De Ritis ratio group and high De Ritis ratio group.

Variables	Low AST/ALT ratio Group	High AST/ALT ratio Group	z/t/χ^2 value	*p*-value
	M (IQR)/Mean ± SD/n (%)	M (IQR)/Mean ± SD/n (%)		
Age (y)	48.5 (42.4, 58.4)	55.8 (46.7, 64.6)	–4.763	<0.001
Gender			26.112	<0.001
Male	147 (81.22)	141 (57.79)		
Female	34 (18.78)	103 (42.21)		
BMI (kg/m^2)	27.00 (24.00, 30.00)	25.00 (23.00, 28.00)	–4.756	<0.001
Preoperative comorbidities				
Hypertension	138 (76.24)	186 (76.23)	0.000	1.000
Diabetes	5 (2.76)	9 (3.69)	0.280	0.785
Hyperlipemia	109 (60.22)	130 (53.28)	2.035	0.167
COPD	2 (1.10)	1 (4.10)	0.068	0.578
CKD	2 (1.10)	6 (2.46)	0.429	0.476
Cerebral vascular disease	10 (5.52)	20 (8.20)	1.131	0.341
Peripheral vessel disease	6 (3.31)	13 (5.33)	0.986	0.354
Smoking History	90 (49.72)	85 (34.84)	9.509	0.003
EF value	60 (60, 63)	60 (58, 63)	–0.385	0.701
Surgical type			0.346	0.659
Total arch replacement	160 (88.40)	211 (86.48)		
Hemiarch reconstruction	21 (11.60)	33 (13.52)		
Total Drainage volume	1420 (920, 2340)	1795 (1187.5, 2805)	–3.152	0.002
Preoperative Laboratory test				
Albumin (g/L)	38.92 ± 5.65	39.49 ± 4.76	–1.106	0.270
TP (g/L)	67.11 ± 6.28	66.32 ± 5.84	1.343	0.180
ALT (U/L)	32.00 (24.00, 50.00)	15.00 (11.00, 21.00)	–12.454	<0.001
AST (U/L)	21.00 (16.00, 28.00)	20.00 (16.00, 26.00)	–0.432	0.665
Creatinine (mg/dL)	83.62 (68.97, 104.07)	80.85 (64.97, 100.51)	–1.694	0.090
BUN (mmol/L)	5.65 (4.57, 7.10)	5.64 (4.51, 7.36)	–0.234	0.815
PT (s)	14.10 (13.40, 14.60)	14.10 (13.4, 14.90)	–1.116	0.264
PTA	86 (80, 96)	86 (77, 95)	–1.090	0.276
INR	1.10 (1.03, 1.15)	1.1 (1.03, 1.18)	–1.152	0.249
APTT (s)	37.50 (34.70, 41.25)	36.6 (34.20, 39.90)	–1.765	0.078

IQR, interquartile range; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; EF, ejection fraction; TP, total protein; ALT, alanine transaminase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; PT, prothrombin time; PTA, prothrombin temporal activity; INR, international normalized ratio; APTT, activated partial thromboplastin time; ICU, intensive care unit; y, year; d, day; s, second.

diagnosed with aortic dissection may have potential liver hypoperfusion which could cause an elevated AST/ALT ratio. Therefore, an elevated AST/ALT ratio would be a biomarker of liver cell injury, which may be the result of liver disease itself or it may be a secondary result of hypoperfusion associated with aortic dissection. Although there were differences in demographic variables between the low AST/ALT ratio group and the high AST/ALT ratio group regarding age, gender and BMI, after univariable and multivariable regression analysis, these variables were not risk factors for drainage volume. It also had been reported that gender has an influence on the AST/ALT ratio in the general population [18], indicating that there is an objective difference in demographic indicators between the groups.

Hepatic injury can be manifested as a drug metabolism or liver-associated coagulation factor synthesis disorder, which may impact coagulation function. Cao *et al*. [19], have shown that patients with an elevated AST/ALT ratio were found to more readily develop an INR ≥4 within 10 days after the initiation of warfarin compared with low De Ritis ratios. This may explain why the elevated AST/ALT ratio was a risk factor for the drainage volume. In our study, a De Ritis ratio >0.92 had an impact on the drainage volume, indicating that patients hepatic dysfunction may have underlying coagulation abnormalities. The exact mechanism responsible for the relationship between AST/ALT ratio and the increased risk of drainage volume is still unclear and requires further investigation.

The type of surgery and the development of postoperative AKI may also influence the total drainage volume. The effect of the surgical type on drainage volume may be attributed to the size of the trauma. In order to avoid the effect of surgery on drainage, we did a sensitivity analysis after excluding patients with drainage greater than 1000

Table 3. Univariate analysis of risk factors compared the HOPG with the LOPG[a].

Variables	Low-output Group	High-output Group	z/t/χ^2 value	p-value
	M (IQR)/Mean ± SD/n (%)	M (IQR)/Mean ± SD/n (%)		
Age (y)	50.9 (43.7, 61.8)	53.9 (45.2, 63.7)	–1.813	0.070
Gender			0.811	0.407
Male	140 (65.73)	148 (69.81)		
Female	73 (34.27)	64 (30.19)		
BMI (kg/m^2)	26.00 (24.00, 29.00)	26.00 (24.00, 29.00)	–0.468	0.640
Preoperative factors				
Hypertension	162 (76.06)	162 (76.42)	0.008	1.000
Diabetes	7 (3.29)	7 (3.30)	0.000	1.000
Hyperlipidemia	117 (54.93)	122 (57.55)	0.296	0.625
COPD	3 (1.41)	0 (0.00)	1.333	0.248
CKD	3 (1.41)	5 (2.36)	0.132	0.503
Cerebral vascular disease	19 (8.92)	11 (5.19)	2.255	0.184
Peripheral vessel disease	12 (5.63)	7 (3.30)	1.353	0.348
Smoking history	87 (40.85)	88 (41.51)	0.019	0.922
EF value	60.00 (60.00, 63.00)	60.00 (58.00, 63.00)	–0.335	0.737
DRr group			8.996	0.003
AST/ALT $<$0.92	106 (49.77)	77 (36.32)		
AST/ALT $\geq$0.92	107 (50.23)	137 (64.62)		
Surgical type			18.931	$<$0.001
Total arch replacement	171 (80.28)	200 (94.34)		
Hemiarch reconstruction	42 (19.72)	12 (5.66)		
Preoperative Laboratory test				
Albumin (g/L)	39.9 (36.2, 42.7)	40.00 (35.95, 42.35)	–0.057	0.954
TP (g/L)	67.44 ± 5.86	65.88 ± 6.13	2.683	0.008
ALT (U/L)	22.00 (14.00, 33.00)	20.00 (13.00, 33.50)	–0.940	0.347
AST (U/L)	20.00 (15.00, 27.00)	21.00 (16.00, 27.50)	–0.926	0.355
Creatinine (mg/dL)	79.33 (65.05, 96.10)	86.02 (70.81, 110.65)	–2.78	0.005
BUN (mmol/L)	5.29 (4.48, 6.51)	5.93 (4.575, 7.92)	–3.288	0.001
PT (s)	14.10 (13.60, 14.75)	14.30 (13.60, 15.10)	–2.635	0.008
PTA	86.00 (79.00, 92.00)	84.00 (76.00, 92.00)	–2.530	0.011
INR	1.10 (1.05, 1.16)	1.11 (1.06, 1.19)	–2.435	0.015
APTT (s)	36.80 (34.35, 40.55)	37.30 (34.30, 40.90)	–0.215	0.830
Hospital stay (d)	10.68 (8.40, 14.72)	14.52 (11.40, 19.33)	–6.464	$<$0.001
ICU stay (d)	3.00 (2.00, 5.00)	5.00 (3.00, 6.00)	–4.697	$<$0.001
In-hospital Mortality	6 (2.82)	6 (2.83)	0.000	1.000
Postoperative complications				
MI	4 (1.88)	3 (1.42)	0.000	1.000
AKI	27 (12.68)	71 (33.49)	25.946	$<$0.001
Postoperative special treatment				
CRRT	9 (4.23)	19 (8.96)	3.874	0.053
Tracheotomy	0 (0.00)	3 (1.42)	1.352	0.123
IABP	2 (0.94)	1 (0.47)	0.000	1.000
Re-open cheat surgery	6 (4.23)	12 (5.66)	2.118	0.157
Re-ICU	1 (0.47)	3 (1.42)	0.257	0.372
Re-intubation	4 (1.88)	11 (5.19)	3.420	0.071

[a] Variables with $p < 0.1$ would be included for the multivariable analysis.

IQR, interquartile range; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; EF, ejection fraction; TP, total protein; ALT, alanine transaminase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; PT, prothrombin time; PTA, prothrombin temporal activity; INR, international normalized ratio; APTT, activated partial thromboplastin time; ICU, intensive care unit; MI, myocardial infarction; AKI, acute kidney injury; CRRT, continuous renal replacement therapy; IABP, intra-aortic balloon pump; y, year; d, day; s, second.

mL on the postoperative day, and the results were consistent with the previous results. Patients with AKI complications postoperatively may also develop fluid shifts into the third space and in addition to increased drainage.

Table 4. Variables significantly associated with High-output following multivariable analysis[a].

Variables	β	OR	95% Confidence Interval		*p*-value
			Lower	Upper	
Age	0.013	1.013	0.994	1.033	0.188
Surgical type*	–1.418	0.242	0.111	0.526	<0.001
CRRT	–0.724	0.485	0.175	1.346	0.165
AKI	1.147	3.148	1.748	5.669	<0.001
Re-intubation	0.554	1.741	0.488	6.205	0.393
Elevated AST/ALT ratio	0.545	1.725	1.115	2.669	0.014
Pre-TP	–0.022	0.978	0.943	1.014	0.231
Pre-Creatinine	0.000	1.000	0.993	1.008	0.924
Pre-BUN	0.078	1.082	0.960	1.218	0.196
Pre-PT	2.176	8.807	0.767	101.146	0.081
Pre-PTA	0.060	1.062	0.990	1.139	0.092
Pre-INR	–14.415	0.000	0.000	5352.561	0.219

[a] The odds ratio and 95% confidence interval were measured through binary logistic regression.

* hemiarch reconstruction vs total arch replacement.

CRRT, continuous renal replacement therapy; AKI, acute kidney injury; ALT, alanine transaminase; AST, aspartate aminotransferase; TP, total protein; BUN, blood urea nitrogen; PT, prothrombin time; PTA, prothrombin temporal activity; INR, international normalized ratio.

Table 5. Sensitive analysis for the risk factor of drainage volume[a].

Variables	β	OR	95% Confidence Interval		*p*-value
			Lower	Upper	
Age	0.014	1.014	0.994	1.034	0.184
Surgical type*	–1.560	0.210	0.091	0.483	<0.001
CRRT	–0.896	0.408	0.140	1.195	0.102
AKI	1.033	2.810	1.547	5.104	0.001
Re-intubation	0.631	1.880	0.522	6.771	0.334
Elevated AST/ALT ratio	0.553	1.738	1.116	2.706	0.014
Pre-Total Protein	–0.027	0.974	0.938	1.010	0.158
Pre-Creatinine	0.001	1.001	0.994	1.009	0.758
Pre-BUN	0.065	1.067	0.944	1.206	0.297
Pre-PT	2.369	10.690	0.900	126.992	0.061
Pre-PTA	0.067	1.069	0.994	1.150	0.071
Pre-INR	–15.724	0.000	0.000	1975.110	0.186

[a] The odds ratio and 95% confidence interval were measured through binary logistic regression.

* hemiarch reconstruction vs total arch replacement.

CRRT, continuous renal replacement therapy; AKI, acute kidney injury; ALT, alanine transaminase; AST, aspartate aminotransferase; TP, total protein; BUN, blood urea nitrogen; PT, prothrombin time; PTA, prothrombin temporal activity; INR, international normalized ratio.

We also found that the median time of hospital and ICU stay in the HOPG were significantly longer than that in the LOPG, which had an impact on the patient's recovery. These results emphasized the importance of paying attention to drainage volume, which could also affect pain management, and altered coagulation.

Limitation

This study is subject to the inherent limitations of retrospective analyses of observational data. Some records, such as the drainage duration, were lost and unavailable for analysis. In order to explore the relationship between variables, we converted two continuous variables into two categorical variables. The basis of conversion into classification variables was the median of total amount of drainage and the approximate value was determined according to the sensitivity of predicting the high and low amount of drainage. Based on our statistical results, we found a correlation between the AST/ALT ratio and the total amount of drainage volume. It is necessary to establish a unified standard before further investigation in order to clearly explore the correlation between an elevated AST/ALT ratio and the drainage volume.

Conclusions

The preoperative elevated AST/ALT ratio is an independent risk factor for pericardial and mediastinal drainage volume in patients undergoing aortic arch surgery. As a readily available biomarker in clinical practice, it might represent a novel marker for individual risk assessment for an increased volume of drainage postoperatively and help to optimize perioperative management for cardiac surgery.

Availability of Data and Materials

The original data of this article can be requested from the corresponding author on reasonable grounds.

Author Contributions

WY, XQ and BJ designed the research study. WY and JS performed the research. WY analyzed the data and wrote the manuscript. QZ and TW provided help and advice on data collection and analysis. XQ, JS, and BJ revised the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This retrospective observational cohort study was conducted in Fuwai hospital from January 2017 to December 2018 and was approved by our Institutional Ethics Committee (record number: 2020-1288). The informed consent was waived because of its retrospective nature.

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Conflict of Interest

The authors declare no conflict of interest.

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