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Original Article

Analysis of risk factors for postoperative acute cerebral infarction in patients with type B aortic dissection

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Abstract: Objective: To study risk factors of postoperative acute cerebral infarction (PACI) in patients with type B aortic dissection (TB-AD). Methods: The data of 36 patients with TB-AD and PACI undergoing endovascular aortic repair (EVAR) from Mar 2018 and Mar 2021 were collected as the PACI group retrospectively. The data of 114 TB-AD patients without PACI were collected as the control group retrospectively. The medical history, surgery-related indicators, general data, imaging data and laboratory test results (D-dimer (D-D), preoperative serum creatinine and preoperative white blood cell count) were compared. Then, logistic regression was applied to analyze risk factors for PACI in TB-AD patients. Results: The surgery time, blood loss and hospital stay of patients in the PACI group were determined to be obviously higher/longer when comparing to those in the control group. Aortic arch radius of curvature and length of proximal anchoring zone showed no significant difference between the two groups. Pearson correlation analysis indicated that D-D level after surgery was positively related to white blood cell count and serum creatinine level in TB-AD patients. Binary logistic regression analysis showed that operation time, emergency surgery, preoperative D-D and preoperative serum creatinine level were independent risk factors for PACI after EVAR in the patients with TB-AD ($P < 0.05$). Conclusion: There are many independent risk factors for PACI after EVAR in patients with TB-AD, and preoperative D-D level and serum creatinine level should be given attention.

Keywords: Type B aortic dissection, postoperative acute cerebral infarction, risk factors, aortic endovascular repair

Introduction

Type B aortic dissection (TB-AD) caused by aortic intima tearing or bleeding within the aortic wall is life-threatening and is characterized by sudden pain and complex clinical symptoms [1]. Endovascular aortic repair (EVAR) has become the treatment for TB-AD in the subacute phase due to the maturation of endoluminal surgery [2, 3]. A previous study showed that EVAR for high-risk TB-AD in the acute phase was related to the high rate of early complications, with a 30-d mortality rate five times higher than that in the patients in the subacute phase, and serious complications such as aortic dissection and stroke were only found in patients receiving operation in the acute phase [4]. As TB-AD patients undergoing surgery in the subacute phase becomes more common, the postoperative complications accompanying the surgery are gaining attention. Qrareya et al. found that the incidence of postoperative complications in AD patients ranged approximately from 4.5% to 15% [5]. The main complications after EVAR include dizziness, spinal cord ischemia, organ failure and most severely, acute cerebral infarction. One disadvantage of EVAR is that it inevitably covers the branches of small arteries, and in severe cases, spinal cord ischemia and even lower body paraplegia will occur. Moreover, because of the graft implantation, potential graft infection may occur, which may cause catastrophic consequences. Previous studies showed that one of the most serious complications was postoperative acute cerebral infarction (PACI), which seriously affects the prognosis of patients [6, 7]. Previous studies have focused on the occurrence of PACI in patients suffering from TB-AD. Kotani et al. [8] performed functional brain MRI in the patients after EVAR and found new lesions occurred in 34% of the patients. However, there

is a paucity of literature exploring the factors influencing the occurrence of PACI in the patients suffering from TB-AD, and a validated quantitative preoperative assessment method has not been established, which has an obvious impact on the efficacy and application of TB-AD surgery. Therefore, in the present study, 36 patients with TB-AD and PACI after EVAR surgery and 114 patients with TB-AD but without PACI after surgery were selected as subjects to investigate the risk factors for PACI after EVAR. To explore the risk factors of PACI in patients with TB-AD it is helpful for doctors to evaluate the probability of acute cerebral infarction in patients with TB-AD before surgery, and to formulate appropriate surgical plans and risk coping strategies for patients.

Materials and methods

General data

The data of 36 patients with TB-AD and PACI after EVAR from Mar 2018 to Mar 2021 were collected as the PACI group retrospectively. The data of 114 patients with TB-AD but without PACI after EVAR were collected as the control group, retrospectively. This study was approved by the Ethics Committee of Jiangxi Provincial People's Hospital, The First Affiliated Hospital of Nanchang Medical College.

Inclusion criteria: (1) Patients with confirmed diagnosis of TB-AD based on CT angiographic findings. (2) Patients who underwent EVAR after admission. (3) Patients who were over 18 years old.

Exclusion criteria: (1) Patients with a history of endoluminal repair of aortic lesions. (2) Those with unsuccessful surgery. (3) Those with preoperative comorbidities of other cardiovascular and cerebrovascular diseases. (4) Those with abnormal coagulation function.

Sample collection and testing

On the morning of the day following admission, 5 ml of fasting venous blood was collected from patients. Preoperative leucocyte counts were determined using an XE-2100 fully automated haematology analyser (Hyson Mecon Corporation, Japan). D-Dimer (D-D) level and preoperative serum creatinine were determined using a CA1500 fully automated haemagglutinator (Hyson Mecon Corporation, Japan) and a Cobas c702 fully automated biochemistry analyser (Roche, Swiss), respectively.

Data were collected, including general data (sex, age, body mass index, smoking, alcohol consumption), medical history (hypertension, diabetes, coronary artery disease and chronic obstructive pulmonary disease), surgery-related indicators (time to surgery, intraoperative bleeding, length of hospital stay and whether or not the surgery was an emergency), imaging data (first breach diameter, radius of curvature (RoC) of the aortic arch and length of the proximal anchorage zone) and laboratory test results (D-D, preoperative white blood cell count and preoperative creatinine).

Observation indicators

The general data, medical history, imaging data and laboratory test results were compared the between the PACI group and the control group. Logistics regression was applied to analyse factors that influence the occurrence of PACI after EVAR in the patients suffering from TB-AD.

Statistical methods

SPSS 20.0 was applied for data analysis. Measurement data were expressed by mean ± SD and compared by *t*-test. Count data were expressed by numbers of cases (%) and compared by *chi-square* test. Pearson correlation analysis was applied for analysing the correlation of double-normally distributed variables. Binary logistics regression was applied to analyse the influencing factors of event occurrence. $P < 0.05$ was considered a statistical difference.

Results

Comparison of baseline information

There was no obvious difference between the PACI group and the control group in terms of sex, age, body mass index, smoking, alcohol consumption, hypertension, diabetes, coronary heart disease and chronic obstructive pulmonary disease ($P > 0.05$). See **Table 1**.

Comparison of surgery-related indicators

The PACI group had longer operative time, more intraoperative bleeding and longer hospital

Table 1. Comparison of baseline information [n (%)]

Item		PACI group (n = 36)	Control group (n = 114)	χ^2/t	*P*
Sex	Male	32 (88.89%)	91 (79.82%)	1.523	0.217
	Female	4 (11.11%)	23 (20.18%)		
Age (years)		63.78±8.69	64.34±9.58	0.312	0.755
Body mass index (kg/m^2)		25.47±3.80	24.99±3.77	0.665	0.507
Smoking		15 (41.67%)	36 (31.58%)	1.241	0.265
Alcohol consumption		11 (30.56%)	30 (26.32%)	0.248	0.619
Hypertension		30 (83.33%)	94 (82.46%)	0.015	0.904
Diabetes		8 (22.22%)	15 (13.16%)	1.732	0.188
Coronary artery disease		0 (0.00%)	2 (1.75%)	-	0.576
Chronic obstructive pulmonary disease		4 (11.11%)	20 (17.54%)	0.842	0.359

PACI: Postoperative Acute Cerebral Infarction.

Table 2. Comparison of surgery-related indicators [n (%), ($\bar{x}$ ± s)]

Group	n	Operating time (min)	Intraoperative bleeding (ml)	Length of stay in hospital (d)	Emergency surgery
PACI group	36	156.17±40.30	169.94±31.40	15.97±3.01	15 (41.67%)
Control group	114	122.69±36.15	157.47±28.57	11.86±2.88	25 (21.93%)
t/χ^2		4.711	2.045	7.384	5.450
P		< 0.001	0.027	< 0.001	0.020

PACI: Postoperative Acute Cerebral Infarction.

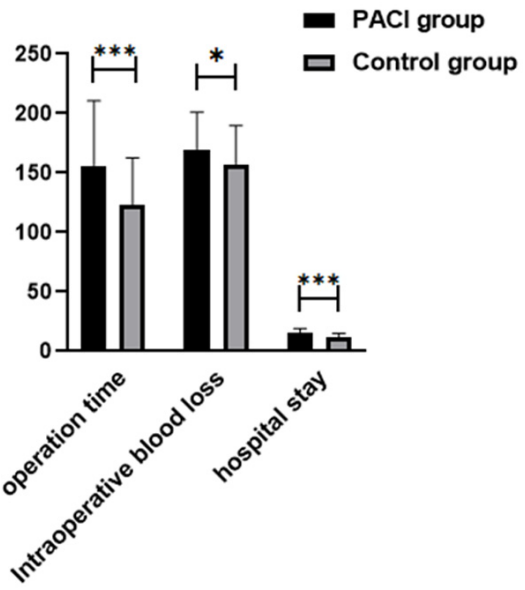

Figure 1. Comparison of surgery-related indicators. Notes: *P < 0.05, ***P < 0.001. PACI: Postoperative Acute Cerebral Infarction.

stay compared to the control group (P < 0.05). There were more patients having emergency surgery in the PACI group than those in the control group (P < 0.05). See **Table 2** and **Figure 1**.

Comparison of imaging indexes

No obvious difference was observed in the first breach diameter, RoC and proximal anchorage zone length between the PACI group and the control group (P > 0.05). See **Table 3** and **Figure 2**.

Comparison of laboratory examination indexes

D-D, preoperative white blood cell count and preoperative creatinine were higher in the PACI group than in the control group (P < 0.05). See **Table 4** and **Figure 3**.

Correlation of pre-surgical D-D levels and leucocyte count and creatinine

Pearson correlation analysis indicated that D-D level after surgery was positively related to white blood cell count and serum creatinine level in TB-AD patients (P < 0.05). See **Figure 4**.

Logistic regression analysis of risk factors for PACI in the patients with TB-AD

With PACI as the dependent variable and sex, age, body mass index, smoking, alcohol con-

Table 3. Comparison of imaging indexes ($\bar{x} \pm s$, mm)

Group	n	Diameter of the first breach	RoC	Length of proximal anchorage area
PACI group	36	11.11±2.65	25.25±5.03	15.39±4.17
Control group	114	10.46±1.89	26.13±4.67	17.50±6.75
t		1.623	0.968	1.770
P		0.107	0.335	0.079

PACI: Postoperative Acute Cerebral Infarction; Roc: Radius Of Curvature.

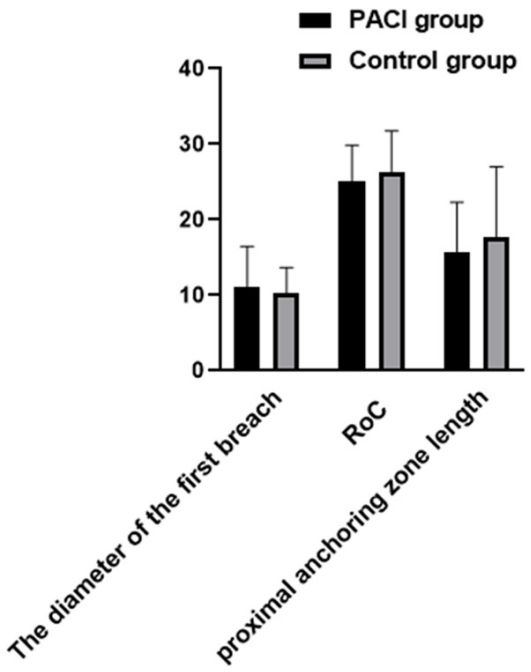

Figure 2. Comparison of imaging indexes. PACI: Postoperative Acute Cerebral Infarction.

sumption, hypertension, diabetes, coronary artery disease, chronic obstructive pulmonary disease, time to surgery, intraoperative bleeding, length of hospital stay, emergency surgery or not, first breach diameter, RoC, proximal anchorage zone length, preoperative D-D and preoperative serum creatinine as independent variables, binary logistic regression analysis indicated that time to surgery, emergency surgery, preoperative D-D and preoperative serum creatinine level were independent risk factors for PACI after EVAR in patients with TB-AD ($P < 0.05$). See **Table 5**.

Discussion

Aortic dissection is a group of serious diseases with a high risk of clinical death. Compared with open surgery, EVAR is less invasive and more effective for TB-AD [9, 10]. Therefore, there is an urgent need to investigate the factors influencing the occurrence of PACI in TB-AD patients and their influencing mechanisms to reduce risk of PACI and improve prognosis. Previously, due to the higher incidence of TA-AD [11, 12] and the involvement of ascending aorta in the patients suffering from TA-AD, the risk of PACI is increased by the upward obstruction of cranial arteries by thrombus. Therefore, most clinical attention has been paid to the factors influencing the occurrence of PACI in TA-AD patients. However, in this study, we found a significant proportion of the patients suffering from TB-AD were also at risk of PACI, so the mechanisms associated with ascending aortic involvement cannot fully explain the mechanisms of PACI in the patients suffering from AD. Therefore, this study investigated the risk factors for PACI in the patients suffering from TB-AD.

This study showed that baseline data and past medical history were similar in the PACI group and the control group, and were not influential factors for the development of PACI after EVAR in the patients with TB-AD. The results of this study are different from the research by Zha et al. [13], who noted that diabetes history was an independent risk factor for postoperative stroke in EVAR with an OR of 3 or more. This is considered to result from the difference in population between the two studies. A significant proportion of patients were under the age of 55 years in the study by Zha et al. [14], whereas in the present research, the patients were relatively older and had a higher coverage of underlying disease, which may explain the insignificant effect of diabetes history. Among the surgical indicators, patients in the PACI group had longer operative time and hospital stay, as well as greater intraoperative bleeding, and the duration of surgery was a risk factor affecting the occurrence of PACI after EVAR in the patients with TB-AD. The risk of PACI was 1.138 times higher in the patients undergoing emergency surgery than in those undergoing non-emergency surgery, in line with the conclusion of previous research [15]. The prolonged duration of surgery and the corresponding prolonged duration of anaesthesia have a greater

Table 4. Comparison of laboratory test indicators ($\bar{x} \pm s$, mm)

Group	n	D-D (mg/L)	Pre-operative white blood cell count (> $12*10^9$/L)	Pre-operative creatinine (μmol/L)
PACI group	36	0.94±0.30	11 (30.56%)	119.27±33.82
Control group	114	0.79±0.24	17 (14.91%)	89.37±17.28
t/Z		3.071	4.410	7.005
P		0.003	0.036	< 0.001

PACI: Postoperative Acute Cerebral Infarction; D-D: D-Dimer.

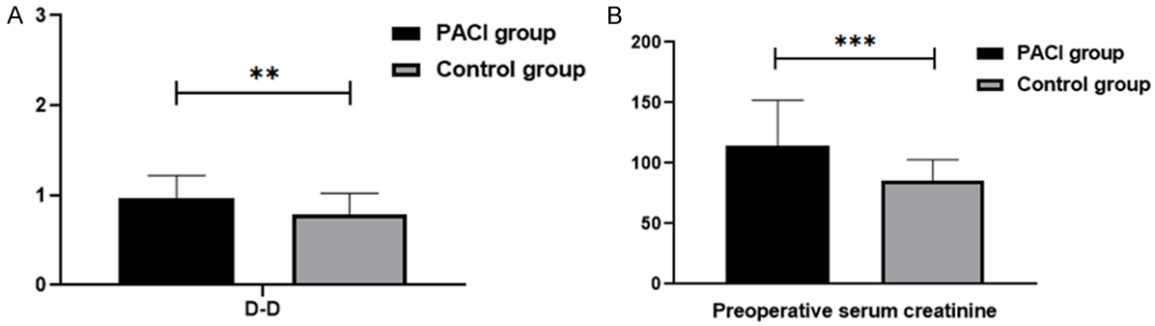

Figure 3. Comparison of preoperative D-D and creatinine (A: D-D; B: Preoperative creatinine). Note: $^{**}P < 0.01$, $^{***}P < 0.001$. D-D: D-Dimer; PACI: Postoperative Acute Cerebral Infarction.

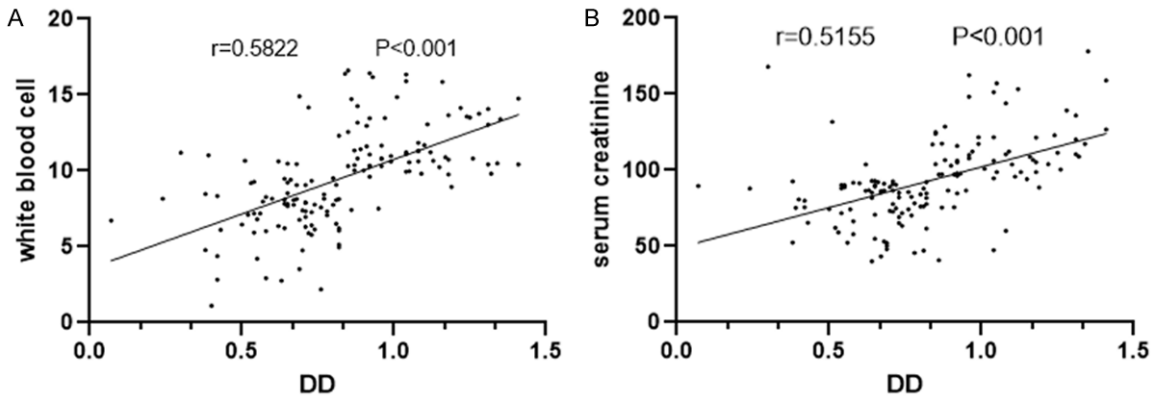

Figure 4. Scatter plot of preoperative D-D versus white blood cell count and serum creatinine (A: White blood cell count; B: Serum creatinine). D-D: D-Dimer.

Table 5. Logistics regression analysis of risk factors for PACI in patients with TB-AD

Factors	β	Wald	P	OR	95% CI
Time of surgery	0.287	4.325	0.038	1.333	1.017-1.746
Emergency surgery	0.129	10.941	0.001	1.138	1.054-1.228
Pre-operative D-D	1.630	5.581	0.019	5.103	1.320-19.735
Pre-operative serum creatinine	1.109	17.252	0.000	3.032	1.796-5.116

PACI: Postoperative Acute Cerebral Infarction; TB-AD: Type B Aortic Dissection; D-D: D-Dimer.

negative impact on the internal environment and haemodynamics of the patients, which may be the mechanism of the increased risk of PACI.

Previous reports indicated that postoperative D-D and C-reactive protein levels were obviously higher in TB-AD patients undergoing emergency surgery than in those undergoing non-

emergency surgery, also, the systemic inflammatory response and coagulation system were activated during the perioperative period in the patients, and the patients undergoing emergency surgery showed a more intense systemic inflammatory response and greater coagulation disorders [16, 17], and were more prone to postoperative complications such as PACI. This study also found that preoperative D-D was an independent risk factor for PACI, with the risk of PACI being over 5 times higher in those with high preoperative D-D levels than in those with low levels. Liu et al. [18] found that D-D level was an independent risk factor for in-hospital mortality in the patients suffering from acute TB-AD and a significant predictor of poor organ perfusion after surgery. D-D level was also found to be meaningful in predicting the long-term prognosis for TB-AD patients after surgery [19]. In addition, the present research indicated that the risk of PACI in the patients with high preoperative serum creatinine levels was over 3 times higher than that in the patients with low creatinine levels. The pathogenesis of PACI is complex and is not only related to inflammation and coagulation system, but oxidative stress is also one of the important mechanisms [20, 21]. When important organs are damaged, patients are prone to water-electrolyte-acid-base imbalance, thus contributing to hypoxaemia [22, 23], which in turn stimulates abnormal responses of oxidative stress, inflammation and coagulation systems in postoperative TB-AD patients and increases the risk of PACI. Meanwhile, some studies have shown that poor preoperative cerebral perfusion in the patients with TA-AD is a predictor of postoperative stroke and poor surgical outcome [24]. Meanwhile, Zhao et al. [25], who performed preoperative CT angiography, diffusion-weighted brain imaging and postoperative brain CT in TA-AD patients, found that the presence of preoperative cerebral infarct lesions in the patients with infarct lesions located in the unilateral cerebral hemisphere and distributed over three lobes was an independent risk factor for new-onset postoperative stroke.

This study has some limitations. First of all, due to the retrospective nature, the in-moment physical and mental status of the research subjects may affect the authenticity and accuracy of the past data reports. Secondly, this study paid less attention to the detection indicators, and the research on the risk factors for PACI in the patients with TB-AD was not comprehensive enough. Finally, the number of samples in this study is small, and there may be sampling bias. It is necessary to expand the scope of the study population, including the number and area of subjects, to refine the results of the study. In assessing the preoperative condition of the patients suffering from TB-AD, the present study lacked appropriate imaging evidence and data to compare the preoperative cerebral perfusion status of patients and the presence of corresponding neurological symptoms, which is a direction for future studies.

Conclusions

In conclusion, D-D, preoperative white blood cell count, preoperative creatinine, length of hospital stay, duration of surgery and emergency surgery rates were higher/longer in TB-AD patients with PACI, and time to surgery, emergency surgery, preoperative D-D and preoperative serum creatinine level were independent risk factors for PACI after EVAR in TB-AD patients.

Disclosure of conflict of interest

None.

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