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ORIGINAL ARTICLE

Prognostic value of TCBI for short-term outcomes in ATAD patients undergoing surgery

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Abstract

Objective Nutritional status has been reported to be associated with the prognosis of cardiovascular diseases. The study aimed to investigate the prognostic value of Triglycerides-total Cholesterol-Body weight-Index (TCBI) for short-term mortality in acute type A aortic dissection (ATAD) patients undergoing surgery.

Methods and results Totally, the data of 290 ATAD patients undergone surgery were, retrospectively, analyzed. After logistic regression analysis, TCBI was identified as an independent predictor of short-term mortality in ATAD surgery. The development of receive operating characteristic (ROC) curve demonstrated that TCBI (AUC = 0.745, $P < 0.001$) could provide well prognostic value for short-term mortality. Accordingly, the optimal cut-off value was identified as 883.5 and patients were divided into high TCBI (> 883.5) and low TCBI (≤ 883.5) groups. Furthermore, Kaplan–Meier analysis illustrated that short-term mortality increased significantly in the low TCBI group than in the high TCBI group ($P < 0.0001$). In addition, the incidence of postoperative renal failure was also elevated in the low TCBI group ($P = 0.0011$).

Conclusion Malnutrition by preoperative TCBI presented strong prognostic value for patients following ATAD surgery. And TCBI could be applied for risk stratification and therapeutic strategy-making in ATAD.

Keywords ATAD · TCBI · Malnutrition · Short-term mortality

Introduction

Acute type A aortic dissection (ATAD) is a life-threatening cardiovascular disease, of which the mortality is high if not intervened on surgical repair [1]. Regardless of the recent improvement in technology and perioperative management, the mortality of surgical treatment in ATAD patients remained high that varied between 10 and 25% [2]. Efforts have been taken to identify the high mortality markers in ATAD patients, which could provide suggestions for therapeutic strategy and perioperative management. And previous studies indicated several risk factors for poor prognosis in ATAD, including age, multiple comorbidities and various inflammatory markers [3, 4]. Nevertheless, the detailed predictors for adverse outcomes of surgical treatment in ATAD patients have not been elucidated.

Triglycerides-total Cholesterol-Body weight-Index (TCBI), as a novel simply calculated index could reflect the current nutritional status of patients. Accumulated studies have reported that TCBI was associated with the prognosis of critically ill patients [5]. And recently, TCBI was implicated as a useful prognostic indicator in patients with coronary artery diseases or heart failure [6, 7]. Though the prognostic value of nutritional status in aortic dissection has been revealed, the predictive value of TCBI in ATAD patients remains unclear. Thus, the study aimed to assess the prognostic value of preoperative TCBI for predicting outcomes in ATAD patients after surgical treatment.

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Methods

Baseline data of study population

The retrospective study enrolled the data of 290 ATAD patients undergone surgery from 2018 to 2020 June in our hospital. The clinical data were collected from the electronic medical record with the written informed consents from patients. And the diagnosis of patients was confirmed by computed tomography from native or others' hospitals. The study was approved by the Ethics Committee of ChangHai Hospital on human research.

The basic variables involved in the study included age, sex, Marfan syndrome and smoking history. The concomitant diseases including hypertension, diabetes, coronary artery diseases (CAD), stroke and acute renal failure were also collected. The data of LVEF, pericardial effusion and pleural effusion were derived from the echocardiograph by the same one operator. The serum indicators consisting of the value of albumin, creatinine, TG and TC were collected first after admission. Accordingly, the TCBI was calculated as followed: TCBI = TG (mg/dL) × TC (mg/dL) × body weight (kg)/1000 [6]. Of the markers, the nutritional status was evaluated by BMI, albumin, TG, TC and TCBI. For the prognosis, the adverse outcome was defined as short-term mortality in 30 days after ATAD surgery. Additionally, the surgical complications were also collected. The diagnosis of postoperative pulmonary infection was based on the computed tomography and bacterial culture of sputum. And preoperative renal failure was diagnosed according to Acute Kidney Injury Network (AKIN) criteria [8]. In addition, the postoperative intubation time > 72 h was considered as prolonged intubation [9].

Statistical analysis

The analysis of the study was performed through Software of R 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria) and SPSS 20. The category parameters were depicted as frequency(percentage) and compared by chi-square test or Fisher's test. And the continuous variables were delineated as mean ± standard deviation or median(percentile), and compared by *T* test or Mann–Whitney *U* test. Subsequently, univariate and multivariate logistic regression analysis were carried for predictors of short-term mortality. In addition, the receive operating characteristic (ROC) curve was established for evaluating the ability for predicting prognosis. The optimal cut-off value was also identified through the ROC curve according to the Youden index method. And method used to determine this cut-off was based on previous reports [10]. Then the data of patients were divided into high TCBI and low TCBI group based on the optimal cut-off value for comparing. The value of $P < 0.05$ was deemed as statistical significance.

Results

Baseline characteristics

In total, the clinical data of 290 ATAD patients were analyzed in the study. The baseline characteristics of the patients were delineated. Of the patients enrolled in the study, the average age was 52.6 ± 9.3 years and 76.6% were male. Totally, 33 patients died in 30 days after ATAD surgery and the short-term mortality was determined as 11.4%. The incidence of postoperative renal failure and infection was collected as 13.4% and 18.3 respectively. In addition, the preoperative nutritional status was assessed by BMI, TCBI and the serum level of albumin, TC (total Cholesterol) and TG (Triglycerides). And the value of BMI (24.8(22.9, 26.9) vs 23.0(22.0, 24.2)), TCBI (967.1(705.5, 1710.3) vs 665.9(458.5, 848.0)), TC (164.8 ± 37.5 vs 146.7 ± 32.3) and TG (87.7(69.1,126.7) vs 70.9(50.5,90.8)) were all high in survival population. Other clinical details could be found in Supplementary Table 1.

Prognostic value of malnutrition by TCBI for short-term mortality in ATAD

Subsequently, univariate and multivariate logistic regression analysis were performed to determine the predictors of short-term mortality after ATAD surgery (Table 1). Through univariate analysis, age, variables including BMI, albumin, TC, TG, LVEF and TCBI were identified. And after multivariate analysis involving discrepant parameters above, age (OR 0.951, 95%CI 0.912–0.992, $P = 0.018$), LVEF (OR 1.068, 95%CI 1.006–1.135, $P = 0.032$), and TCBI (OR 1.004, 95%CI 1.001–1.007, $P = 0.022$) were determined as independent predictors of short-term mortality after ATAD surgery. For further evaluating the prognostic value of TCBI in predicting ATAD mortality, the ROC curve was established in nutritional parameters including BMI, albumin, TC, TG and TCBI. Consistently, TCBI (AUC = 0.745, $P < 0.001$) presented well predictive value for short-term mortality in ATAD, while the prognostic value of BMI, albumin, TC and TG were low (Fig. 1).

Short-term survival analysis

After the predictive value of TCBI for short-term mortality in ATAD was presented, the optimal cut-off value of TCBI was analyzed through the ROC curve. And the optimal cut-off value of TCBI for short-term mortality was identified as 883.5 based on the Youden index method (Supplementary Figure 1). Then the data were divided high TCBI group (TCBI > 883.5) and low TCBI group (TCBI ≤ 883.5)

Table 1 Logistic regression analysis for p**re**operative characteristics predictive of mortality

Variables	Univariate		Multivariable	
	OR (95%CI)	*P* value	OR (95%CI)	*p* value
Age, years	0.927 (0.891–70.964)	**< 0.001***	0.951 (0.912–0.992)	**0.018***
Male	0.952 (0.408–2.220)	0.909		
BMI	1.165 (1.1023–1.326)	**0.021***	0.951 (0.912–0.992)	0.658
Marfan syndrome	1.030 (0.292–3.628)	0.963		
Bicuspid aortic valves	0.635 (0.072–5.607)	0.683		
Smoking	1.040 (0.473–2.286)	0.923		
Hypertension	1.391 (0.666–2.905)	0.380		
Diabetes	1.431 (0.179–11.453)	0.736		
CAD	0.280 (0.069–1.141)	0.076		
Stroke	0.245 (0.043–1.393)	0.113		
Acute renal failure	0.781 (0.302–2.018)	0.609		
Albumin	1.079 (1.000–1.163)	**0.050***	1.006 (0.915–1.107)	0.894
Creatinine	0.999 (0.991–1.008)	0.858		
Bilirubin	0.999 (0.968–1.030)	0.926		
TG	1.012 (1.002–1.023)	**0.019***	0.970 (0.939–1.002)	0.064
TC	1.016 (1.004–1.027)	**0.009***	0.990 (0.970–1.011)	0.355
TCBI	1.002 (1.001–1.003)	**0.002***	1.004 (1.001–1.007)	**0.022***
LVEF	1.054 (1.004–1.108)	**0.035***	1.068 (1.006–1.135)	**0.032***
Pericardial effusion	1.431 (0.565–3.625)	0.450		
Pleural effusion	1.983 (0.253–15.524)	0.514		
Coronary sinus tear	0.400 (0.149–1.079)	0.070		

*The value of $P < 0.05$ was noted as bold

BMI body mass index, *CAD* coronary artery disease, *TG* total glyceride, *TC* total cholesterol, *TCBI* triglyceride cholesterol, body weight index, *LVEF* left ventricular ejection fraction.

according to the optimal cut-off value. Subsequently, the result of Kaplan–Meier analysis demonstrated that the short-term mortality in the low TCBI group was significantly higher than in the high TCBI group ($P<0.001$) (Figure 2), further indicating the prognostic value of TCBI in ATAD.

Surgical complications associated with malnutrition by TCBI

Postoperative complications were summarized in Table 2. Of the 142 patients with low TCBI, 28 (19.7%) experienced postoperative renal failure. And the incidence of postoperative renal failure was significantly elevated in the low TCBI group compared with the high TCBI group. Furthermore, the Kaplan–Meier analysis provided evidence for that the occurrence of postoperative renal failure was higher ($P = 0.0011$) in the low TCBI group (Fig. 3). In addition, the Pleural fluid in 24 h after surgery was also higher in the low TCBI group ($P = 0.042$). However, the incidence of other postoperative complications including infection, stroke and paraparesis presented no significant difference between the two groups.

Discussion

In the present study, the prognostic value of TCBI for mortality in ATAD patients undergoing surgical treatment was investigated. And we found that ATAD patients with lower TCBI were prone to poor surgical prognosis, whereas the predictive value of other single nutritional indexes including BMI and albumin was limited. Given that TCBI was derived from common and objective laboratory indexes, it was promising enough to be applied in clinics to provide evidence for adverse outcomes in ATAD patients.

As one of the most catastrophic cardiovascular diseases, the mortality of ATAD after emergency surgery remained high [11]. Thus, establishing preoperative predictive model for prognosis was beneficial for therapeutic strategies. Although several scoring systems have been developed for ATAD prognosis prediction [12], the malnutrition facet of patients was always ignored. Nevertheless,

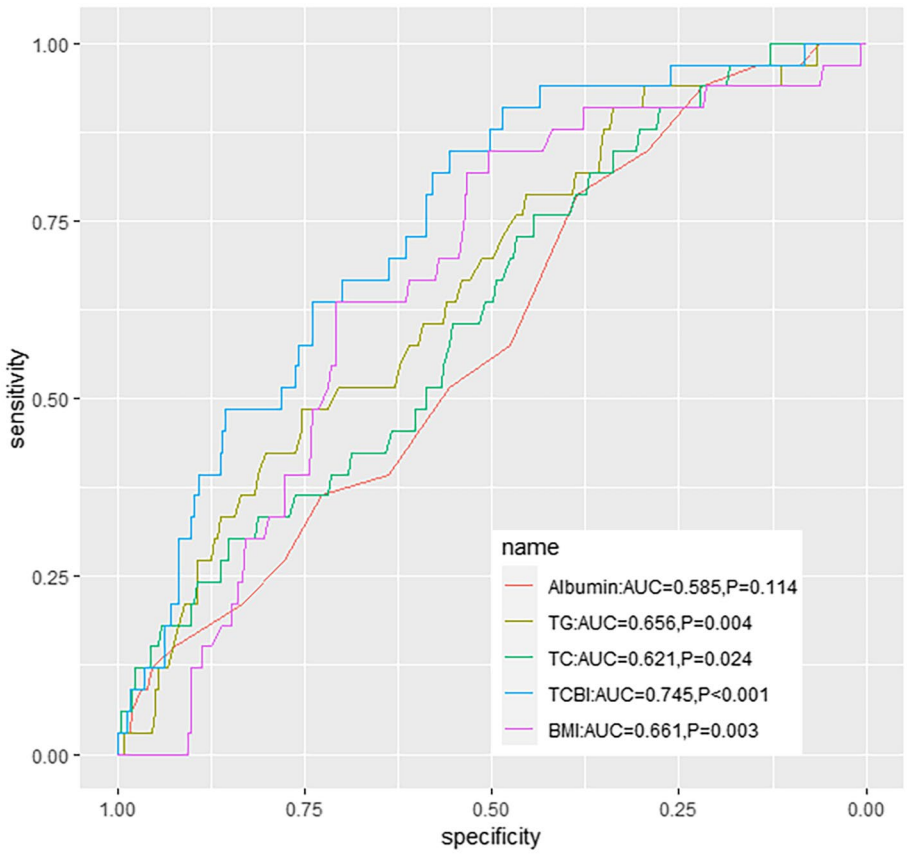

Fig. 1 The receiver operating characteristic curve of nutritional status by several indicators to determine the predictive accuracy for short-term mortality in 30 days after ATAD surgery. *TG* Triglycerides, *TC* Total cholesterol, *TCBI* Triglycerides-total cholesterol-body weight-index, *AUC* Area under the curve

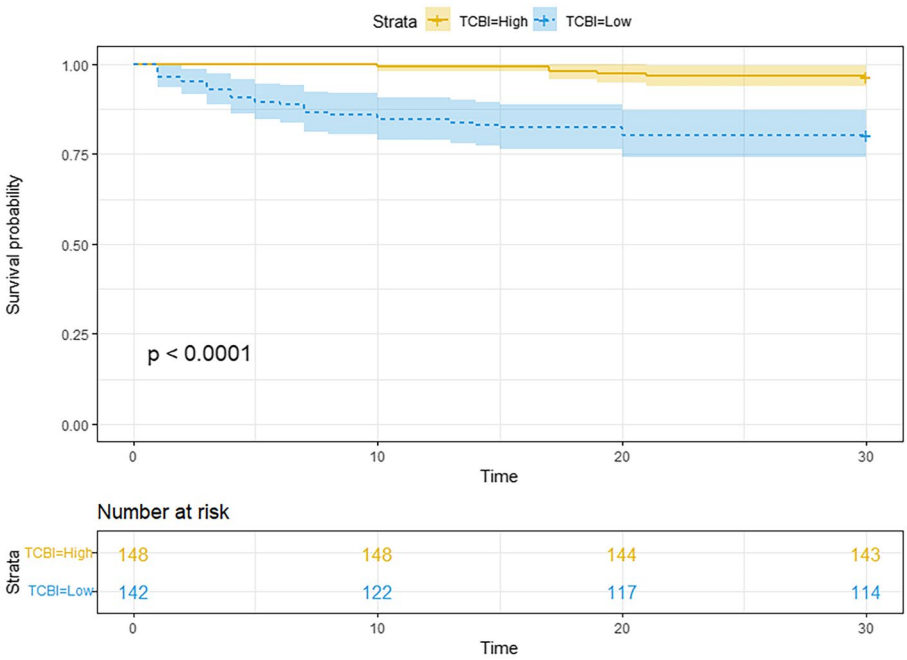

Fig. 2 Kaplan–Meier curve analysis for the short-term mortality in 30 days after ATAD surgery between the high TCBI (> 883.5) group and low TCBI (≤ 883.5) group. *CBI* Triglycerides-total cholesterol-body weight-index

Table 2 Postoperative outcomes for different TCBI groups

Variables	TCBI ≤ 883.5 ($n = 142$)	TCBI > 883.5 ($n = 148$)	P value
Reoperation for bleeding	7 (4.9)	9 (6.1)	0.799
Prolonged intubation	43 (30.3)	53 (35.8)	0.322
Stroke	6 (4.2)	7 (4.7)	1.000
Renal failure			**0.009***
None	114 (80.3)	137 (92.6)	
Stage I	7 (4.9)	4 (2.7)	
Stage III	9 (6.3)	5 (3.4)	
Stage III	12 (8.5)	2 (1.4)	
Infection	29 (20.4)	24 (16.2)	0.366
Paraparesis	3 (2.1)	2 (2.0)	1.000
Pleural fluid in 24 h	673.5 ± 468.7	571.7 ± 377.2	**0.042***
Pericardial effusion drainage	16 (11.3)	12 (8.1)	0.428
Pleural effusion drainage	53 (37.3)	55 (37.2)	1.000
Hospital length of stay	22.6 ± 17.7	26.5 ± 16.9	0.052
ICU length of stay	10.7 ± 14.9	11.0 ± 12.8	0.863
Death	28 (19.7)	5 (3.4)	**< 0.001***

*The value of $P < 0.05$ was noted as bold

ICU intensive care unit

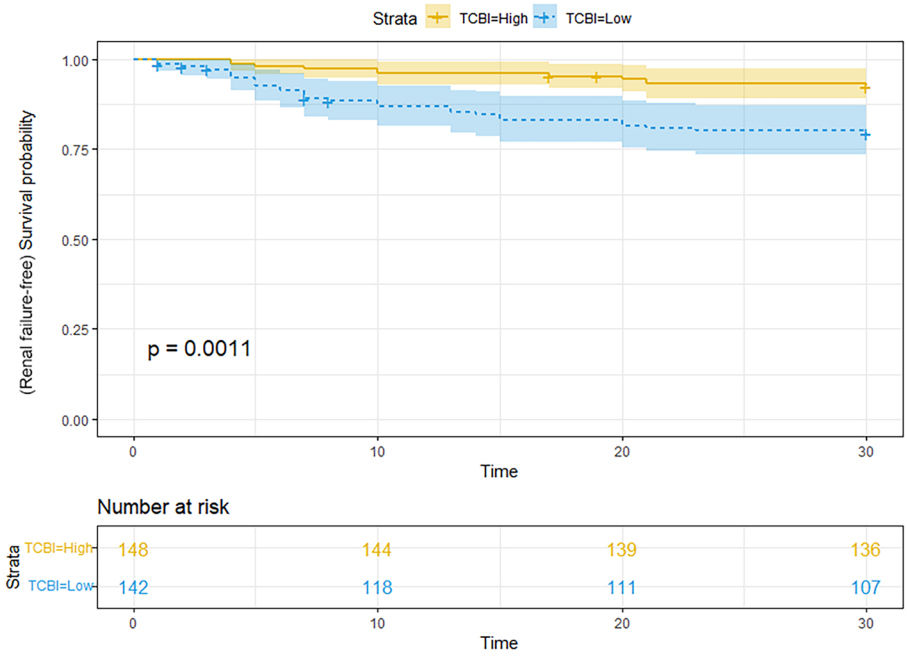

Fig. 3 Kaplan–Meier curve analysis for the postoperative renal failure in 30 days after ATAD surgery between the high TCBI (> 883.5) group and the low TCBI (≤ 883.5) group. *CBI* Triglycerides-total cholesterol-body weight-index

previous study has demonstrated that ATAD patients undergoing surgical repair were at high risk for malnutrition [13]. It was reasonable to speculate that preoperative malnutrition status may add risks for surgical complications including increased mortality in ATAD patients. TCBI is a novel and simple nutrition tool, whose calculation required multiplying 3 cardiology-friendly variables [14]. And the result of our study confirmed that ATAD patients with frailty by low TCBI were more likely to bear a poor prognosis.

In clinical settings, there were numbers of nutritional indices proposed, including subjective questionnaires and objective indexes. However, the paucity of validated nutritional indices resulted to the inconsistency and

underestimation of malnutrition in clinic [5]. Despite all this, the contribution of frailty by malnutrition to poor outcomes after cardiac surgery have been demonstrated [15]. And most studies regarding the nutritional status employed nutritional indices obtained from subjective parameters and questionnaires concentrating on food intake and physical activities [16]. Nevertheless, objective indexes seemed more appropriate to be applied in emergency settings. And previous studies have proposed that a lower prognostic nutritional index (PNI) may be associated with in-hospital mortality of ATAD surgery [17, 18], indicating the malnutritional role of ATAD patients objectively. But the integration of inflammatory markers suggested that the PNI emphasized more on malnutritional facet in inflammatory prognostication [19]. Thus, the role of malnutrition by complete nutritional markers in ATAD surgery were warranted to be clarified.

TCBI, as an objective nutritional index consisting of body weight and serum level of TC and TG, could reflect the intrinsic metabolism of fat, cholesterol, carbohydrates and sugar [5]. Originally, TCBI was established for nutrition assessment in atherosclerotic cardiovascular diseases [6]. Additionally, the association between TCBI and the mortality of other cardiovascular diseases was delineated, including dilated cardiomyopathy and acute decompensated heart failure [7, 20]. In our study, the result presented the prognostic value of TCBI in ATAD, which was better than BMI. Though BMI was also a surrogate indicator for the prognostic evaluation in ATAD, the common phenomenon of 'obesity paradox' existing in the cardiovascular field restricted the significance of BMI. The adverse outcomes of cardiovascular diseases in low BMI patients may be mediated by poor nutrition and frailty [21]. Though the prognostic significance of malnutrition by TCBI was demonstrated, the comparison of the prognostic value of different nutritional indexes in ATAD was required in further study.

The mechanism underlying the relevance between lower TCBI and poor outcomes of ATAD patients was still unclear. However, lower TCBI reflected the malnutritional status and the poor general condition is related to all-cause mortality in ATAD [18]. In addition, ATAD patients are suffered from ischemia, hypoxia and circulatory dysfunction in the whole body, a stated high decomposition and low synthesis of nutrients, which directly affect the ATAD surgical prognosis [22]. Moreover, malnutritional status in ATAD patients will further lead to weakened immune system, while the long-term ATAD surgery causes the secretion of larger amounts of inflammatory factors [18]. The immune system disorder could lead to systemic inflammatory response syndrome, which may result in multiple organ injury. And in our study, the occurrence of renal failure after surgery was higher in low TCBI patients. But the specific pathophysiological mechanisms need further study.

Comparing with other nutritional markers, the most significant advantage of TCBI was its characteristics of simplicity and easy availability in the clinic. The results of the study delineate for the first time to our knowledge an important role of TCBI in predicting the mortality and morbidity of ATAD surgery. Therefore, TCBI could be enrolled in the classification and scoring system for the ATAD therapy, as an aspect of nutritional status. In addition, the results provided further evidence for the imperativeness of the utilization of nutritional therapy in ATAD patients, which may improve surgical outcomes [13].

Nevertheless, the study has several limitations. Firstly, the study was a retrospective study with some typical flaws including various bias. Second, the data enrolled in the study was from a single center in Asia, the result from which may not be suitable for the general population. For instance, the cut-off value derived from our study was different from previous studies. Thus, further investigations involving multiple centers were required to validate the conclusion and determine a suitable cut-off value. In addition, it's notable that Asian individuals are predisposed towards visceral obesity, compared to white individuals [23]. Therefore, further study in different races were merited. And the extremely obese patients or patients with dyslipidemia with poorly controlled TG and cholesterol that were not excluded from the study may affect the result. Finally, some potential risk factors such as hemodynamic data were failed to be collected.

Conclusion

Low TCBI, reflecting physical malnutritional status, was closely associated with short-term surgical outcomes in ATAD patients. As a novel and simple nutritional marker, TCBI was easily calculated and could be routinely in the clinic. Therefore, in addition to being involved in the traditional scoring system, TCBI have enough ability to provide evidence for risk stratification and perioperative management in ATAD patients.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11748-023-01949-0.

Declarations

Conflict of interest The authors declare that we have no financial conflict of interest.

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