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Prognostic factors of hospital mortality for unplanned re-exploration after cardiovascular surgery

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Abstract

Objective To explore the prognostic factors of hospital mortality for unplanned re-exploration after cardiovascular surgery. Methods We retrospectively analyzed the data of 100 patients who underwent unplanned re-exploration after cardiovascular surgery in our hospital between May 2010 and May 2020. There were 77 males and 23 females, aged (55.1±15.2) years. Demographic characteristics, operation information, perioperative complications were collected to set up a database. The patients were divided into survival group and non-survival group according to hospital mortality. Logistic regression was used for multivariable analysis to explore the prognostic factors of hospital mortality. These statistically significant indicators were selected for drawing the receiver operating characteristic curve of the evaluation model, calculating the area under the curve(AUC) and evaluating the effectiveness of the new model with Hosmer-Lemeshow C-statistic. Results Hospital mortality was 26.0% (26/100). Multivariate logistics regression revealed that the operation time of unplanned re-exploration, the worst blood creatinine within 48h before the re-exploration, the worst lactate within 24h after the re-exploration, cardiac insufficiency, respiratory insufficiency, and acute kidney injury were independent prognostic factors ($p<0.05$). The AUC of the new assessment model constituted by these prognostic factors was 0.910, and the Hosmer-Lemeshow C-statistic was 4.153 ($P= 0.762$). Conclusions The operation time of unplanned re-exploration, the worst blood creatinine value within 48h before the re-exploration, the worst lactate value within 24h after the re-exploration, cardiac insufficiency, respiratory insufficiency, and acute kidney injury were independent prognostic factors of hospital mortality for unplanned re-exploratio after cardiovascular surgery.

Prognostic factors of hospital mortality for unplanned re-exploration after cardiovascular surgery

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[**Abstract] Objective** To explore the prognostic factors of hospital mortality for unplanned re-exploration after cardiovascular surgery. **Methods** We retrospectively analyzed the data of 100 patients who underwent unplanned re-exploration after cardiovascular surgery in our hospital between May 2010 and May 2020. There were 77 males and 23 females, aged (55.1±15.2) years. Demographic characteristics, operation information, perioperative complications were collected to set up a database. The patients were divided into survival group and non-survival group according to hospital mortality. Logistic regression was used for multivariable analysis to explore the prognostic factors of hospital mortality. These statistically significant indicators were selected for drawing the receiver operating characteristic curve of the evaluation model, calculating the area

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under the curve(AUC) and evaluating the effectiveness of the new model with Hosmer-Lemeshow C-statistic. **Results** Hospital mortality was 26.0% (26/100). Multivariate logistics regression revealed that the operation time of unplanned re-exploration, the worst blood creatinine value within 48h before the re-exploration, the worst lactate value within 24h after the re-exploration, cardiac insufficiency, respiratory insufficiency, and acute kidney injury were independent prognostic factors (p <0.05). The AUC of the new assessment model constituted by these prognostic factors was 0.910, and the Hosmer-Lemeshow C-statistic was 4.153 (P= 0.762).**Conclusions** The operation time of unplanned re-exploration, the worst blood creatinine value within 48h before the re-exploration, the worst lactate value within 24h after the re-exploration, cardiac insufficiency, respiratory insufficiency, and acute kidney injury were independent prognostic factors of hospital mortality for unplanned re-exploratio after cardiovascular surgery. To identify thess factors can promote preventive measures effectively and improve the prognosis of patients.

[Key words] cardiovascular surgery; re-exploration; hospital mortality; prognostic factor

Unplanned re-exploration is a serious adverse event after cardiovascular surgery, which will prolong the patient's hospital stay, ICU stay, mechanical ventilation time, and ultimately lead to an increase in the incidence of complications[1-3]. The study showed that hospital mortality rate of patients underwend unplanned re-exploration was 8%-25% [4], which was far higher than that of patients who did not underwent secondary thoracotomy. A large number of previous studies have mostly focused on patients with severe bleeding or cardiac arrest after cardiac surgery, focusing on the factors related to the second open thoracotomy after cardiovascular surgery. These results showed that elderly age, low body mass index, long cardiopulmonary bypass time, and secondary surgery are independent prognostic factors for patients who require a redo thoracotomy after cardiovascular surgery [5-7]. On the basis of previous research, combined with the characteristics of our hospital, we took patients who underwent unplanned re-exploration after cardiac and aortic surgery as the research objectives, and explored the prognostic factors of hospital mortality after re-exploration. In order to better screen critically ill patients after redo thoracotomy, improve the clinical treatment effectively, and improve the prognosis of patients.

Materials and Methods

Research objective We retrospectively analyzed the data of consecutive patients who underwent cardiac and aortic surgery in our hospital between May 2010 and May 2020. Inclusion criteria: (1) accepted cardiac and aortic surgery; (2) stayed in the ICU after the operation; (3) performed unplanned re-exploration for exploratory surgery. Exclusion criteria: Accept minimally invasive surgery, including robotic heart surgery. A total of 4 329 patients undergoing cardiac and aortic surgery were admitted during the period, of which 110 patients were stranded in the ICU after unplanned re-exploration after cardiovascular surgery, and 10 minimally invasive surgery were excluded. Thererfor, a total of 100 patients were included in the analysis. There were 77 males and 23 females, aged (55.1+-15.2) years (range: 15 to 75 years), and body mass index was (22.2+-3.0) kg/m^2 (range: 17.1 to 35.2 kg/m^2). Fifty-five patients had a history of hypertension, and 17 patients had a history of diabetes.

This study is a retrospective study, with informed consent from patients or one of family members. This study has been approved by the ethics committee of the Chongqing Kanghua Zhonglian Cardiovascular Hospital and Army Medical Center of PLA, and has been recognized as exempt from ethical review.

Research methods 2.1 Information Collection Collect the patient's demographic characteristics, operation information, postoperative information and perioperative complications. Demographic characteristics includes age, sex, body mass index, high blood pressure and diabetes history. Operation information includes operation time, operation methods (including, coronary artery bypass grafting, valve surgery, aortic surgery and other operations), whether it is an emergency operation, whether it is a second operation, and whether it is an extracorporeal bypass operation. The postoperative information includes the reason and time of the re-exploration and the re-operation time, the liver and kidney indexes (serum creatinine, urea nitrogen, AST, ALT, total bilirubin, direct bilirubin) of the patient within 48 hours, the worst blood lactate and blood potassium values within 24 hours, whether intra-aortic balloon pump (IABP) is required, whether

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extracorporeal membrane oxygenation (ECMO) therapy or continuous renal replacement therapy (CRRT) is required. Perioperative complications mainly including cardiac insufficiency (New York Heart Association grade III˜IV), acute kidney injury, perioperative liver insufficiency, respiratory insufficiency, lung and blood infection, craniocerebral complications (brain infarction, cerebral hemorrhage, coma, delirium and confusion), atrial fibrillation and ventricular fibrillation. 2.2 Establish an assessment model of inpatient mortality The end of the observation was the hospital mortality of the patients. The differences between the variables of the survival group and the death group were compared, and meaningful variables of univariate analysis were incorporated into the Logistics regression model for multivariate analysis to clarify the prognostic factors that affect the patient's death in hospital, and construct a scoring model based on the prognostic factors. 2.3 Test the evaluation performance of the model These statistically significant indicators were selected for plotting the receiver operation characteristic curves, calculating the area under the curve(AUC). The Hosmer-Lemeshow C-statistic was used to evaluate the efficiency of the new model.

Statistical analysis SPSS 22.0 statistical software was used to analyze the data. The quantitative data of the normal distribution is expressed as ?x +- s, and the independent sample t test is used for the comparison between groups; the quantitative data of the non-normal distribution is expressed as M (QR), and the non-parametric Mann-Whitney U test is used for the comparison between groups.Frequency and percentage are expressed, and comparisons between groups are performed by χ^2 test or Fisher's exact probability method. Univariate analysis$P$ <0.05 variables were included in the Logistics regression model for multivariate analysis to determine the prognostic factors of the patient's hospital mortality, and based on the results of the multivariate analysis, the receiver operating characteristic curve was drawn and the AUC was calculated. The difference was statistically significant with P <0.05.

Results

In this study, the hospital mortality of unplanned re-exploration was 2.5% (110/4 329), and the hospital mortality of the enrolled patients was 26.0% (26/100). The results of univariate analysis showed that there were statistically significant differences in the operation time, whether it was a cardiopulmonary bypass operation, and whether it was an emergency operation between the survival group and the non-survival group (Table 1).

Compared with patients in the survival group, patients in the non-survival group had a lower rate of re-exploration due to excessive drainage, however, a higher rate of re-exploration due to ventricular fibrillation and unexplained circulatory instability. In non-survival group, the second thoracotomy exploratory operation time is longer, and the ratio of ECMO and CRRT before and after the second exploratory is higher. The differences in the worst liver and kidney function indexes within 48 hours before and after the re-exploration and the worst blood lactic acid value and the worst serum potassium value within 24 hours before and after the re-exploration between the two groups were statistically significant (Table 2). The incidence of cardiac insufficiency (New York Heart Association grade III˜IV), respiratory insufficiency, acute kidney injury, perioperative liver insufficiency, blood infection, and craniocerebral complications in the non-survival group after the re-exploration was significantly higher than that of survival group of patients (Table 3).

The statistically significant variables in the univariate analysis were incorporated into the Logistics regression model for multivariate analysis. The results showed that the worst blood creatinine value within 48h before the re-exploration, the worst blood lactate value within 24h after the re-exploration, cardiac insufficiency, respiratory insufficiency, and acute kidney injury are the prognostic factors of hospital mortality in patients undergoing re-exploration after cardiovascular surgery (Table 4). Based on these prognostic factors, the evaluation model of hospital mortality of patients with re-exploration after cardiovascular surgery was constructed. The AUC of this model was 0.910, and the evaluation efficiency was good (χ^2=4.153, P =0.762).

In addition, according to the reasons for the re-exploration, the patients are divided into A (ventricular fibrillation + unexplained circulatory instability re-exploration patients) and B (different drainage + pericardial tamponade + re-exploration patients with other reasons) group. The time of the re-exploration in group A

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was 3.0 (3.0) h, which was longer than 2.0 (0.5)h in group B (Z = -5.929,P =0.000); the ICU retention time was 5 (7) d, which was longer than 3 (5) d in group B (Z = -2.148, P =0.032); mechanical ventilation time was 111.0 (170.6) min, which was longer than 76.0 (101.3) min in group B (Z = -2.065, P =0.039).

Discussion

Cardiac and aortic surgery is the main treatment for cardiovascular disease. Postoperative bleeding and cardiac arrest are the main complications that lead to early postoperative death or serious adverse events. When these complications are difficult to correct through conservative treatment, in order to avoid further deterioration of the disease, patients often need to undergo secondary thoracotomy exploration. The re-exploration will bring the patient a large amount of foreign blood products, the risk of mediastinal and deep soft tissue infections, and it is a prognostic factor for severe postoperative complications [8-10]. The surgical trauma of the second thoracotomy exploration and the perioperative volume control of the patient make the body prone to heart and kidney dysfunction, respiratory insufficiency, and even multiple organ dysfunction syndrome, which seriously affects the patient's prognosis.

In this study, the second thoracotomy exploratory operation time of patients in the non-survival group was significantly higher than that of patients in the survival group. Research results show that the operation time is obviously related to postoperative complications. Every time of the operation time is extended by 1 hour, the risk of complications will increase accordingly [11-13]. However, in addition to the operation method itself, the severity of the patient's disease and the level of the surgeon will also affect the operation time [14]. In the future, it is necessary to further explore the reasons for the prolonged operation time in order to better clarify the relationship between it and the patient outcome.

Blood lactic acid level is also a prognostic factor for hospital mortality after cardiac surgery, and it can more sensitively reflect the state of hypoperfusion and insufficient oxygen supply in the early stage [15-16]. The hemodynamics of cardiacr surgery patients are not stable within 24 hours after operation, which is likely to cause lactic acid accumulation. Therefore, it is very important to closely monitor the changes of lactic acid within 24 hours after operation. Once abnormal blood lactic acid is found, if it can effectively improve tissue perfusion and oxygenation in a short period of time, it will significantly improve the clinical treatment effect of cardiac surgery patients.

Acute kidney injury is a common serious complication after cardiac surgery and an independent prognostic factor of hospital mortality after cardiac surgery. Serum creatinine is closely related to changes in renal function after cardiac surgery. A slight increase in this index (>0.017 mmol/L) will significantly prolong hospital stay and mortality [17-18]. The results of our study showed that the worst serum creatinine value in the non-survival group within 48 hours before the second thoracotomy exploration was significantly higher than that of the survival group, suggesting that monitoring of serum creatinine during the perioperative period has a certain value in evaluating the outcome of patients. The AUC of this model is 0.910, and the evaluation performance is good (χ^2=4.153,P =0.762), which further shows that these prognostic factors have a high evaluation value for the hospital mortality of patients with re-exploration. Additonally, there is a good degree of fit between the data and the patient's outcome. To clarify the prognostic factors of hospital mortality in patients with re-exploration can effectively guide us to timely screen critically ill patients after cardiaovascular surgery, adjust clinical treatment strategies in time, and improve the prognosis of patients.

Among the 100 patients in this study, 25 patients had a re-exploration due to unexplained circulatory instability and ventricular fibrillation. Among them, 48.0% (12/25) patients died. This group hostital mortality (48.0%) was much higher than that of patients hostital mortality [18.7% (14/75)] who had re-exploration due to large drainage and other reasons. Compared with the former, the purpose of the second exploratory thoracotomy in the latter group is clear. It can effectively relieve the symptoms of patients and improve the prognosis through timely and effective second exploratory thoracotomy to stop bleeding and place drainage. When the patient undergoes a second exploratory thoracotomy due to circulatory instability or ventricular fibrillation caused by an unknown reason, the purpose and method of the operation before re-exploration are not clear. Secondary exploratory thoracotomy is often only used as a rescue operation. It is

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necessary to choose cardiopulmonary resuscitation, application of mechanical assistance, or another surgical treatment such as coronary artery bypass grafting according to the patient's intraoperative situation, which makes the re-operation time relatively prolonged and seriously affects the prognosis of patients. However, since this study only included patients who underwent secondary thoracotomy due to ventricular fibrillation or circulatory instability, the pros and cons of the treatment results compared with patients who did not undergo secondary thoracotomy are still uncertain, and further analysis is needed in the future. Clarifying the purpose of surgery and the reason for re-exploration has high clinical value for evaluating the patient's condition and formulating precise treatment plans.

Conclusions

This study still has some limitations. First of all, whether anticoagulant drugs are used before re-exploration, the type of anticoagulant drugs used and the time of application have a greater impact on postoperative bleeding and the prognosis of patients [19-20]. In addition, due to the lack of original data, the corresponding analysis of anticoagulant drugs could not be performed in this study. Secondly, this study is a single-center retrospective study with a small sample size, which reduces the scientific nature of the research results. In the future, we need to collect more complete case data while expanding the sample size, and further verify the results through multi-center studies.

Data availabity statement : all data used during this study can be shared.

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Conflict of interest: All authors declare that there is no conflict of interest.

Ethical review: This study has been approved by the ethics committee of the Chongqing Kanghua Zhonglian Cardiovascular Hospital and Army Medical Center of PLA, and has been recognized as exempt from ethical review.

Informed consent (or waiver) statemen t: This study is a retrospective study, with informed consent from patients or one of family members.

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