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Research Article

Predictive Value of Thromboelastography for Postoperative Blood Loss in Infants Undergoing Cardiac Surgery

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Abstract

Thromboelastography (TEG) has emerged as a critical tool in promptly identifying the risk of postoperative bleeding, especially in infants and young children undergoing cardiac surgery. By meticulously analyzing TEG parameters, clinicians gain a profound understanding of patients' coagulation status, enabling timely intervention to minimize and manage postoperative bleeding risks. The present study adopts a rigorous, prospective, and observational approach to explore the relationship between intraoperative TEG test results and postoperative blood loss. Furthermore, it aims to assess the potential of intraoperative TEG testing as an early predictor of postoperative bleeding in high-risk pediatric patients. In this process, a key focus is placed on perioperative red blood cell suspension and platelet transfusion volume, as well as their association with TEG testing outcomes. Our findings reveal a significant correlation between the volume of red blood cell suspension and platelet transfusion and the MA value derived from TEG testing. The MA value, a pivotal indicator in TEG test results, represents the maximum clotting strength. Notably, during perioperative red blood cell suspension and platelet transfusion, the MA value often exhibits corresponding changes. These changes not only reflect improvements in coagulation function but also provide clinicians with an objective basis for evaluating the effectiveness of blood transfusion. However, despite the notable impact of blood transfusion on MA values, our study did not detect statistically significant associations between blood transfusion and other TEG parameters, including TEG-ACT values, α-Angle, and LY30. This absence of significant associations may be attributed to the differential effects of various transfusion components on the coagulation process, as well as the influence of confounding factors such as patient age, comorbidities, and surgical procedure type.

Keywords

Thromboelastography, Cardiac Surgery, Postoperative Hemorrhage, Cardiopulmonary Bypass

1. Introduction

In recent years, the advancement of surgical techniques and perioperative management has significantly improved the survival rate of children with congenital heart disease. However, postoperative bleeding remains a serious complication that can lead to adverse outcomes. Therefore, identifying the risk factors of postoperative bleeding and taking timely measures to prevent and control it are crucial for improving the surgical outcomes of these patients. Postoperative bleeding after cardiac surgery is an important factor affecting the prognosis and mortality of patients. Postoperative bleeding occurs in about 20% of patients after cardiac surgery, about 10% of patients have massive bleeding, and up to 5% of pa-

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tients need urgent exploration to stop bleeding [1]. Studies have shown that massive postoperative bleeding is one of the independent risk factors for the increased incidence of major adverse events after cardiac surgery in children with congenital heart disease, namely dialysis and extracorporeal membrane oxygenation (ECMO) support [2], which can further complicate the recovery process and increase the burden on the healthcare system. To identify the risk factors of postoperative bleeding in infants undergoing cardiac surgery early, so as to help clinicians detect and treat postoperative bleeding early.

Thromboelastography (TEG) has been used to evaluate primary and secondary coagulopathy for more than 80 years [3]. Its application in the perioperative period of cardiac surgery has gradually received attention, and it is also used in liver transplantation, obstetrics, trauma or various types of massive hemorrhage surgery and other fields. As a point of care testing (POCT) technology, TEG has important clinical significance in perioperative coagulation function assessment, anticoagulation monitoring, postoperative bleeding risk prediction, and guidance of component blood transfusion.

One potential tool for early identification of postoperative bleeding risk is the thromboelastography (TEG) test. TEG is a hemostasis testing method that provides a dynamic and comprehensive evaluation of the coagulation process. It can assess the viscoelastic properties of blood clots, reflecting the overall coagulation status of the patient.

Previous studies [4, 5] have shown that intraoperative TEG test results can provide valuable information about the coagulation status of patients undergoing cardiac surgery. By analyzing the TEG parameters, such as reaction time, clot formation time, and maximum clot firmness, clinicians can assess the risk of postoperative bleeding and make informed decisions about perioperative hemostasis management. Moreover, intraoperative TEG testing has the potential to identify patients with a high risk of postoperative bleeding early on. This allows clinicians to take proactive measures [6], such as adjusting anticoagulant therapy or preparing for possible postoperative bleeding, thereby reducing the occurrence of adverse events and improving patient outcomes.

In conclusion, intraoperative TEG testing can be a valuable tool for early identification of postoperative bleeding risk in infants undergoing cardiac surgery. By analyzing the TEG parameters, clinicians can gain insights into the coagulation status of patients and take timely measures to prevent and control postoperative bleeding. Future studies are needed to further validate the role of intraoperative TEG testing in predicting and managing postoperative bleeding in this patient population.

Therefore, this study aims to observe the relationship between intraoperative TEG test results and postoperative blood loss, and to explore whether intraoperative TEG test can identify early postoperative bleeding in infants with high risk of postoperative bleeding.

2. Methods

This study is a prospective, observational study was to explore pediatric cardiac surgery, especially in extracorporeal circulation (cardiopulmonary bypass, CPB) under the support of blood coagulation changes and postoperative bleeding. And many medical studies, this study did not involve any interventions, but focuses on the observation and record the natural course and response of patients. children aged 0-3 years who underwent open cardiac surgery under CPB in West China Hospital of Sichuan University from October 2020 to December 2022 were enrolled. Exclusion criteria: (1) age > 3 years old; (2) preoperative extracorporeal life support; (3) preoperative renal insufficiency; (4) severe infection, such as sepsis; (5) participating in other clinical studies that conflicted with this study during the same period. Postoperative blood loss was recorded as the volume of pericardial and mediastinal drainage per hour after the children were transferred to PICU, the statistical nodes were 4h, 12h, and 24h after the operation. In this study, TEG detection was done by an advanced TEG 5000 instrument, which ensured the accuracy and reliability of the test results.

3. Results

During the study period, a rigorous screening process was conducted, resulting in the identification of 296 patients. Of these patients, 251 children were excluded due to their age exceeding three years or the absence of CPB. Subsequently, a total of 84 children were eligible for enrollment in the study. However, six children were subsequently lost to follow-up as they withdrew from the study due to the decision to abandon treatment. Consequently, the final cohort for statistical analysis comprised 39 children.

Table 1 presents a comprehensive analysis of the correlation between TEG test results and the utilization of blood products. Notably, a statistically significant correlation was observed between the amount of red blood cell suspension and platelets utilized during the perioperative period and the MA value, which represents the maximum clot strength in the TEG test results. Conversely, no statistically significant difference was observed in the relationship between the use of blood products and the TEG-ACT value, α-Angle, or lysis 30 (LY30).

4. Discussion

TEG is considered to offer more comprehensive details regarding risk factors for bleeding compared to traditional coagulation testing methods [7]. TEG has been utilized for assessing the risk of hemorrhage following knee surgery, pediatric cardiac surgery, and various other surgical procedures [8]. The R parameter quantifies the time taken for coagulation to commence, thereby encapsulating the efficacy of various coagulation factors. On the other hand, MA serves as an indicator of maximum clot firmness, encapsulating the collective functionality of fibrinogen and platelets.

The value of whole blood tests in diagnosing and guiding perioperative treatment and transfusion in the bleeding patient is well recognized and has been demonstrated by several authors [9]. Always about TEG in perioperative blood management research also confirmed that TEG conclusion there was a link to a certain extent [10], and the postoperative blood loss, but we only observed in the study of MA value and perioperative red blood cell suspension and statistical relationship in the usage of platelet. Compared with standard laboratory coagulation tests that can only provide static coagulation indicators, TEG test can provide a complete and dynamic coagulation process. TEG test is undoubtedly a better choice in identifying the cause of bleeding, predicting bleeding and improving coagulation. Intraoperative TEG MA<45 mm is associated with the incidence of intraoperative bleeding in pediatric patients undergoing complex cardiac surgery, and intraoperative prophylactic platelet transfusion may be associated with a reduction in ICU bleeding events in patients with MA<45 mm [11]. Platelet dysfunction can be expected in complex cardiac surgery cases due to factors such as the influence of non-physiological perfusion on coagulation function during cardiopulmonary bypass, the activation of platelets by non-biological materials, the inhibition of platelet function by systemic heparinization, and the destruction of blood components by mechanical injury of prolonged CPB bypass [12]. Deep hypothermic circulatory arrest (DHCA) technique is required in some cardiac surgeries, and low temperature can affect the coagulation function of children [13]. Forman et al. [14] performed TEG detection in 22 neonates treated with systemic hypothermia. It also predicted the risk of bleeding in children, TEG parameters were significantly different in experiments performed at 37.0 ℃ and 33.5 ℃, indicating impaired coagulation at 33.5 ℃. Their results also showed that K, αAngle, MA, and coagulation index (CI) were significantly associated with clinical bleeding, suggesting that TEG testing still has application value in bleeding risk monitoring under low temperature. However, in order to avoid direct comparison of simple, raw, numerical TEG results with standard hemostatic tests, it is the overall clinical impact that is more important when evaluating the clinical value of TEG. To assess the clinical impact of TEG, in Carter's study [15], five clinicians reviewed patients' clinical status, included standard laboratory test results, and developed a theoretical treatment plan, which was changed 71%, 44%, 53%, 60%, and 7% of the time, respectively (overall 47%). Overall show that TEG detection supports both the testing results of the blood clotting basis, has increased the standard test, provides additional information, make the clinicians have a better knowledge of the bleeding. TEG test can evaluate the coagulation status of patients, which can be used as an early diagnosis and prediction method for clinical bleeding events, and contribute to better coagulation function management.

It is indeed noteworthy that our study was not without its limitations, and these limitations may have had a significant impact on the interpretation and application of our results. Firstly, one of the most significant limitations was the relatively small sample size. With a limited number of patients included in our study, we may have been restricted in our ability to detect subtle yet potentially significant associations between thromboelastography (TEG) parameters and other outcomes of interest. This constraint may have led to the underreporting of important findings or the inability to detect meaningful trends that could have provided valuable insights into the use of intraoperative TEG testing in this patient population.

To address this limitation, larger studies with more patients would be imperative. Such studies would not only enhance our statistical power but also provide a more robust evidence base for the utilization of intraoperative TEG testing in infants undergoing open cardiac surgery with cardiopulmonary bypass (CPB). With a larger sample size, we would be able to detect smaller yet potentially clinically significant differences in TEG parameters and their association with postoperative bleeding and other outcomes.

Secondly, another limitation of our study was its single-center design. Conducting the study at a single hospital may have limited the generalizability of our findings. Surgical practices, patient demographics, and available resources can vary significantly between hospitals and regions, and these factors can have a significant impact on the results of surgical studies. Therefore, it is crucial to replicate our study in other centers and settings to assess the reproducibility and applicability of our results. By replicating our study in different centers, we can gain a more comprehensive understanding of the variations in surgical practices and patient characteristics that may affect the outcomes of intraoperative TEG testing. This would enable us to validate our findings in a more diverse patient population and assess the consistency of the results across different settings.

Finally, our study specifically focused on infants undergoing open cardiac surgery with CPB. While this population represents a high-risk group for postoperative bleeding, the results of our study may not be directly applicable to other surgical populations or age groups. The coagulation status and the need for blood product support can vary significantly depending on the type of surgery, the age of the patient, and other underlying conditions [16].

Future studies should explore the potential role of intraoperative TEG testing in different surgical scenarios and patient demographics. By including a wider range of surgical procedures and age groups, we can gain a more comprehensive understanding of the utility of TEG testing in managing postoperative bleeding and other coagulation-related complications.

In conclusion, our study provides valuable insights into the potential benefits of intraoperative TEG testing in infants undergoing complex cardiac surgery with CPB. However, it is important to acknowledge the limitations of our study and the need for further research to confirm and expand our findings. With larger sample sizes, more diverse patient populations, and replication in different settings, we can gain a deeper understanding of the role of intraoperative TEG testing in managing postoperative bleeding and other coagulation-related issues in this high-risk population.

5. Conclusion

There was a noteworthy correlation observed between the quantity of red blood cell suspension and platelets administered during the perioperative period and the MA value, which represents the maximum clot strength, in the TEG test results. However, statistical analysis did not reveal any significant difference in the relationship between the utilization of blood products and the TEG-ACT value, α-Angle, or lysis 30 (LY30).

Table 1. *The results of TEG test were correlated with the use of blood products.*

P	RBC (ml/kg)	FFP (ml/kg)	Platelets (ml/kg)	Prothrombin complex (IU/kg)
TEG-ACT	0.622	0.146	0.522	0.576
MA	0.016	0.189	0.012	0.717
α－Angle	0.395	0.053	0.443	0.053
lysis 30 (LY30)	0.127	0.285	0.073	0.506

Abbreviations

TEG	Thromboelastography
CPB	Cardiopulmonary Bypass
POCT	Point of Care Testing
ECMO	Extracorporeal Membrane Oxygenation

Ethics Approval and Consent to Participate

This is a single-center observational study. All patient data were collected from the preoperative, intraoperative and postoperative medical records of patients undergoing cardiac surgery under cardiopulmonary bypass. All children included in the study had signed informed consent from their immediate family members.

Author Contributions

Yuan Yuan is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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