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Research Article

The Relationship Between Perioperative Blood Product Use and the Incidence of Postoperative Renal Injury in Infants Undergoing Cardiac Surgery

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Abstract

Cardiac Surgery Associated Acute Kidney Injury (CS-AKI) is a serious complication that occurs in patients following cardiac surgery. It is characterized by the rapid decline in kidney function, leading to potential long-term kidney damage or even kidney failure. CS-AKI is a significant health concern, as it not only prolongs hospital stays and recovery time but also increases the risk of mortality. This study, conducted as a prospective observational study, aimed to investigate the relationship between perioperative blood product use and the incidence of postoperative acute kidney injury (AKI) in infants and young children undergoing cardiac surgery. It examined the perioperative use of these blood products and its association with the occurrence of AKI. The findings of this study revealed a significant association between the use of red blood cell suspension and platelets and the development of postoperative AKI. This suggests that the administration of these blood products during cardiac surgery may increase the risk of kidney injury in infants and young children. However, it is important to note that the study did not find a statistically significant association between plasma transfusion volume and the incidence of AKI. This suggests that while the use of certain blood products may contribute to the risk of AKI, the volume of plasma transfused does not seem to have a significant impact. The findings of this study provide valuable insights into the perioperative management of infants and young children undergoing cardiac surgery. It underscores the importance of carefully considering the use of blood products during surgery and taking necessary measures to minimize the risk of AKI.

Keywords

Cardiac Surgery, Postoperative Hemorrhage, Acute Kidney Injury

1. Introduction

Cardiac Surgery Associated Acute Kidney Injury (CS-AKI) refers to acute kidney injury after cardiac surgery. CS-AKI is one of the most common complications after cardiac surgery, and the incidence of CS-AKI in adults is 12-43% [1]. Pediatric CS - the incidence of AKI is higher than the adult, the incidence of neonatal CS - AKI as high as 62% [2], Its clinical manifestations are sudden and rapid decline of renal function, increase of serum muscle liver or decrease of urine output. CS-AKI not only increases the risk of death, but also prolongs the duration of mechanical ventilation, ICU and hospital stay, and increases the cost of hospitalization [3], It can even lead to chronic renal insufficiency, increase long-term mortality, and

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affect the long-term prognosis of children [4].

CS - AKI mechanism is not fully clear, mainly related to the following factors, including: insufficient oxygen for kidney, perioperative hypotension caused renal hypoperfusion, systemic inflammatory response syndrome and oxidative stress, hemolysis, kidney ischemia-reperfusion injury, tiny artery embolism, renal toxicity drugs, etc [5]. Renal function is highly dependent on oxygen supply. Under the conditions of ECC non-pulsatile perfusion, hemodilution, and renal vasoconstriction caused by catecholamines, the kidney is prone to imbalance of oxygen supply and demand, leading to renal tissue hypoxia and renal function damage [6]. Therefore, early detection of renal hypoperfusion and insufficient oxygen supply in ECC and timely intervention are of great clinical significance for reducing the incidence of CS-AKI and improving the prognosis of patients.

This study aims to investigate the correlation between the use of blood products and the incidence of postoperative acute kidney injury (AKI) in infants and young children undergoing cardiac surgery with cardiopulmonary bypass (CPB).

2. Methods

This study was a prospective observational study. All of the data derived from heart surgery in patients with preoperative, intraoperative and postoperative medical records. 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. Primary Outcome Measures CS-AKI, was diagnosed using the pRIFLE criteria, and the time window was one week after surgery [7, 8]. The estimated creatinine clearance (eCrCl) was calculated using a modified Schwartz-Lyon formula [9]. This study of anaesthesia and extracorporeal circulation management of west China hospital routine management standards. Data analysis by SPSS 25.0 statistical software.

3. Results

A total of 296 patients were screened during the study period, of which 212 children were excluded because of age > 3 years or no CPB. A total of 84 children were enrolled in the study, of which 6 children were lost to follow-up after withdrawing from the study because of giving up treatment, and a total of 78 children were included in the statistical analysis.

According to pRIFLE criteria, postoperative AKI children happens (AKI) and postoperative AKI children group (N - AKI) preoperative and intraoperative basic data are shown in table 1, there were no significant differences in baseline data between the two groups. The happening of the CS - AKI is determined by postoperative eCrCL, postoperative eCrCL and the relationship between perioperative blood product usage as shown in table 2, according to the results of postoperative eCrCl value and perioperative red blood cell suspension, platelet consumption of correlation, but the relationship between plasma infusion quantity has no obvious statistical significance.

Table 1. *Preoperative and intraoperative baseline data of AKI and non-AKI groups.*

	AKI (n=40)	N-AKI (n=38)	P
Hight (cm)	57.67 ±10.63	64.95 ±15.7	0.498
Weight (kg)	5.06 ±2.81	6.52 ±3.73	0.251
BSA	0.28 ±0.1	0.33 ±0.13	0.251
Hb (g/L)	126.95 ±25.86	122.68 ±24.98	0.441
Hct (L/L)	0.38 ±0.08	0.38 ±0.08	0.576
The duration of anesthesia (min)	463.05 ±117.99	453.24 ±109.63	0.170
The length of operation (min)	354.63 ±120.09	348.53 ±113.05	0.581
CPB time (min)	187.2 ±87.7	174.39 ±67.17	0.450
Blocking time (min)	104.65 ±47.38	101.13 ±50.37	0.508
Heparin (U/kg)	412.85 ±62.93	425.38 ±82.05	0.417
Protamine (mg/kg)	4.51 ±2.22	4.19 ±1.47	0.103
Basic ACT	175.4 ±28.78	170.34 ±27.26	0.954
After neutralizing heparin ACT	170.93 ±28.17	170.82 ±27.24	0.797

	AKI (n=40)	N-AKI (n=38)	P
Machine blood (ml/kg)	20.01 ±19.13	17.52 ±16.61	0.602
Autologous blood (ml/kg)	22.14 ±30.13	13.13 ±23.59	0.071

Table 2. *Relationship between postoperative eCrCL and perioperative blood product use.*

P	RBC (ml/kg)	FFP (ml/kg)	Platelets (ml/kg)
eCrC1	0.013	0.209	0.046

4. Discussion

In the present study, we aimed to delve deeper into the association between the administration of blood products and the subsequent occurrence of acute kidney injury (AKI) in a specific patient population - infants and young children undergoing cardiac surgery with cardiopulmonary bypass (CPB). Given the crucial role of renal function in maintaining homeostasis and the high risk of renal dysfunction in this patient group, our findings could have significant implications for clinical practice and patient outcomes.

Firstly, it is noteworthy that the use of blood products in cardiac surgery is often necessary to manage perioperative blood loss and maintain hemodynamic stability. However, the potential adverse effects of these interventions, particularly on renal function, have been a source of concern for clinicians [10]. Therefore, our study provides valuable insights into this complex relationship, offering a more nuanced understanding of the risks involved.

Our results indicate that there is a correlation between the use of certain blood products, such as red blood cell suspensions and platelets, and the occurrence of postoperative AKI [11]. Administration of RBC is primarily based on measurement of haemoglobin or haematocrit, but still with marked variability in transfusion practices between centres [12]. This finding is consistent with previous studies that have suggested a link between blood transfusion and renal dysfunction. However, it is important to note that the relationship is not absolute, and other factors, such as the patient's underlying condition and the surgical technique used, may also play a role.

Additionally, our study found no significant association between the amount of plasma infused and the incidence of AKI. This suggests that, while plasma transfusion may be necessary in some cases, it may not be a significant contributor to renal dysfunction in this patient population. This finding is interesting and may help clinicians to make more informed decisions about the use of plasma in cardiac surgery patients. A novel approach to studying the link between transfusion of certain blood products and AKI involves matching risk factors using propensity methods. McGrath et al. utilized this strategy to assess platelet transfusions as a standalone risk factor for AKI after on-pump cardiac surgery [13]. The propensity matching was conducted on comparable risk factors, encompassing age, duration of cardiopulmonary bypass, red blood cell transfusions, preoperative creatinine levels, and haematocrit values. Consistent with the findings of the present study, no significant correlation was observed between platelet transfusion and the occurrence of new-onset renal failure necessitating dialysis. This statistical approach ensures a more precise assessment of the risk associated with the variable of interest, owing to the extensive matching process that takes into account the majority of potential confounders. However, due to the inability to simultaneously match patients based on fresh frozen plasma (FFP) and cryoprecipitate, the impact of these variables could not be accurately evaluated. Given the diverse patterns of transfusion and the multifactorial etiology of acute kidney injury (AKI), these results should be interpreted with caution. The administration of platelets and FFP is aimed at enhancing haemostatic capacity, while red blood cell transfusion is intended to increase oxygen-carrying capacity. These blood products are not interchangeable, but the administration of FFP and platelets may contribute to the reduction of bleeding, thereby potentially decreasing the need for red blood cell transfusion.

Considering transfusion patterns and AKI's multifactorial etiology, results should be interpreted cautiously. Platelets and FFP are used to improve haemostatic capacity, while RBCs increase oxygen carrying capacity. These blood products are not interchangeable. By giving FFP and platelets, bleeding is likely to decrease, reducing the need for RBCs [14]. A low haematocrit during CPB is associated with an increased risk of AKI [15]. This may be due to preoperative anaemia, haemodilution, bleeding, or a combination. About 2/3 of patients with KDIGO stage 3 had intraoperative haematocrit $\leq$ 25%, compared to 1/3 without AKI. A low haematocrit affects oxygen delivery to the kidneys, increasing AKI risk. [16]. On top of the independent association of anaemia and transfusion with AKI, these risk factors have been shown to act synergistically through combined exposure [17]. Furthermore, significant

bleeding has been established as an individual risk factor, associated with a threefold elevation in the risk of acute kidney injury (AKI) [15]. However, due to the intricate interrelationship between anaemia and transfusions, it is virtually impossible to conclusively ascertain through observational data whether a restrictive transfusion strategy holds any beneficial effects in relation to acute kidney injury (AKI). Additionally, the previously mentioned heterogeneity in indications precludes the conduct of a randomised clinical trial to evaluate the efficacy of fresh frozen plasma (FFP) and platelets.

It is worth mentioning that the occurrence of AKI in this patient population is multifactorial, and our study only focused on the relationship between blood product usage and AKI. Future studies could explore other potential risk factors, such as the type and duration of surgery, the use of nephrotoxic drugs, and the patient's preoperative renal function, to further refine our understanding of AKI in this context.

In conclusion, our study provides valuable insights into the complex relationship between blood product usage and postoperative AKI in infants and young children undergoing cardiac surgery with CPB. While the use of certain blood products may be associated with an increased risk of AKI, other factors also play a role. Therefore, clinicians should carefully consider the risks and benefits of blood transfusion in this patient population and take a multifaceted approach to reducing the incidence of AKI and improving patient outcomes.

5. Conclusion

Postoperative eCrCl values associated with perioperative consumption suspended red blood cells, platelets, and the relationship with the amount of plasma infusion has no obvious statistical significance. Future studies could further explore the mechanisms underlying the association between blood product use and AKI, as well as identify potential strategies to mitigate this risk. In conclusion, Cardiac Surgery Associated Acute Kidney Injury is a significant complication that requires attention and proactive management. This study highlights the importance of perioperative blood product use as a potential factor contributing to the occurrence of AKI. While further research is needed to fully understand the underlying mechanisms, these findings provide a valuable starting point for improving perioperative care and reducing the risk of AKI in patients undergoing cardiac surgery.

Abbreviations

CS-AKI	Cardiac Surgery Associated Acute Kidney Injury
CPB	Cardiopulmonary Bypass

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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