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Tactics of managing children-patients with post-coagulopathy cardiac surgery interventions

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Abstract

Background: Children with congenital heart disease undergoing complicated pediatric cardiac surgery with cardiopulmonary bypass (CPB) experience considerable post-operative mortality and morbidity due to post-operative bleeding. An impairment in the blood clotting system primarily contributes to excessive bleeding in children following heart surgery.

Aim: to assess the different methods for the treatment of pediatric patients with post-coagulopathy cardiac surgery.

Methods: Pubmed, Web of Science, Scopus, Embase, SpringerLink, and the Cochrane Library in order to find various articles concerning this topic were searched. The search strategy; (cardiac surgery) AND (pediatric) AND (coagulopathy) AND (post-operative) was used. The investigation ended in April 2022.
Scientific novelty: Post-coagulopathy cardiac surgery is a relatively new medical field that has seen tremendous advances in the past decade. It involves the use of specialised techniques to reduce the risk of bleeding during and after cardiac surgery. This includes the use of anticoagulants, thrombolytics, and other medications to reduce clotting and improve outcomes. In addition, newer technologies such as robotic-assisted surgery have been developed to improve precision and accuracy during cardiac procedures. Therefore, this review aims to address the tactics of managing children-patients with post-coagulopathy cardiac surgery

Conclusion: The management of children-patients with post-coagulopathy cardiac surgery is a particularly challenging area due to their unique physiology and anatomy. As such, there is a need for novel approaches to ensure optimal outcomes for these patients. For example, research has shown that using anticoagulants in combination with thrombolytics can reduce the risk of bleeding complications following cardiac surgery in pediatric patients.

Keywords: cardiac surgery, pediatric, coagulopathy, post-operative, managemen

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Introduction

Haemostasis is the process of preventing and controlling bleeding; it is critical to maintain blood within a damaged blood vessel. A normal haemostatic systems include four components: vasculature, fibrinolytic proteins, coagulation factors, and platelets [1]. A deficiency in these components can cause coagulopathy. There are two types of coagulopathy: primary and secondary. A blood vessel or platelet deficiency is a primary haemostasis disease. Secondary diseases, on the other hand, involve quantitative or qualitative abnormalities in

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clotting factors or their inhibitors [2]. Children's cardiac surgery is a complicated and sensitive procedure that needs special care and knowledge. A number of heart diseases, including congenital heart defects, acquired heart disease, and other cardiac abnormalities, can be treated with the help of surgery. Paediatric cardiac surgery aims to improve the patient's quality of life by addressing the underlying issue and re-establishing normal heart function. The patient's and their family's management must be carefully considered during the delicate and complicated post-coagulopathy heart surgery. After post-coagulopathy cardiac surgery, educating young patients thoroughly about their condition is the first step in handling them. Medical personnel must clarify both the procedure's hazards and any potential consequences that can emerge. It's crucial to explain patients how to manage their food and lifestyle following the procedure as well as to explain the intake of needed medications. Cardiovascular illnesses are the leading cause of death worldwide, and during the past 20 years, the number of deaths from cardiac causes has rapidly increased. According to statistics, 7.3 million people die from cardiovascular diseases each year; by 2030, this number is predicted to rise to 23.6 million [3]. The number of cardiac procedures has significantly increased due to the rise in the prevalence of cardiovascular diseases. More than a million people worldwide have these kinds of operations every year. The increase in heart surgery rates supports the need to understand possible complications, such as bleeding, significantly contributing to mortality and morbidity [4].

Research Problem

Children that undergo complicated heart procedures often experience a variety of complications. One of the frequent and dangerous consequences of these operations is the post-operative coagulopathy. Physicians are unable to establish how to avoid such complications. Additionally, physicians find difficulties in determining how to manage the post-operative coagulopathy

Research Focus

In this review, one focused on determining the pathophysiology of coagulopathy after paediatric cardiac surgery and evaluating various ways to manage the coagulopathy that happen after cardiac operations in paediatric patients.

Research Aim and Research Questions

In this review, different methods for the treatment of paediatric patients with post-coagulopathy cardiac surgery are assessed.

1. What are the indications for paediatric cardiac surgery?
2. What are the causes of coagulopathy that happen after cardiac operations in paediatric patients?
3. What is the pathophysiology of coagulopathy after cardiac operations in paediatric patients?
4. What is the best way to manage coagulopathy and bleeding after cardiac operations in paediatric patients?

Research Methodology

General Background

Significant perioperative blood loss following paediatric cardiac surgery necessitates blood product transfusions. Transfusions in this susceptible population come with significant hazards and effects on clinical outcomes. The immaturity of the haemostatic system, excessive activation of the haemostatic system, hemodilution from the CPB circuit, and preoperative anticoagulant medications are some of the greater transfusion requirement causes in children. Clinicians use a variety of therapies to control bleeding because the causes of coagulopathy are frequently multifactorial. These therapies include antifibrinolytics to prevent fibrinolysis, cryoprecipitate or fibrinogen concentrate on raising fibrinogen concentrations, platelet transfusions to treat thrombocytopenia and platelet dysfunction, frozen plasma or prothrombin complex concentrate (PCC) to replenish depleted clotting factors and to enhance thrombin generation.

The first step in treating coagulopathy is identifying it; various patient and procedural risk factors have been found to be indicators of excessive bleeding. Pre-procedure medication management is essential since heart surgery patients frequently use anticoagulants or antiplatelet medications. Antifibrinolytics are crucial adjuncts to prevent transfusions, and there is conflicting evidence to support the use of perfusion techniques, including sequestration, red cell salvage, and retrograde autologous priming of the bypass circuit. Detecting the patient's coagulation state enables targeted product replacement and reduces the need for transfusions of greater volume.

The aim of the work was to evaluate different tactics for managing children patients with post-coagulopathy cardiac surgery. PubMed, Web of Science, Scopus, Embase, SpringerLink, and the Cochrane Library were searched in order to find various articles concerning this topic. The next search strategy was used: (cardiac surgery) AND (pediatric) AND (coagulopathy) AND (postoperative) and the researches ended in April 2022. Some types of publications, such as proposals, letters, procedures, and opinions were excluded. The references involve articles that were chosen because of their relation to the topic.

Data Analysis

In this review, the results of previous trials and retrospective studies that tried to determine the best options for the management of coagulopathy after paediatric cardiac surgeries were gathered and compared. Any statistical analysis methods were not used the conclusions are made by comparing these results.

Research Results | Literature review

The title and the abstract were done, and then a full-text screening of these articles was accomplished in order to choose the articles related to our topic. Only a small number of the 486 papers concerned tactics for managing children patients with post-coagulopathy cardiac surgery interventions. Data on the coagulopathy rate after cardiac surgery in children and the management of this coagulopathy are adequately covered in 45 articles. Although they do not provide sufficient data for the aetiology of postoperative coagulopathy in children, they provide helpful information on the outcomes of different interventions for paediatric patients with postoperative coagulopathy in Figure 1.

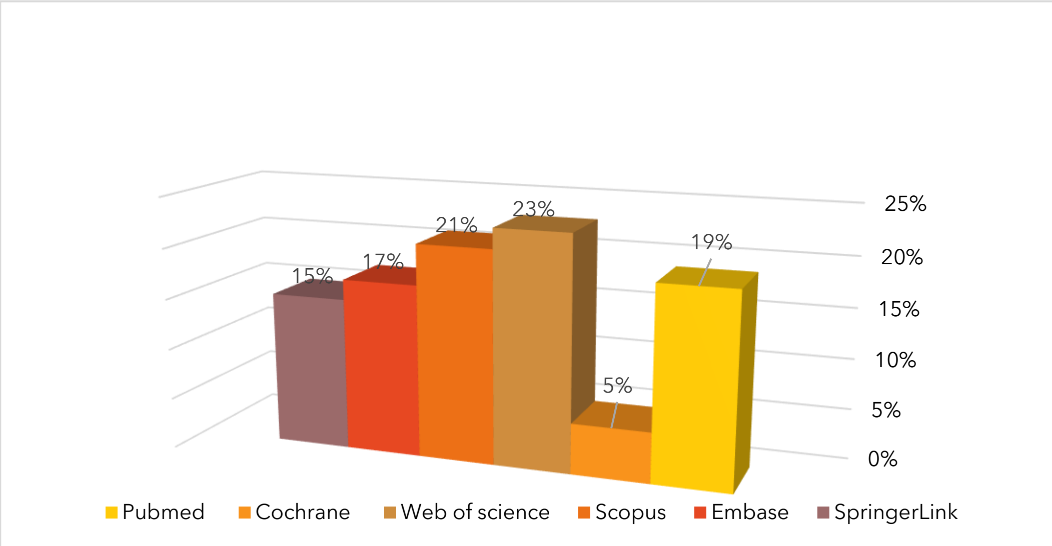

Figure 1. **The results of our search**

There are two types of coagulopathy: primary and secondary. A platelet or blood vessel abnormality is a primary haemostasis disease. In contrast, secondary diseases are characterised by quantitative or qualitative changes in the clotting factors or their inhibitors. Anticoagulants, inhibitors of certain factors, direct thrombin inhibitors, and non-specific inhibitors are all examples of inhibitors [5]. Most chronic disorders, including vitamin K deficiency, liver disease, anticoagulant therapy, and disseminated intravascular coagulation (DIC), are associated with acquired coagulation disorder [8, 9]. A deficiency in platelet number, factor deficiency, and the presence of circulating coagulation factor inhibitors are investigated using laboratory tests such as the complete blood count (CBC), prothrombin time (PT), activated partial thromboplastin time (aPTT), and mixing test in order to evaluate these disorders [6,7].

Perioperative coagulopathy is frequently observed in patients having heart surgery, and it is linked to significant bleeding, a higher need for blood transfusions, and repeated attempts to achieve surgical haemostasis. Postoperative morbidity, mortality, and expenses will all be negatively impacted by all of these factors. Anticoagulants, antiplatelet medications, and genetic bleeding abnormalities are a few examples of preoperative causes of coagulopathy. Intraoperative variables are another cause of coagulopathy (e.g. hemodilution, consumption, and activation of coagulation factors and platelets, hypothermia, heparin administration, metabolic acidosis, hypocalcaemia, and excessive fibrinolysis). For the perioperative care of coagulopathy, preventative and therapeutic strategies are advised. There is conflicting information regarding the ability of preoperative or intraoperative testing to identify patients likely to experience severe bleeding after cardiac surgery due to coagulopathy. Preoperative evaluations of coagulation status, coagulation-interacting medications, and intraoperative coagulopathy risk factors constitute this preventive strategy's first step. During cardiovascular surgery, platelet dysfunction is a primary cause of bleeding, especially in patients on antiplatelet medications. Although platelet function assays are accessible, their use in assessing actively bleeding patients has not yet been proven. We consider appropriate Heparin antagonism, consistent clot stability/firmness by antifibrinolytics and blood products, and then platelet dysfunction in a sequential manner when dealing with surgical coagulopathy.

Pathophysiology of coagulopathy

Coagulation cascade

A perioperative clinician must recognise the complex relationships between the two systems that work together to keep the blood in circulation in a fluid state, especially when there is a pre-existing haematological problem. The haemostatic system is activated by pathological circumstances necessitating anaesthesia, surgery, or any other intrusive procedure. Trauma, pathogenic agents, or cytokines can also disrupt this balance. Thus, prothrombotic and prohaemorrhagic abnormalities are both highly likely to occur during the perioperative time [8]. Other factors that could make things worse include metabolic acidosis, extracorporeal circulation, hypoxia, and hypothermia.

The interactions between vessel walls, platelets, and adhesive proteins that result in the creation of the initial "platelet plug" are the cause of primary haemostasis. Numerous factors, including negatively charged heparin-like glycosaminoglycan, the synthesis, and secretion of platelet inhibitors, neutral phospholipids, coagulation inhibitors, and fibrinolysis activators, contribute to the antithrombotic properties of the endothelial cells lining the vascular wall. In comparison, the sub endothelial layer is quite thrombogenic and contains proteins, including laminin, vitronectin, and thrombospondin, that are important for platelet adherence in addition to von Willebrand factor (vWF) and collagen [9,10]. Arteriolar vasospasm, caused by any vascular injury, is mediated by neurogenic reflex mechanisms and the release of regional mediators such as platelet-derived thromboxane A2 (TxA2) and endothelin.

Coagulation cascade

Traditional classifications include extrinsic and intrinsic pathways, both leading to the activation of factor X. The traditional theory of blood coagulation is particularly helpful for comprehending in vitro testing, but it leaves out the crucial part played by cell-based surfaces in in-vivo coagulation. The following observations, however, do not seem to support contact activation, which is essential for in vivo haemostasis [11,12]. FXII, high-molecular-weight kininogen, or prekallikrein deficient individuals do not bleed excessively. In addition, individuals with hemophilia C, who are fully deficient in factor XI, experience mild haemorrhagic disease. Patients with only trace amounts of factor XI can survive substantial injuries without experiencing extraordinary bleeding [13,14]. Haemophilia A and B are caused by deficiencies of FIX and FVIII (intrinsic pathway factors); however, the traditional definition of two coagulation pathways leaves it unclear why either kind of hemophiliac cannot simply clot blood through the unaffected pathway Figure 2.

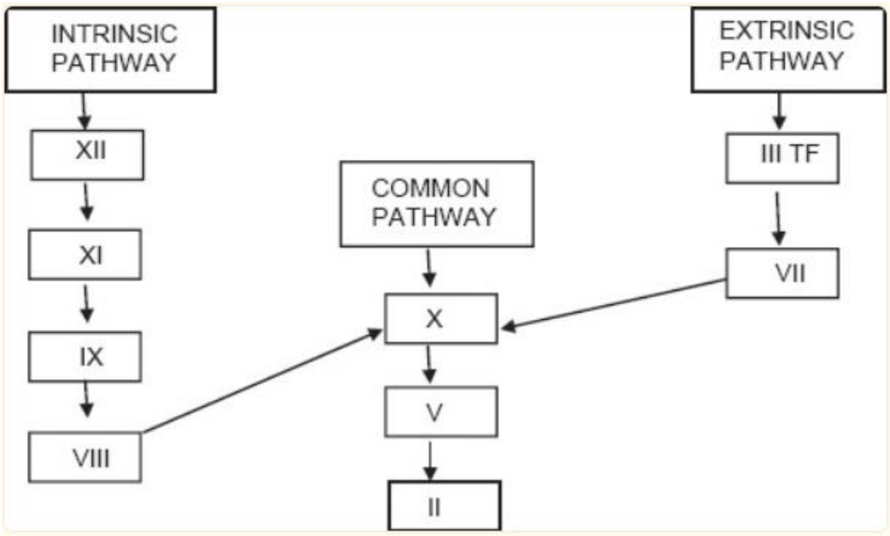

Figure 1. **Pathways of the coagulation process [15].**

Causes of coagulopathy

Coagulation disorders affect the body's capacity to regulate blood clotting. A thrombosis or haemorrhage might be the outcome of coagulation problems. There are various diseases that might lead to these clotting disorders [16]. Haemophilia, Von Willebrand disease, Liver Disease, DIC, Vitamin K deficiency, Platelet dysfunction, Factor V Leiden, Antithrombin III (ATIII) deficiency, Protein S or protein C deficiency, and Antiphospholipid antibody syndrome are disorders that cause coagulopathy [17]. Coagulopathy may be brought on by physiologic abnormalities like hypothermia, acidosis, or hemodilution brought on by the administration of fluid or blood. Still, it is also possible for severely injured patients to develop an acute coagulopathy independently of, or in addition to, these conditions [13,18,19]. This latter condition is referred to by several names in the literature, including the acute coagulopathy of trauma-shock (ACoTS), trauma-induced coagulopathy (TIC), early coagulopathy of trauma (ECT), and acute traumatic coagulopathy (ATC).

After paediatric heart surgery, coagulopathy is a frequent complication. This is mostly caused by hemodilution, which leads to platelet dysfunction and clotting factor depletion. It has been established that there is a direct correlation between blood loss, post-cardiopulmonary bypass (CPB) coagulopathy, and the need for transfusions. The morbidity and death rates following cardiac surgery increase when excessive bleeding occurs. The bleeding may be the result of surgical complications or poor haemostasis [20,21]. Cardiopulmonary bypass (CPB)-assisted cardiac surgery results in a coagulopathy that, in the event of a severe case, may increase the risk of perioperative bleeding complications. Early detection and characterization of coagulopathy increase the chance of starting countermeasures to reduce perioperative transfusion requirements and blood loss [22,23]. Thromboelastometry / thromboelastography (TEM/TEG) can detect perioperative coagulopathy, and routine intraoperative TEM/TEG has been shown to minimise transfusion requirements in both adult and paediatric cardiac surgery. The risk of bleeding complications in paediatric cardiac surgery is exacerbated by complex operations in low-weight children with an undeveloped coagulation system. Early detection and characterisation of the coagulopathy using TEM/TEG will maximise the chance for early treatment of haemostatic abnormalities if bleeding occurs [24,25]. Paediatric cardiac surgery research using TEM/TEG revealed that patients with congenital heart disease have defective clot formation, especially in children with cyanotic heart disease.

Aetiologies of cardiac surgery in children

In some cases, the surgery is life-saving and can help improving the life quality for a child. However, it is important to understand the potential causes of cardiac surgery in children so parents and caregivers can be aware of any potential issues. Congenital Heart Defects; One of the most common causes of cardiac surgery in children is congenital heart defects. These are structural problems with the heart that are present at birth. They can range from mild to severe and may require surgical intervention to correct them. Common congenital heart defects include ventricular septal defect (VSD), atrial septal defect (ASD), patent ductus arteriosus (PDA), tetralogy of Fallot, transposition of the great arteries, and coarctation of the aorta [26,27]. Paediatric cardiac surgery is a specialised field of medicine that focuses on treating children with congenital heart defects. This type of surgery is typically performed by paediatric cardiologists and cardiac surgeons specially trained to treat children's hearts [28]. During the procedure, the surgeon will make an incision in the chest wall and use specialized tools to repair or replace damaged structures. Depending on the severity of the defect, this may involve repairing or replacing valves, arteries, veins, or other parts of the heart. Paediatric cardiac surgery aims to improve a child's quality of life by correcting any structural abnormalities that may be causing symptoms such as shortness of breath, chest pain, fatigue, and irregular heartbeat. In some cases, it can even save a child's life if left untreated. After surgery, children typically need to stay in the hospital for several days for monitoring and recovery before they can go home [29].

Acquired Heart Disease

Acquired heart disease refers to any condition that affects the heart after birth. It can be caused by infection, inflammation, or other medical conditions such as diabetes or high blood pressure. Some acquired heart diseases may require surgical intervention, such as valve repair or replacement or coronary artery bypass grafting (CABG) [30]. Early diagnosis and treatment can help improving outcomes for children with cardiac conditions and reduce their risk for complications from surgery.

Cardiac surgery intervention in children

Cardiac surgery intervention in children is a complex and delicate process that requires specialized care and expertise. It is a procedure that can be used to treat a variety of heart conditions, including congenital heart defects, acquired heart disease, and other cardiac abnormalities. The goal of cardiac surgery intervention in children is to improve the quality of life for the patient by correcting the underlying problem and restoring normal cardiac function [31,32].

Kazakhstan is home to a growing number of paediatric cardiac surgery centres, offering specialised care for children with congenital heart defects. These centres provide a range of services, from diagnosis and treatment to post-operative care. The country has seen a significant increase in the number of paediatric cardiac surgeries performed in recent years, with many of these procedures being performed on children from other countries in the region. The success rate for these surgeries is high, and the quality of care provided is excellent. With the help of highly trained medical professionals and state-of-the-art equipment, Kazakhstan is becoming an increasingly popular destination for paediatric cardiac surgery [28].

The first step in any cardiac surgery intervention in children is to diagnose the condition. This typically involves a physical exam, imaging tests such as an echocardiogram or MRI, and blood tests. Once the diagnosis has been made, the doctor will discuss with the family what type of surgery is best suited for their child's condition. Depending on the severity of the condition, it may be necessary to perform open-heart surgery or minimally invasive procedures such as catheterization or stenting [33].

The open-heart surgery is a major procedure that requires general anaesthesia and involves making an incision in the chest wall to access the heart. During this procedure, surgeons may repair or replace damaged valves or vessels, correct congenital defects, or perform bypass grafts to improve the blood flow to certain areas of the heart. Minimally invasive procedures are less invasive than open-heart surgery and involve inserting catheters into small incisions to repair or replace valves or vessels without incision in the chest wall [34]. After any type of cardiac surgery intervention in children, there will be a period of recovery time during which doctors will monitor their patient's progress closely. During this time, it is important for parents to follow all instructions given by their doctor regarding medications and activity levels for their child. In some cases, physical therapy may also be recommended to help strengthen muscles weakened by prolonged bed rest during recovery from open-heart surgery.

Overall, cardiac surgery intervention in children can be a life-saving procedure when correctly performed by experienced medical professionals. It can help restore normal cardiac function and improve the quality of life for patients with serious heart conditions.

Management children-patients with post-coagulopathy

Post-coagulopathy cardiac surgery is a complex and delicate procedure that requires careful management of both the patient and their family. This article evaluates some tactics for managing children-patients with post-coagulopathy cardiac surgery.

The first step in managing children-patients with post-coagulopathy cardiac surgery is to provide them with comprehensive education about their condition. It is important for healthcare professionals to explain the risks associated with the procedure, as well as any potential complications that may arise. Additionally, it is important to provide information about how to manage their diet and lifestyle after the procedure, as well as any medications they may need to take. This education should be personalized to each individual patient's needs and should be provided in a way that is easy for them to understand [35]. It is also important for healthcare professionals to provide emotional support for children-patients with post-coagulopathy cardiac surgery. This can include offering reassurance, listening to their concerns, and providing comfort during difficult times.

Additionally, it can be beneficial for healthcare professionals to involve family members in the care process so that they can provide additional support and understanding. It is also important for healthcare professionals to monitor the progress of children-patients with post-coagulopathy cardiac surgery closely. This includes regularly assessing their physical condition, monitoring vital signs, and performing any necessary tests or procedures as needed. Additionally, it is important for healthcare professionals to keep track of any changes in symptoms or behaviour so that they can intervene if necessary.

Several studies have indicated that providing antifibrinolytic drugs after paediatric-cardiac surgery lowers the activation of the inflammatory and fibrinolytic systems, based on our understanding of the pathophysiology of post-cardiac surgery coagulopathy. It also reduces postoperative blood loss and the requirement for blood transfusions. Tranexamic acid, aprotinin, and aminocaproic acid are examples of pharmaceutical agents [37, 38]. Thrombolytic drugs work by causing fibrin, von Willebrand factor, and platelet surface glycoproteins (GPIb and GPIIb/IIIa) to degrade. A similar activity was observed during and after conducted cardiopulmonary bypass (CPB), which resulted in platelet dysfunction. As a result, the fibrinolytic-induced platelet deficiency may be decreased by using antifibrinolytic medications such aprotinin, which inhibit fibrinolytic enzyme activity. (38). Patients receiving aprotinin therapy for CPB had normal 2-antiplasmin levels, preserved GP1b platelet receptors, better platelet aggregation, and less blood loss than patients who do not get aprotinin medication. Other antifibrinolytic drugs, such as tranexamic acid and aminocaproic acid, have similar effects; however they are less effective against platelet dysfunction and receptor lysis than aprotinin.

Finally, it is essential for healthcare professionals to ensure that children-patients with post-coagulopathy cardiac surgery receive follow up care after the procedure has been completed. This includes regular appointments with a cardiologist or other specialist as well as ongoing monitoring of their condition by primary care providers or other medical personnel. Additionally, it can be beneficial for patients and families to receive counselling or other forms of psychological support if needed in order to help them cope with any emotional issues related to their condition or treatment plan [39]. By following these tactics, healthcare professionals can ensure that children-patients with post-coagulopathy cardiac surgery receive comprehensive care throughout every stage of their treatment plan. By providing education about their condition, offering emotional support, monitoring progress closely, and ensuring follow up care after the procedure has been completed, healthcare providers can help ensure positive outcomes for these patients and their families. Table 1 one compares the fresh frozen plasma and recombinant factor concentrates.

Table 1. Compares the fresh frozen plasma and recombinant factor concentrates

Criteria	Fresh Frozen Plasma	Recombinant Factor Concentrates
Source	Donated human blood	Produced through genetic engineering
Composition	Contains all clotting factors and plasma proteins	Contains specific clotting factors
Administration	Requires blood typing and cross-matching, takes time to thaw and prepare for use, requires large volume infusion	Can be administered quickly, does not require blood typing or cross-matching, smaller volume infusion
Efficacy	Can correct coagulopathy in most cases, but may not provide enough of specific clotting factors in severe cases	Provides specific clotting factors needed for correction of coagulopathy, more effective in severe cases
Risks/Complications	Risk of transfusion reactions, transmission of infections, fluid overload, allergic reactions, and transfusion-related acute lung injury (TRALI)	Risk of allergic reactions and inhibitors formation
Cost	Relatively inexpensive compared to factor concentrates	More expensive than fresh frozen plasma

Discussion

The likelihood of post- CPB bleeding has been predicted by a number of patient and procedural risk factors. Older age, body habitus, critical preoperative status, impaired renal and hepatic function, prior cardiac surgery, surgical complexity, ventricular assist device implantation or explantation, heart transplantation, and most importantly, the length of CPB, are non-modifiable risk factors [40,41]. Short cessation times for antiplatelet medications and other anticoagulants, preoperative anaemia and thrombocytopenia, and nadir CPB haemoglobin levels are all modifiable risk factors for perioperative coagulopathy [42].

Sebastian et al [43] found that transfusion of blood components is frequently required due to the nature and complexity of heart surgery. However, there is growing evidence that it is not benign and may result in harmful effects following cardiac surgery. Fresh whole blood (less than 48 hours from donor to transfusion) has been shown to minimise haemorrhage in children under the age of 2 who are having difficult congenital heart surgery [44]. However, other studies have not demonstrated any advantages of fresh whole blood. Antifibrinolytics are drugs that inhibit the breakdown of fibrin, a protein that forms blood clots. They are commonly used in the management of post-cardiac surgery coagulopathy to prevent excessive bleeding. The most commonly used antifibrinolytic drug in cardiac surgery is tranexamic acid (TXA). TXA has been shown to reduce blood loss and transfusion requirements in patients undergoing cardiac surgery. However, there are concerns about its potential side effects, such as thromboembolic events and renal dysfunction. Epsilonaminocaproic acid (EACA), tranexamic acid (TXA), and aprotinin, a serine protease inhibitor, are effective in lowering bleeding and transfusion in paediatric patients following heart surgery. Many centres switched to EACA or TXA when most institutions stopped carrying aprotinin. Every medicine has a different dosage regimen [45]. Recently, it has been reported that TXA dose regimens based on pharmacokinetic modelling and intended to create low, moderate, or high plasma concentrations in neonates and babies under 2 months of age, infants between 2 and 12 months of age, and children more than 12 months of age. Similar to the neonatal dose adjustment for EACA, these dosage recommendations account for age-related variations in clearance and are intended to create a specific concentration in the bypass prime rather than a weight-based bolus. Coagulation factor concentrates (CFCs) have been used in the management of post-cardiac surgery coagulopathy for several decades. Post-cardiac surgery coagulopathy is a common complication that occurs after cardiac surgery, and it is characterized by abnormal bleeding and clotting. The use of CFCs has been shown to be effective in managing this condition, and it has become an important part of the standard of care for patients undergoing cardiac surgery. CFCs are derived from human plasma and contain specific clotting factors that are deficient in patients with coagulopathy. These factors include factor VIII, factor IX, factor XIII, and von Willebrand factor. CFCs are available in different formulations, including fresh frozen plasma (FFP), cryoprecipitate, prothrombin complex concentrate (PCC), and recombinant factor concentrates [46]. FFP is the most commonly used CFC in the management of post-cardiac surgery coagulopathy. It contains all the clotting factors found in plasma and can be used to replace multiple clotting factors simultaneously. However, FFP has several limitations, including the need for blood typing and cross-matching, a high risk of transfusion-related complications such as transfusion reactions and infections, and a limited shelf life [47]. Cryoprecipitate is another form of CFC that contains high concentrations of fibrinogen, von Willebrand factor, and factor VIII. It is often used as an alternative to FFP when fibrinogen levels are low or when there is a need for rapid correction of bleeding. PCC is a concentrated form of clotting factors II, VII, IX, and X that can be used to rapidly correct coagulopathy. PCC has several advantages over FFP, including a lower volume requirement for administration, a longer shelf life, and a lower risk of transfusion-related complications. Recombinant factor concentrates are synthetic forms of clotting factors that are produced using genetic engineering techniques [48]. They have several advantages over plasma-derived CFCs, including a lower risk of viral transmission and a longer shelf life. However, they are more expensive than plasma-derived CFCs and may not be readily available in all healthcare settings. The use of CFCs in the management of post-cardiac surgery coagulopathy is based on the principle of replacing deficient clotting factors to restore normal haemostasis. The choice of CFC depends on the specific clotting factor deficiency, the severity of coagulopathy, and the patient's clinical condition. Several studies have demonstrated the effectiveness of CFCs in managing post-cardiac surgery coagulopathy. A randomised controlled trial conducted by Pei et al. showed that the use of PCC was associated with a significant reduction in bleeding and transfusion requirements compared to FFP in patients undergoing cardiac surgery [48]. Another study by Despotis et al. showed that the use of cryoprecipitate was associated with a significant reduction in bleeding and transfusion requirements compared to FFP in patients undergoing coronary artery bypass grafting [49].

Kunz et al [41] performed a single-centre, retrospective study and found that a higher protamine: heparin ratio may be associated with adverse haemostatic effects, with lower ratios associated with a 10 g/L lower haemoglobin differential on arrival to the ICU, a 70 ml lower drain tube output at 4 hours, and a 56% reduction in red cell transfusion. Given the high morbidity and mortality associated with post-operative anaemia and transfusion, this provides another possible haemo conservation technique.

Bartoszko et al [50] found that platelet dysfunction, hypofibrinogenemia, reduced thrombin production, and hyperfibrinolysis are the four most critical underlying processes for coagulopathy in this setting. In terms of the inflammatory component of coagulopathy, there is no evidence that immunologic or anti-inflammatory therapies are successful in changing patient outcomes.

Despite their effectiveness, the use of CFCs in the management of post-cardiac surgery coagulopathy is not without risks. The most common adverse events associated with CFC administration include thromboembolic events, allergic reactions, and transfusion-related complications.

Conclusions and Implications

1. It is important providing a safe and supportive environment for children-patients with post-coagulopathy cardiac surgery.

2. Parents should be involved in the care of their children-patients in order to ensure and to receivie the best possible care.

3. Procedural risk factors for postoperative coagulopathy include: older age, body habitus, critical preoperative status, impaired renal and hepatic function, and prior cardiac surgery.

4. A close monitoring of vital signs and laboratory values should be conducted to ensure the proper patient's recovering.

5. Additional information about post-operative care and lifestyle modifications should be provided to both the patient and their family members to ensure a proper recovery and long-term health outcomes.

7. Regular appointments should be scheduled in order to monitor the progress and to address any concerns or issues that may arise during recovery.

8. Fresh frozen plasma and recombinant factor concentrates are both effective in managing post cardiac surgery coagulopathy in children.

9. The choice between fresh frozen plasma and recombinant factor concentrates should be based on the specific patient needs, including their age, weight, and medical history.

10. Recombinant factor concentrates are more targeted and have a lower risk of adverse reactions, but they may be more expensive and less readily available than fresh frozen plasma.

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