TRANSFUSION IN CHILDREN

Pediatric transfusion is a complex area of medicine spanning a wide age range from intrauterine life to young adults. The clinician must balance the risks and benefits of transfusion in each age group and be aware of the indications for specific component therapy. Compared to adult practice, there is a relative lack of high quality research to form evidence-based guidelines.

Given the potential risks of transfusion, blood conservation strategies eg. use of cell saver, should be employed where feasible. Blood component therapy rather than whole blood transfusion is preferred. Risks, benefits and alternatives to transfusion should be discussed with the parents/ guardian of the patient preoperatively.

The goals of transfusion are to:

1. Maintain oxygen transport
2. Maintain normovolaemia
3. Correct ongoing bleeding

Before the start of any surgery where bleeding risk is high, adequate blood products should be available in theatre. There is no universal 'transfusion trigger' in children. Transfusion thresholds will vary depending on the child's initial hematocrit, underlying medical problems, and degree on ongoing bleeding in proportion to the total blood volume of the child. ROTEM™ is available to guide transfusion therapy, if indicated.

Blood volume in children	
Age	**Estimated blood volume**
Premature infant	90-100 ml/kg

Newborn	80-90 ml/kg
Infant <1 year	75-80 ml/kg
Child >1 year	70-75 ml/kg

Blood Loss and Replacement

$$\text{Allowable blood loss} = \frac{\text{Estimated blood volume} \times (Hct_i - Hct_p)}{Hct_i}$$

Hct_i = initial haematocrit
Hct_p = lowest allowable perioperative haematocrit

Normal and acceptable haematocrit (Hct) values in paediatric patients

Age	Normal Hct (mean)	Normal Hct (range)	Acceptable Hct (in well compensated patients with no cardiorespiratory disease)
Premature infant	45	40-45	35
Newborn	54	45-65	30-35
3 months	36	30-42	25
1 year	38	34-42	20-25

6 years	38	35-43	20-25

Packed Cells / Whole Blood
Indications for Red Blood Cell (RBC) transfusion:

Common RBC transfusion triggers	
Clinical Situation	**Hb Transfusion Trigger (g/dL)**
Neonate in ICU	12
Patients undergoing chemotherapy- stable	8
Patients undergoing chemotherapy- unstable/ febrile	9
Patients with chronic anaemia on regular transfusion therapy	9

- Hb < 8g/dL, although lower thresholds may be acceptable in asymptomatic children.
- Consider the need for RBC transfusion when >40ml/kg crystalloids have been given or the blood loss exceeds 15% of the child's blood volume (depending on the initial Hb).

Transfusion may be indicated at higher thresholds in children with cyanotic heart disease.

Whole blood: 6ml/kg will increase Hb by 1g/dl

Packed cells: 4ml/kg will increase Hb by 1g/dl

In case of emergency, non-crossmatched type specific blood is available within 30 minutes upon request. If blood is required more urgently, use O negative packed cells.
The administration of blood should be guided by the intraoperative measurement of haematocrit/ haemoglobin, and the clinical status of the patient.

Platelets

Indications for platelet transfusion	
Surgery/ Invasive procedure	Platelets <50 000/dl However, higher counts may be needed in surgeries with high risk of bleeding eg. intracranial neurosurgery and cardiac surgery
Platelet function defects	Transfuse if there is bleeding or high risk of bleeding, regardless of actual platelet count.
Bleeding/ Massive transfusion	Maintain platelet count 100 000/dl in the presence of DIC and traumatic brain injury.

Volume required for transfusion: 5 to 20ml/kg.
Transfusion of 5-10ml/kg platelets will raise platelet count by 30-50 x 10^9/L.

In Singapore, platelets for paediatric patients can be ordered as single units of "apheresed platelets paediatric (APP)" or cell-separated platelets (CSP).
1 unit of CSP ≡ 4 to 6 units of APP

Fresh Frozen Plasma (FFP)
Indications for FFP transfusion:

- Severe clotting factor deficiency and bleeding
- Following massive blood transfusion or bleeding post cardiopulmonary bypass, in the presence of abnormal coagulation
- Disseminated intravascular coagulopathy (DIC)
- Clotting factor replacement when no specific coagulation factor concentrates are available

Volume required for transfusion: 10 to 20ml/kg.

Cryoprecipitate
Cryoprecipitate contains high amounts of Factor VIII, von Willebrand factor, fibrinogen and Factor XIII.

Indications for transfusion:

- Fibrinogen deficiency, in the setting of clinical bleeding, massive transfusion, post cardiopulmonary bypass, trauma, DIC or advanced liver disease.

Volume required for transfusion: 5ml/kg or 1-2 units/10kg.

Clotting factor concentrates
Indicated for replacement of specific clotting factor deficiencies.

To calculate dose required to achieve a desired concentration:

- Dose of Factor VIII (FVIII) = % desired rise in plasma FVIII x body weight (kg) x 0.5

- Dose of Factor IX (FIX) = % desired rise in plasma FIX x body weight (kg)

Recombinant Factor VIIa

Recombinant factor VIIa (rFVIIa) has been approved by the U.S FDA for use in haemophilia A and B patients for the treatment of bleeding episodes and prevention of bleeding during surgical or invasive procedures in these patients. rFVIIa has also been used in non-haemophiliac patients to control massive bleeding refractory to conventional therapies, as an off-label indication. The use of rFVIIa in paediatric patients has been reported for rescue therapy for post cardiopulmonary bypass bleeding, postoperative/ intraoperative haemorrhage, bleeding due to trauma, fulminant liver failure, liver transplantation, drug-induced coagulopathies and non-haemophiliac bleeding disorders.

rFVIIa dosing recommendations:

- Initial 90μg/kg, repeat doses may be given at 2 hour intervals for a maximum of 2 doses.
- rFVIIa should not be mixed with other infusion solutions and administered IV, over 2-5min.
- rFVIIa efficacy is optimized when coagulation factor activity, platelet number and function, blood pH, ionized calcium and body temperature are optimized.
- There is currently no evidence to support prophylactic rFVIIa administration.

Special requirements for blood products

Leucodepleted "CMV negative" blood products should be given to:

- Haematopoietic stem cell transplant patients
- Solid organ transplant recipients
- Immunocompromised patients at risk of infection with intracellular organisms
- Congenital immunodeficiencies
- Premature neonates
- Intrauterine transfusions
- Patients with frequent non-haemolytic febrile transfusion reactions

Irradiated blood products should be given to patients at risk of developing graft versus host disease:

- Directed donations (from blood relatives)
- HLA selected/ matched platelet transfusions
- Granulocyte transfusions
- Intrauterine and all subsequent neonatal exchange transfusions
- Congenital cellular immunodeficiency disorders, especially T-cell immunodeficiency syndromes
- Haematopoietic stem cell transplant patients
- Hodgkin lymphoma
- Patients receiving nucleoside analogues
- Anaphylactic reaction — Severe reaction with hypoxia, hypotension

Pre-transfusion assessment

1. Review the indication to transfuse.
2. Identification check prior to initiating blood transfusion is essential to prevent serious transfusion errors.
    - Identification must include 2 unique identifiers (patient's name and NRIC).
    - Correct blood product and patient identity must be double checked between 2 healthcare personnel.
3. Calculate the volume to be transfused and rate of transfusion.
    - All transfusions must be completed within 4 hours of spiking a pack.
4. Clear documentation of blood product transfusion.
    - All transfusions (blood pack number, time of transfusion & volume given) should be entered in the anaesthesia chart and handed over to the Recovery nurse or ICU staff.

Complications during transfusion

The most common immediate adverse reactions to transfusion are fever, chills and urticaria. The temperature should be monitored as chills and urticaria may not be visible if the child is paralysed and covered under drapes. All suspected transfusion reactions must be reported to the blood bank immediately.

Monitor for Transfusion Reactions

- Febrile non-haemolytic reaction — Fever, rigors, skin rash, wheezing
- Haemolytic reaction: presents with haemoglobinuria, loin pain

Treatment of Transfusion Reactions

- STOP transfusion. Vital sign monitoring every 15 mins
- Allergic reaction- IV Diphenhydramine 1mg/kg and IV Hydrocortisone 4mg/kg
- Suspected haemolytic reaction — Repeat group and crossmatch
- Direct Coomb's Test (DCT). Notify and liaise with blood bank

Ideal ABO Group of Blood Component to be Transfused

Patient ABO group	RBC	Platelets	FFP
A 1st choice 2nd choice	 A O	 A B	 A AB
B 1st choice 2nd choice	 B O	 B A	 B AB
AB 1st choice 2nd choice	 AB A or B	 AB A or B	 AB -
O 1st choice 2nd choice	 O -	 O A or B	 O A or B

Reference:

1. Guzzetta et al. Review of the off-label use of rFVIIa in pediatric cardiac surgery patients. Anesth Analg 2012; 115:364-78.
2. KKH Paediatric Baby Bear Handbook