RECOMMENDATIONS FOR STAFF INVOLVED WITH CHILDREN WITH ANAEMIA UNDERGOING SURGERY

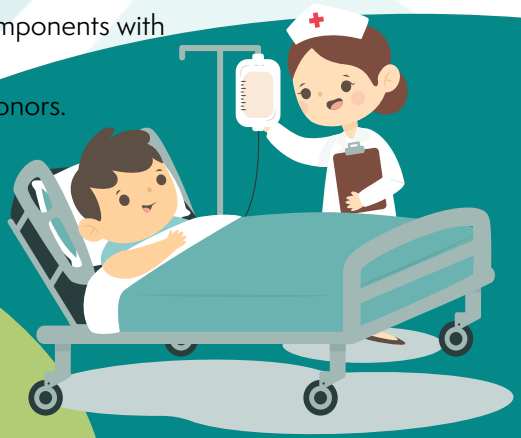
Guidelines specific to the perioperative management of paediatric patients undergoing surgery at risk of bleeding and transfusion are available, as are specific paediatric blood management strategies.[3,67,68,70]

Specific perioperative recommendations:

- Preoperative Hb should be optimised by treating iron deficiency anaemia (see Figure 13)
- Tranexamic acid should be considered in all children undergoing surgery where there is risk of significant bleeding (see detailed paediatric section for dosing)
- Red cell salvage should be considered in all children at risk of significant bleeding undergoing surgery, children undergoing cardiac surgery with cardiopulmonary bypass (CPB) and where transfusion may be required
- A postoperative Hb transfusion threshold of 70g/L should be used in stable patients without major comorbidity or bleeding
- For surgery in neonates, use the same transfusion triggers used for non-surgical neonates, but adjust according to level of respiratory support and post-natal age (see Figure 12)
- Transfusion volumes for non-bleeding infants and children should be calculated to take the post-transfusion Hb to no more than 20g/L above the transfusion threshold. The following calculation may be used:

$$\textit{Volume to transfuse}\ (\text{ml}) = \frac{\text{Desired Hb (g/l)} - \text{Actual Hb (g/l)} \times \text{Weight (kg)} \times \text{Factor}}{10}$$

  It is reasonable to use a factor of 4 to avoid over-transfusion, but this should be assessed on an individual patient basis. 4ml/kg approximates to a one unit transfusion for a 70–80kg adult, typically giving an Hb increment of 10g/L[69]
- When using a restrictive red blood cell transfusion threshold, consider a threshold of 70g/L and a haemoglobin concentration target of 70–90g/L after transfusion
- There is insufficient evidence to make a recommendation regarding an appropriate transfusion threshold during cardiopulmonary bypass (CPB) for non-cyanotic or cyanotic patients
- For stable children with non-cyanotic heart disease, a restrictive transfusion threshold of 70g/L following CPB is recommended. There is insufficient evidence to make a recommendation for children with cyanotic heart disease
- In neonates (both cyanotic and non-cyanotic) or actively bleeding or unstable children following CPB, a higher Hb threshold may be appropriate, and signs of inadequate oxygen delivery can provide additional information to support transfusion
- Patients should be reassessed clinically and Hb checked after each unit of red blood cell they receive unless they are bleeding
- Where Hb monitoring is feasible and available, via point of care sampling or non-invasively, this should be used to ensure the smallest necessary volume is transfused over three to four hours, although more rapid rates should be used in hypovolaemia
- It is recommended that recipients under one year of age be transfused with components with neonatal/infant specification, eg Paedipacks
- Hospitals should develop policies to minimize exposure of infants to multiple donors.



Guideline for the Management of Anaemia in the Perioperative Pathway

Anaemia in children undergoing surgery

While most surgery for children and young people does not involve transfusion, some children undergo elective surgery with over a 10% risk of transfusion. Examples include in orthopaedics: femoral/pelvic osteotomies and scoliosis surgery; in urology: nephrectomies, and bladder reconstructions; in general surgery: anorectal reconstruction and bowel resections: and in neurosurgery: craniotomies and craniosynostosis procedures.

The number of medically complex children booked for these types of surgery is also increasing; comorbidities such as prematurity, maternal iron deficiency, rapid growth periods, cerebral palsy, inflammatory bowel disease, renal conditions and childhood cancers increase the incidence of preoperative anaemia. In conjunction with a relatively small circulating blood volume this increases the risk of requiring transfusion.

Anaemia may also be found incidentally in children undergoing emergency surgery, for example appendectomy and trauma. The principles outlined in Recommendations for staff admitting emergency patients for surgery should be used for children and young people.

There is growing evidence of adverse perioperative outcomes in neonatal and paediatric patients undergoing surgical procedures with preoperative anaemia. Work shows high rates of anaemia (24–32%), higher odds of requiring a blood transfusion and increased mortality in anaemic children.[125,126]

Iron deficiency is the leading cause of anaemia in all paediatric age groups (except in very preterm infants in the first weeks of life).[67] The causes of neonatal anaemia are preterm delivery before establishment of normal red cell and iron stores in the last trimester, expansion of blood volume with growth, bone marrow depression, and increased red cell destruction, eg infection or haemolytic disease.

Blood transfusion carries additional risks, the highest being Transfusion Associated Circulation Overload (TACO) which is an iatrogenic complication occurring in up to 1 in 100 transfusions. Neonates and infants are at risk of hyperkalaemia following blood transfusion. To reduce this risk 'fresh blood' is recommended in this group, see Figure 12. The recommendations section includes consideration of tranexamic acid. A dosing regimen of 10 to 30 mg/kg (maximum 1g) loading dose of tranexamic acid followed by 2 to 10 mg/kg/hour maintenance infusion rate for paediatric trauma and surgery has been recommended.[127,128] Future research should focus on determining the ideal tranexamic acid plasma therapeutic concentration for maximum efficacy and minimal side-effects.[127] Figure 13 summarises preoperative options for children with anaemia. Iron dosing regimens are available in the children's BNF. Common preparations are Sodium feredetate (Sytron) or Ferrous Fumarate (Galfer syrup). The therapeutic oral dose of elemental iron to treat deficiency is 3–6mg/kg (max 200mg) daily. The current recommendation is that it is given in two to three divided doses, although Hepcidin may down-regulate absorption in children as it does in adults.

The Australian Blood Authority PBM guideline contains practical evidence-based advice and additional PBM strategies such as prevention of hypothermia and use of 'as-needed' rather than routine blood sampling.[129] There are studies suggesting that a high percentage of paediatric transfusion recipients receive only one transfusion during their admission, some of which may have been avoidable.[81,130]

As preventative medicine is becoming routine in preoperative care, it is worthwhile noting the potential association between iron deficiency in childhood and long-term adverse neurodevelopmental outcomes.[131]

Figure 12 Suggested transfusion thresholds for preterm neonates[68]

	Suggested transfusion threshold Hb (g/L)		
Postnatal age	**Ventilated**	**On oxygen or Non-invasive Positive Pressure Ventilation (NIPVV)**	**Off oxygen**
First 24 hours	<120	<120	<100
≤ week 1 (day 1–7)	<120	<100	<100
≤ week 2 (day 8–14)	<100	<95	<75 or <85*
> Week 3 (day 15 onwards)	<100	<85	<75 or <85*

Preterm is defined as <37 weeks gestational age at birth. This table also applies to very preterm neonates (<32 weeks).

*Depending on clinical situation.

Adapted from British Committee for Standards in Haematology (2016) Guidelines on transfusion for fetuses, neonates and older children[68]

Figure 13 Management of children with anaemia preoperatively[129]

Ferritin <20 mcg/L	Ferritin 20–50 mcg/L	Ferritin >50 mcg/L
Iron deficiency anaemia	**Possible iron deficiency anaemia**	**Unlikely iron deficiency anaemia**
Review clinical history and identify cause. Start treatment: ■ oral iron 3–6mg/kg/day of elemental iron **Address causes** of dietary iron deficiency: ■ increase dietary iron ■ if <1 year of age, cease cow's milk and use an infant formula ■ if 1 to 2 years of age, reduce cow's milk to <500mL daily Assess haematological response within two to four weeks. Continue treatment for three months after Hb recovery. If oral iron is ineffective or is not tolerated, **consider other causes of anaemia** and use of IV. iron.	Review and **address any causes** of iron deficiency: ■ increase dietary iron ■ if <1 year of age, cease cow's milk and use an infant formula ■ if 1 to 2 years of age, reduce cow's milk to <500mL daily Correlate with MCV/MCH and CRP. Consider therapeutic trial of iron: ■ oral iron 3mg/kg/day of elemental iron ■ Assess haematological response within two to four weeks. If anaemia persists, **consider other causes:** ■ Thalassaemia and other haemoglobinpathies ■ anaemia of chronic disease ■ haemolytic anaemia ■ B12 deficiency ■ folate deficiency ■ other	Correlate with MCH/MCV and CRP Ferritin may be elevated in the setting of inflammation. However, iron deficiency may still be present, particularly where TSAT <20%. **Consider other causes** of anaemia: ■ Thalassaemia and other haemoglobinpathies ■ anaemia of chronic disease ■ haemolytic anaemia ■ B12 deficiency ■ folate deficiency ■ other

This algorithm applies to all patients, including those undergoing procedures in which substantial blood loss is anticipated.

The reference ranges are based on criteria from the Royal College of Pathologists of Australasia, and they may require local adaptation.

Note Monofer® is unlicensed in <18yrs and Ferinject® <14 years.