Transfusion Handbook

10: Effective transfusion in paediatric practice


Please note the Transfusion Handbook has not been updated since 2014 and requires review. Guidance within the Handbook may therefore be out of date with other current guidelines.

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**Essentials**

- The potential risks and benefits must always be considered when making the decision to transfuse children but there is a lack of high-quality research evidence on which to base guidelines.
- SHOT has reported a higher incidence of serious adverse events related to transfusion in children (including identification errors).
- Children transfused in fetal or neonatal life have the longest potential lifespan in which to develop late adverse effects of transfusion.
- Extra safety measures for blood components for fetal, neonatal and infant transfusion include enhanced donor selection and screening for clinically significant blood group antibodies (paediatric antibody tests or ‘PAnTs’).
- Fresh frozen plasma (FFP) and cryoprecipitate for all patients born on or after 1 January 1996 is imported from countries with a low risk of variant Creutzfeldt–Jakob disease (vCJD) and is pathogen-inactivated.
- Transfusion volumes and rates for children should be carefully calculated and prescribed in mL, not component units, to minimise dosing errors and reduce the risk of circulatory overload.
- Intrauterine transfusion of red cells (for haemolytic disease of the fetus and newborn (HDFN)) or platelets (for neonatal alloimmune thrombocytopenia (NAIT)) and neonatal exchange transfusion are complex procedures requiring multidisciplinary input. They should only be performed in specialist units.
- Randomised controlled trials suggest that restrictive Hb transfusion thresholds (similar to current UK guidelines) are safe in clinically stable neonates requiring small volume ‘top-up’ transfusions. However, there is still uncertainty, especially about long-term outcomes, and further research is needed.
- Low platelet counts are common in sick neonates but the relationship of thrombocytopenia to serious bleeding and appropriate triggers for platelet prophylaxis remain uncertain.
- A significant proportion of FFP transfusions in patients in neonatal intensive care units (NICUs) and paediatric intensive care units (PICUs) are given to non-bleeding patients with minor abnormalities in coagulation parameters of uncertain significance.
- A restrictive red cell transfusion policy (threshold 70g/L) is safe for clinically stable children on PICUs.
- Guidelines for the transfusion management of haemato-oncology patients are similar to adult guidelines, although a more liberal platelet prophylaxis policy may be justified.
- Transfusion management of major haemorrhage in children is largely based on experience with adult patients. Age-specific blood components should be used as long as urgent provision of blood is not delayed. Tranexamic acid is now recommended for children with major traumatic haemorrhage.

Paediatric transfusion is a complex area of medicine covering a wide age range from intrauterine life to young adults. The prescriber must balance the risks and benefits of transfusion in each age group and be aware of the indications for special components. However, compared to adult practice there is a relative lack of high-quality research to inform evidence-based guidelines. The UK National Comparative Audit of the Use of Red Cells in Neonates and Children 2010 ([http://hospital.blood.co.uk/library/pdf/NCA_red_cells_neonates_children.pdf](http://hospital.blood.co.uk/library/pdf/NCA_red_cells_neonates_children.pdf)) showed that 74% of transfused patients received a single red cell component during their admission, suggesting that many transfusions might be avoidable.

The Serious Hazards of Transfusion (SHOT) initiative has reported a higher rate of adverse events in children, including identification errors, especially in the first year of life. Identification errors include confusion of maternal and neonatal samples, problems with multiple births, and failure to apply (or maintain) identification bands. Extra blood component safety measures have been developed for individuals transfused in fetal or neonatal life who have the longest potential lifespan in which to develop late adverse effects of transfusion. Components for fetal, neonatal and infant transfusion are collected from previously tested donors who have given at least one donation in the last two years. These components are screened for clinically significant blood group antibodies (including high-titre anti-A and anti-B) and an indirect antiglobulin test is performed – often known as ‘PAnTs’ (paediatric antibody tests). Fresh frozen plasma
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(FFP) and cryoprecipitate for all patients born on or after 1 January 1996 is imported from countries with a low risk of vCJD and is pathogen-inactivated (methylene blue or solvent detergent – see Chapter 3).

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10.1: Fetal transfusion

The most common indications for intrauterine transfusion (IUT) are red cells for prevention and treatment of fetal anaemia due to haemolytic disease of the fetus and newborn (HDFN) or parvovirus infection and platelets for neonatal alloimmune thrombocytopenia (NAIT). This is a highly specialised area of medical practice requiring close collaboration between experts in fetal medicine, haematology and blood transfusion, and rapid access to blood counting. Even in the most expert hands IUT carries a risk of fetal death of 1–3% per procedure and fetomaternal haemorrhage may cause further sensitisation and worsening of HDFN.

10.1.1: Intrauterine transfusion of red cells for HDFN

Maternal aspects of the management of HDFN are covered in Chapter 9. The objective of red cell IUT is to prevent or treat life-threatening fetal anaemia (hydrops fetalis) and allow the pregnancy to continue to a stage where a viable baby can be delivered (ideally at least 36 weeks gestation). High-risk pregnancies are monitored by weekly fetal Doppler ultrasound scans to measure middle cerebral artery peak systolic velocity, an indication of the severity of fetal anaemia, and regular ultrasound monitoring of fetal growth. Fetal blood sampling is indicated if severe anaemia before 24 weeks gestation is suspected, if there has been a previous intrauterine death, or if there is a rapid increase in maternal red cell alloantibody levels.

Guidelines for IUT vary between specialist units but published indications include a haematocrit of <0.25 between 18 and 26 weeks of gestation and <0.3 after 26 weeks. The target haematocrit after IUT is usually around 0.45. To balance the competing risks of fetal anaemia and the hazards of invasive IUT procedures, the transfusion programme is started as late as possible and the frequency of transfusion is reduced by giving the maximum safe volume of a special red cell component with a high haematocrit (Table 10.1). Transfusion volume is calculated by the fetal medicine specialist using a formula based on the haematocrits of the donor blood and fetus, the estimated fetal-placental blood volume and the target haematocrit. The component is warmed to 37°C immediately before transfusion. Whenever possible, red cells for IUT are requested well in advance of the planned transfusion, in close communication with the Blood Services. In extreme emergencies, where delay in obtaining special IUT blood would be life-threatening, blood from a neonatal exchange transfusion unit or paedipack should be used (irradiated if time allows) but not maternal blood. The SHOT Annual Report 2012 included a neonatal death from transfusion-associated graft-versus-host disease (TA-GvHD) when non-irradiated non-leucodepleted maternal red cells were used for an urgent IUT (http://www.shotuk.org/shot-reports/report-summary-and-supplement-2012/). Babies who have received IUT should be transfused with irradiated cellular blood components until 6 months of post-gestational age.

Table 10.1 Red cell component for IUT
Plasma reduced (haematocrit 0.7–0.85)

In citrate phosphate dextrose (CPD) anticoagulant (theoretical risk of toxicity from additive solutions)

Leucocyte-depleted

Less than 5 days old (to avoid hyperkalaemia)

Cytomegalovirus (CMV) antibody negative

Sickle screen negative

Irradiated to prevent TA-GvHD (shelf life 24 hours)

Usually group O with low-titre haemolysins (or ABO identical with the fetus)

RhD and Kell negative and red cell antigen negative for maternal alloantibodies

Indirect antiglobulin test (IAT) crossmatch compatible with the mother’s plasma

10.1.2: Intrauterine transfusion of platelets and management of NAIT

The IUT of platelets is used in the treatment of severe fetal thrombocytopenia due to platelet alloimmunisation (neonatal alloimmune thrombocytopenia – NAIT). NAIT is the platelet equivalent of HDFN. Maternal alloantibodies to antigens on fetal platelets cause fetal and/or neonatal thrombocytopenia with a high (10%) risk of intracerebral haemorrhage. Nearly all cases are caused by antibodies to HPA-1a (80–90% of cases), HPA-5b or HPA-3a. The mother is negative for the implicated platelet antigen and NAIT is diagnosed by demonstrating the platelet alloantibody in maternal serum. The diagnosis is most often made when an otherwise healthy neonate presents with purpura and an isolated severe thrombocytopenia. Subsequent ‘at risk’ pregnancies should be managed in a fetal medicine centre as prenatal management is rapidly evolving (Peterson et al., 2013). Management is influenced by any history of previous fetal losses and their timing. Fetal blood sampling and platelet transfusion carry a significant risk of life-threatening haemorrhage (suitable platelets should always be immediately available when fetal blood sampling is performed). There is an increasing trend to use a non-invasive approach with maternal intravenous immunoglobulin and steroids and to avoid fetal transfusion where possible. Hyperconcentrated platelets for IUT are specially prepared by the Blood Services (see Table 10.2) and transfusion should be planned in advance. The transfusion volume is determined from the fetal and platelet concentrate platelet count and estimated feto-placental volume. Platelets are transfused more slowly than IUT red cells because of a risk of fetal stroke.
### Table 10.2 Platelets for intrauterine transfusion

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPA-compatible with maternal alloantibody</td>
</tr>
<tr>
<td>Hyperconcentrated to at least $2000 \times 10^9/L$</td>
</tr>
<tr>
<td>Irradiated</td>
</tr>
<tr>
<td>CMV negative</td>
</tr>
</tbody>
</table>

Neonates with suspected or proven NAIT who are severely thrombocytopenic (<30 $\times 10^9/L$) should be transfused with HPA-compatible platelets. HPA1a/5b negative platelet units are usually available ‘off the shelf’ from the Blood Services. Neonates with intracranial haemorrhage (ICH) or a previous affected sibling with ICH are transfused at a threshold of 50 $\times 10^9/L$. If HPA-compatible platelets are not available in a clinically relevant time frame, random donor neonatal platelets should be transfused and will produce a temporary platelet increment in most cases. Spontaneous recovery of the platelet count usually occurs within 1 to 6 weeks as maternally derived antibody levels fall. For babies with persistent severe thrombocytopenia, intravenous immunoglobulin improves the count in around 75% of cases, but response is often delayed for 24–48 hours.

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### 10.2: Neonatal transfusion

Neonates are defined as infants up to 28 days after birth. Most neonatal transfusions are carried out in low birth weight preterm infants treated on neonatal intensive care units (NICUs). Transfusion triggers in neonates are controversial and mainly based on expert clinical opinion, although recent randomised controlled trials of ‘liberal’ versus ‘restrictive’ red cell transfusion policies in very low birth weight preterm babies are starting to influence clinical guidelines.

#### 10.2.1: Neonatal red cell exchange transfusion

Neonatal red cell exchange transfusion is mainly used in the treatment of severe hyperbilirubinaemia or anaemia in babies with HDFN. It removes antibody-coated neonatal red cells and reduces the level of plasma unconjugated bilirubin (the cause of bilirubin encephalopathy). The steep decline in the incidence of HDFN following the introduction of maternal anti-D Ig prophylaxis, more effective antenatal monitoring and treatment, and the use of intensive phototherapy and intravenous immunoglobulin postnatally has made red
cell exchange transfusion an uncommon procedure that should only be performed in specialist units by experienced staff. A ‘double volume exchange’ (160–200 mL/kg) removes around 90% of neonatal red cells and 50% of bilirubin.

The Blood Services produce a special red cell component for neonatal exchange transfusion (Table 10.3). It is ordered in specially by hospitals when required and close collaboration between the clinical team, hospital transfusion laboratory and blood service is essential. The component should be warmed to 37°C immediately before transfusion. It should be irradiated if this requirement does not cause clinically important delay in provision (irradiation is essential if the baby has received IUT).

Table 10.3 Red cells for neonatal exchange transfusion

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma reduced with haematocrit of 0.5–0.6 (NHSBT 0.5–0.55)</td>
<td>To reduce the risk of post-exchange polycythaemia</td>
</tr>
<tr>
<td>In CPD anticoagulant</td>
<td></td>
</tr>
<tr>
<td>Less than 5 days old</td>
<td></td>
</tr>
<tr>
<td>Irradiated (essential if previous IUT)</td>
<td></td>
</tr>
<tr>
<td>CMV negative</td>
<td></td>
</tr>
<tr>
<td>Sickle screen negative</td>
<td></td>
</tr>
<tr>
<td>Usually produced as group O (with low-titre haemolysins)</td>
<td></td>
</tr>
<tr>
<td>RhD negative (or RhD identical with neonate) and Kell negative</td>
<td></td>
</tr>
<tr>
<td>Red cell antigen negative for maternal alloantibodies</td>
<td></td>
</tr>
<tr>
<td>IAT crossmatch compatible with maternal plasma</td>
<td></td>
</tr>
</tbody>
</table>

10.2.2: Large volume neonatal red cell transfusion

Large-volume transfusion, equivalent to a single circulating blood volume (approximately 80 mL/kg), is mainly used in neonatal cardiac surgery. The component supplied (mean unit volume 294 mL) is in SAG-M anticoagulant (see Chapter 3) and has the same specification as that used for neonatal ‘top-up’ transfusions. It should be transfused less than 5 days from donation to reduce the risk of hyperkalaemia. Irradiated blood is required in babies with known or suspected T-cell immunodeficiency, such as DiGeorge syndrome, in which case the blood should be transfused within 24 hours of irradiation.
10.2.3: Neonatal ‘top-up’ transfusion

Repeated small-volume ‘top-up’ red cell transfusions (up to 20 mL/kg) are commonly carried out in preterm babies, mainly to replace losses from repeated blood testing exacerbated by reduced red cell production (‘anaemia of prematurity’). Up to 80% of preterm babies weighing less than 1500 g at birth are transfused at least once. Indications for transfusion in this group have largely been based on the Hb concentration combined with the cardiorespiratory status of the baby (e.g. requirement for oxygen or ventilatory support) and factors such as weight gain, although the evidence base is weak. The new British Committee for Standards in Haematology (BCSH) Transfusion Guidelines for Neonates and Older Children (https://b-s-h.org.uk) suggest the transfusion thresholds summarised in Table 10.4.

Table 10.4 Summary of BCSH recommendations for neonatal top-up transfusions

<table>
<thead>
<tr>
<th>Postnatal age</th>
<th>Suggested transfusion threshold Hb (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ventilated</td>
</tr>
<tr>
<td>First 24 hours</td>
<td>&lt;120</td>
</tr>
<tr>
<td>&lt;=Week 1 (days 1–7)</td>
<td>&lt;120</td>
</tr>
<tr>
<td>Week 2 (days 8–14)</td>
<td>&lt;100</td>
</tr>
<tr>
<td>&gt;=Week 3 (day 15 onwards)</td>
<td>&lt;85</td>
</tr>
</tbody>
</table>

Several randomised controlled trials have addressed the risks and benefits of liberal or restrictive red cell transfusion policies in very low birth weight infants. A systematic review by the Cochrane Collaboration in 2011 found a modest reduction in exposure to transfusion in the restrictive transfusion groups and no significant difference in mortality, major morbidities or survival without major morbidity. The approximate lower limits used to define a ‘restrictive’ transfusion policy in these trials are shown in Table 10.5. Although many experts now favour a restrictive transfusion policy (Venkatesh et al., 2013), it is important to note the Cochrane Review comment that ‘the safe lower limits for haemoglobin transfusion thresholds remain undefined, and there is still uncertainty regarding the benefits of maintaining a higher level’. Further large clinical trials are advocated, especially to address the issues of longer term (including neurodevelopmental) outcomes and cost-effectiveness. Most local guidelines are closer to the restrictive thresholds used in the trials.

Table 10.5 Approximate capillary Hb transfusion thresholds used for ‘restrictive’ transfusion policies in studies evaluated by the Cochrane Review
Many neonatal red cell transfusions are given to replace losses from frequent blood sampling. This can be reduced by avoiding non-essential tests, using low-volume sample tubes, validated near patient testing, micro-techniques in the laboratory, and non-invasive monitoring where possible. Donor exposure can also be reduced by allocating single donor units, split into ‘paedipacks’, to babies predicted to need more than one transfusion episode within the expiry date of the donation. This requires close collaboration between the clinical team and blood transfusion laboratory.

The specifications for neonatal/infant small-volume red cells for transfusion are shown in Table 10.6. The typical transfusion volume is 10–20 mL/kg (higher end of dose for severe anaemia or bleeding) administered at 5 mL/kg/h. Top-up transfusions in excess of 20 mL/kg are not recommended because of the risk of transfusion-associated circulatory overload (TACO).

During the first 4 months of life ABO antigens may be poorly expressed on red cells and the corresponding ABO antibodies may not have yet developed (making confirmation by ‘reverse grouping’ unreliable). Maternal IgG ABO antibodies may be detected in neonatal plasma. Wherever possible, samples from both the mother and infant should be tested for ABO and RhD grouping, an antibody screen should be performed on the larger maternal sample, and a direct antiglobulin test (DAT) on the infant’s sample. Because of the significant risk of ‘wrong blood in tube’ errors due to misidentification, the infant’s blood group should be verified on two separate samples (one of which can be a cord blood sample) as recommended for adult patients, providing this does not delay the emergency issue of blood. If there are no atypical maternal antibodies and the infant’s DAT is negative, top-up transfusions can be given without further testing during the first 4 months of life. Details of pretransfusion testing in neonates and infants are given in the 2013 BCSH guidelines for pre-transfusion compatibility procedures in blood transfusion laboratories (https://b-s-h.org.uk/). Irradiated neonatal components are indicated if the infant has previously received IUT or has a proven or suspected T-cell immunodeficiency disorder.

Table 10.6 Red cells for small-volume transfusion of neonates and infants

<table>
<thead>
<tr>
<th>Postnatal age</th>
<th>Respiratory support</th>
<th>No respiratory support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>115 g/L</td>
<td>100 g/L</td>
</tr>
<tr>
<td>Week 2</td>
<td>100 g/L</td>
<td>85 g/L</td>
</tr>
<tr>
<td>Week 3</td>
<td>85 g/L</td>
<td>75 g/L</td>
</tr>
</tbody>
</table>
Haematocrit 0.5–0.7

In SAG-M anticoagulant/additive solution (approximately 20 mL residual plasma)

Up to 35 days from donation

Group O (or ABO-compatible with baby and mother) and RhD negative (or RhD compatible with the neonate)

In practice, many hospitals use O RhD negative CMV seronegative for neonates

### 10.2.4: Neonatal platelet transfusions

Severe thrombocytopenia (<50x10^9/L) is a common finding in infants treated on NICUs, especially in sick preterm neonates (NAIT is discussed in section 10.1). There is no clear correlation between the severity of thrombocytopenia and major bleeding, such as intraventricular haemorrhage, suggesting other clinical factors are important. Audits show that, contrary to many published guidelines, the majority of platelet transfusions are given as ‘prophylaxis’ in the absence of bleeding. A randomised trial is comparing transfusion thresholds of 25 and 50x10^9/L. Meanwhile, an example of suggested transfusion thresholds is given in Table 10.7. Single donor apheresis platelets manufactured to neonatal specifications are used. They should be CMV-negative and ABO RhD identical or compatible with the recipient. A typical dose is 10–20 mL/kg.

**Table 10.7 Suggested transfusion thresholds for neonatal prophylactic platelet transfusion (excluding NAIT)**

<table>
<thead>
<tr>
<th>Platelets &lt;20 or 30x10^9/L</th>
<th>In the absence of bleeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platelets &lt;50x10^9/L</td>
<td>Bleeding, current coagulopathy, planned surgery or exchange transfusion</td>
</tr>
<tr>
<td>Platelets &lt;100x10^9/L</td>
<td>Major bleeding, major surgery (e.g. neurosurgery)</td>
</tr>
</tbody>
</table>

### 10.2.5: Neonatal FFP and cryoprecipitate transfusion

Normal neonates have different, age-related values for common coagulation screening tests compared to older children and adults. This complicates the diagnosis of ‘coagulopathy’. At birth, vitamin-K-dependent clotting factors are 40–50% of adult levels and are lowest in preterm infants. The prothrombin time (PT), thrombin time (TT) and activated partial thromboplastin time (APTT) may be longer, although overall...
haemostatic function may be normal. In addition, most laboratories rely on published neonatal reference ranges, which may differ from those using local analysers and reagents. Disseminated intravascular coagulation (DIC) is common in sick neonates and haemorrhagic disease of the newborn due to vitamin K deficiency may cause major bleeding in babies who have not received appropriate vitamin K prophylaxis at birth.

Sick neonates in intensive care are commonly transfused with fresh frozen plasma (FFP), which carries a significant risk of serious acute transfusion reactions (see Chapter 5). The 2009 National Comparative Audit of the use of FFP (http://hospital.blood.co.uk/safe_use/clinical_audit/national_comparative/index.asp) confirmed that, contrary to published guidelines, 42% of FFP transfusions to infants were given ‘prophylactically’ in the absence of bleeding, on the basis of abnormal clotting tests. BCSH guidelines recommend that FFP should be used for:

- Vitamin K deficiency with bleeding
- DIC with bleeding
- Congenital coagulation factor deficiencies where no factor concentrate is available (Factor V deficiency)

The dose of FFP is usually 12–15 mL/kg. The degree of correction is unpredictable and clotting tests should be repeated after administration.

FFP should not be used as routine prophylaxis against peri/intraventricular haemorrhage in preterm neonates (evidence from a randomised controlled trial), as a volume replacement solution, or just to correct abnormalities of the clotting screen.

Cryoprecipitate is used as a more concentrated source of fibrinogen than FFP and is primarily indicated when the fibrinogen level is <0.8–1.0 g/L in the presence of bleeding from acquired or congenital hypofibrinogenaemia. The usual dose is 5–10 mL/kg.

FFP for neonates (and all patients born on or after 1 January 1996) is imported from countries with a low risk of vCJD and is pathogen-inactivated. Methylene blue inactivation is used by the UK Blood Services and commercial pooled solvent detergent treated FFP is also available. It should be ABO identical with the recipient or group AB (group O FFP should only be given to neonates of group O).

10.2.6: Neonatal granulocyte transfusion

There is no conclusive evidence from randomised controlled trials to support the use of granulocyte transfusions in neutropenic, septic neonates. Current guidelines do not recommend their routine use in the absence of further prospective studies.

10.2.7: T-antigen activation

Occasional severe haemolytic reactions have been reported in neonates or infants receiving blood or FFP containing anti-T antibodies. The T-antigen may be exposed on the surface of neonatal red cells by neuraminidase-producing bacteria such as Clostridium spp., often in association with necrotising enterocolitis (NEC). As T-antigen activation is often found in healthy neonates and severe haemolysis is very rare, the need to screen neonates with NEC and make special components available remains controversial and is not performed in many countries. Red cells in SAG-M, containing only small amounts of plasma, are regarded as safe. All non-essential transfusions of FFP and platelets should be avoided. If low-titre anti-T components are regarded as essential, platelets in platelet suspension medium can be used and methylene blue treated FFP with a low titre of anti-T may be available from the Blood Services.
10.3: Transfusion of infants and children

Transfusion is performed much less often in older infants and children. The most commonly transfused groups are children on paediatric intensive care units (PICUs), those undergoing cardiac surgery, transfusion-dependent children with inherited conditions such as thalassaemia major, and those following intensive chemotherapy for haematological malignancy or cancer. Transfusion guidelines and blood components for older children are similar to those for adult patients (see appropriate sections of the handbook). Blood transfusion for children with haemoglobinopathies is covered in Chapter 8.

The dose of blood components for infants and children should always be carefully calculated and prescribed in mL, rather than as ‘units’ to prevent errors and avoid potentially dangerous circulatory overload. Dedicated paediatric transfusion charts or care pathways can also reduce dosing and administration errors. It is recommended that:

- Red cells are transfused at up to 5 mL/kg/h (unless there is active major bleeding) and the transfusion should be completed within 4 hours (see Chapter 4).
- Apheresis platelets should be used for all children <16 years old to reduce donor exposure. The typical dose for children weighing less than 15 kg is 10–20 mL/kg. Children above 15 kg may receive a single apheresis donation (approximately 300 mL). The recommended rate of administration is 10–20 mL/kg/h. Platelets should be ABO-compatible to reduce the risk of haemolysis caused by donor plasma. RhD negative girls should receive RhD negative platelets if at all possible. If RhD positive platelets have to be given, anti-D immunoglobulin should be administered (a dose of 250 IU intramuscularly or subcutaneously should cover up to five apheresis platelet donations given within a 6-week period).
- FFP should not be administered prophylactically in non-bleeding patients or to ‘correct’ minor abnormalities of the PT or APTT before invasive procedures. When indicated, a dose of 12–15 mL/kg should be administered at a rate of 10–20 mL/kg/h with careful monitoring for acute transfusion reactions or circulatory overload. FFP should not be used to reverse warfarin anticoagulation unless prothrombin complex concentrate (PCC) is unavailable.

10.3.1: Paediatric intensive care

The TRIPICU randomised controlled trial in stable critically ill children by Lacroix et al. in 2007 found that a restrictive Hb transfusion trigger (70 g/L) was as safe as a liberal Hb trigger (95 g/L) and was associated with reduced blood use. It remains uncertain whether this can be extrapolated to unstable patients.

Expert opinion now generally favours an Hb transfusion trigger of 70 g/L in stable critically ill children, which is the same as the recommendation for adult patients (see Chapter 7). A higher threshold should be considered if the child has symptomatic anaemia or impaired cardiorespiratory function.

There is little high-grade evidence to underpin guidelines for the administration of platelets and FFP in this group. In general, guidelines developed for adult patients are used (see Chapter 7).

10.3.2: Haemato-oncology patients
Children undergoing treatment for malignancy are generally transfused in a similar manner to adult patients. A red cell transfusion trigger of 70 g/L is appropriate for clinically stable patients without active bleeding. Platelet transfusion guidelines are also similar to those developed for adult practice, although a higher rate of bleeding in children with haematological malignancies has been reported. The 2004 BCSH Transfusion Guidelines for Neonates and Older Children recommend a standard platelet transfusion threshold of $10^9$ /L in non-infected, clinically stable children. A threshold of $20 \times 10^9$/L is recommended in the presence of severe mucositis, DIC or anticoagulant therapy. Patients with DIC in association with induction therapy for leukaemia and those with extremely high white cell counts may be transfused at $20–40 \times 10^9$/L and a similar level is appropriate for performance of lumbar puncture or insertion of a central venous line.

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10.4: Major haemorrhage in infants and children

There is little research evidence to underpin clinical guidelines for the management of children with major haemorrhage. In general, principles developed in adult practice have been extrapolated to the care of children (see Chapter 7). Well-rehearsed local protocols, excellent communication with the transfusion laboratory and involvement of appropriate senior staff with paediatric expertise are important elements of successful care.

Emergency group O RhD negative red cells should be rapidly available, with the option of moving to group-specific blood when the identity of the patient and the blood group have been verified. The transfusion laboratory should be informed of the age and (estimated) weight of the patient to guide selection of appropriate blood components. Age-specific components should be used if available in a clinically relevant time frame. Otherwise, the ‘next best’ adult component should be used until specialised products are available. Where red cell:FFP transfusion ratios are employed, the ratio should be based on volume (mL), rather than ‘units’. Once the patient has been stabilised by ‘damage control resuscitation’ and transfusion based on clinical signs, appropriate therapeutic targets (based on rapid return laboratory or near-patient testing) are: Hb 80 g/L; fibrinogen >1.0 g/L; PT ratio <1.5; platelet count >$75 \times 10^9$/L.

Based on the CRASH-2 study in adults, the Royal College of Paediatrics and Child Health now recommends the use of tranexamic acid in children after major trauma in a dose of 15 mg/kg (maximum 1 000 mg) infused intravenously over 10 minutes followed by 2 mg/kg/h (maximum 125 mg/h) until bleeding is controlled.