

**National Comparative
Audit of Blood Transfusion**



NHS
Blood and Transplant



2022 Audit of Patient Blood Management in Elective Paediatric Surgery

December 2024



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Standard	Audit findings	Recommendation
<p>Standard 1: All children undergoing major elective surgery with risk of bleeding have a pre-operative full blood count performed at least 6 weeks prior to the planned date of surgery.</p>	<p>75% (551/735) of children undergoing planned surgery with a significant risk of blood loss had a pre-operative assessment.</p> <p>90.9% (668/735) children had a full blood count performed preoperatively.</p> <p>18% (119/653) of all children (where the haemoglobin result was reported) were anaemic on their last haemoglobin check before surgery, with the highest prevalence 27% (54/210) in those under 5 years.</p>	<p>All children and young people should be offered preoperative health screening for procedures with a significant risk of blood loss, at least 6 weeks pre-operatively, which should include checking the full blood count. Two potential points in the pathway are at booking and in the preoperative assessment clinic.</p> <p>Local policies should clearly define who is responsible for reviewing and acting on results and for follow-up to ensure pre-operative anaemia treatment is effective.</p>
<p>Standard 2: The pre-operative Hb is optimised by treating iron deficiency.</p>	<p>11% (81/735) of all children were given iron preoperatively, majority orally.</p> <p>81% (17/21) of all children with anaemia were treated empirically with iron without laboratory confirmation of iron deficiency.</p>	<p>Centres should have a clear pathway for investigation and management of pre-operative anaemia in children.</p>
<p>Standard 3: A peri-operative Hb transfusion trigger of 70 g/L should be used in stable children without major comorbidity or bleeding</p>	<p>29.8% (219/735) of children required a peri-operative allogeneic blood transfusion, 66.1% (158/239) of these transfusions were given intraoperatively.</p> <p>27/69 (39.1%) of postoperative transfusions were given due to Hb <70 g/L. The majority of the rest were given due to ongoing blood loss, clinical symptoms or haemoglobin <80 g/L with significant comorbidities. In 10/69 cases (14.5%) the reason for transfusion was unknown.</p>	<p>The rationale for transfusion should be clearly documented, particularly where the Hb is outside standard triggers.</p>
<p>Standard 4: Tranexamic acid is given to all children undergoing surgery where there is risk of significant bleeding, unless contraindicated</p>	<p>Tranexamic acid was given to 68.8% (506/735) of eligible children.</p>	<p>Tranexamic acid must be considered for all children undergoing surgery where there is risk of significant bleeding, unless contraindicated. Centres should update their policies to incorporate the 2022 Joint Royal College guidance and the dosing schedule in paediatrics which now encourage wider usage of tranexamic acid.</p>
<p>Standard 5: Red cell salvage is considered in all children undergoing surgery who are at risk of significant bleeding and where transfusion may be required,</p>	<p>Cell salvage was used in 43.8% (322/735) of cases and in 79.8% (257/322) of these the salvaged blood was reinfused.</p>	<p>Centres should have a specific policy for cell salvage in paediatrics. This should be considered for all children weighing at least 10 kg having surgery with a risk of blood loss >10% of blood volume. https://doi.org/10.1111/anae.14331</p>

<p>providing there are appropriately trained staff</p>	<p>In 38.4% (84/219) of children who received an allogeneic transfusion, cell salvage had not been used.</p> <p>Only half of centres with cell salvage have a specific paediatric protocol.</p>	
<p>Standard 6: All families of children who undergo surgery with a risk of blood loss are given information pre-operatively regarding blood transfusion.</p>	<p>In 77.8% (572/735) of cases there was evidence that the family was informed of the possible need for transfusion but only 16.6% (122/735) had documented written/digital information provision.</p>	<p>The risk of transfusion and strategies offered to avoid transfusion should be included in the consent process before major paediatric surgery with a risk of blood loss. Families must be given written information about transfusion. This could be in an electronic format, such as providing the QR code for national resources (NHSBT, 2024)</p> <p>Centres should have a means of recording that written information has been provided, e.g. using a code on electronic records, which can be readily audited.</p>

Background

Pre-operative assessment and recognition of anaemia is a well-recognised tenet of Patient Blood Management (PBM) in adults. Much of the evidence to date has reported on the association between pre-operative anaemia and adverse outcomes in adults, with less data relevant to children.

Iron deficiency prevalence may be particularly high in some subgroups of children such as young children and adolescent girls. Studies investigating pre-operative anaemia and peri-operative mortality in paediatrics and neonates have demonstrated a high rate of anaemia (24-32%) (Weyand 2023) and increased mortality in anaemic children (Goobie, 2016).

Guidance for transfusion thresholds in children is provided in national guidelines (New, 2016). These and other recent international guidelines recommend a restrictive transfusion strategy - i.e. considering transfusion when the haemoglobin level is less than 70 g/L (strong recommendation, moderate certainty evidence) in most hospitalised children at risk of critical illness who are haemodynamically stable (Carson, 2023). There were clear messages in the 2024 Infected Blood Inquiry that children (and parents of children) must be informed about blood transfusion, including risks, and the need to offer strategies to avoid the need for transfusion. Use of tranexamic acid and alternatives to transfusion, such as cell salvage, are core elements of PBM in adults (Devereux 2022), but less is known about their uptake in paediatric peri-operative practice.

It has been shown in several UK local audits that there is differing practice around anaemia identification and management in children before elective surgery (Ladak, 2024). There may be opportunities to save blood and reduce the number of unnecessary transfusions in children undergoing surgery, particularly in orthopaedic surgery such as scoliosis correction. While blood transfusion is generally considered very safe, children are at higher risk of acute transfusion reactions compared to adults (Wang 2022) and can be particularly susceptible to transfusion associated circulatory overload (TACO), especially if care is not taken over transfusion volumes. With a long post-transfusion life expectancy, greater consideration also needs to be given to potential long-term consequences of transfusion in this patient population.

Although there are guidelines which include peri-operative management of children undergoing surgery at risk of bleeding and transfusion (NICE, 2015; NBA, 2016; New et al, 2016), the overall focus for peri-operative PBM in UK hospitals has been on adults. This audit was therefore conducted to assess peri-operative practice of PBM in children, by comparison to selected national standards. The audit would also inform directions for further research, for example the effectiveness of treating anaemia pre-operatively to improve surgical and other outcomes in children.

Aims of the audit

- Compare PBM practice against standards in guidelines for a cohort of children at multiple UK Centres undergoing elective surgery where blood loss is expected to be significant.
- Provide benchmarking feedback to participating Centres on opportunities for improvement.

A range of key performance standards were agreed by the audit committee:

Criterion	Evidence Base /Guidelines
Standard 1: All children undergoing major elective surgery with risk of bleeding have a pre-operative full blood count performed at least 6 weeks prior to the planned date of surgery.	- International Consensus Statement on the peri-operative management of Anaemia and Iron deficiency Anaesthesia Dec 2016
Standard 2: The pre-operative Hb is optimised by treating iron deficiency.	- NICE quality statement 2016 - British Society of Haematology: Guidelines on transfusion for fetuses, neonates and older children 2016
Standard 3: A peri-operative Hb transfusion trigger of 70 g/L should be used in stable children without major comorbidity or bleeding	- British Society of Haematology: Guidelines on transfusion for fetuses, neonates and older children 2016
Standard 4: Tranexamic acid is given to all children undergoing surgery where there is risk of significant bleeding, unless contraindicated	- British Society of Haematology: Guidelines on transfusion for fetuses, neonates and older children 2016
Standard 5: Red cell salvage is considered in all children undergoing surgery who are at risk of significant bleeding and where transfusion may be required, providing there are appropriately trained staff	- British Society of Haematology: Guidelines on transfusion for fetuses, neonates and older children 2016
Standard 6: All families of children who undergo surgery with a risk of blood loss are given information pre-operatively regarding blood transfusion.	- NICE quality statement 2016

Methodology

All hospitals in the UK that perform predefined major paediatric surgical procedures were invited to participate. An initial survey was conducted to ascertain that the audit targeted all appropriate hospitals and types of surgery in the paediatric population.

Centres were asked to audit a maximum of 40 cases, with no minimum number of cases. Centres were able to include cases seen during the whole of 2022.

Inclusion criteria:

- Children less than 18 years of age
- Had undergone elective surgery where blood loss was expected to be significant, targeting the following index cases:
 - Femoral and/or pelvic osteotomy, hip reconstruction, open reduction of hip
 - Craniotomy
 - Scoliosis surgery
 - Nephrectomy
 - Renal transplant
 - Anorectal malformation correction
 - Craniosynostosis surgery
- Group and screen sample was taken or blood cross-matched for the procedure.

We excluded the following from the audit:

- Children with haemoglobinopathies and any form of haematological malignancy
- Children less than 4 weeks old (due to different recommended transfusion targets in neonates)
- Any form of urgent or emergency surgery
- Any redo or second side surgery
- Cardiac surgery (due to different recommended transfusion targets and cardiopulmonary bypass priming)

Centres were also asked to complete an organisational questionnaire allowing us to understand the context in which care is delivered. The organisational questionnaire is included in Appendix I and the clinical data collection form in Appendix 2.

Organisational Survey Results

25/31 Centres returned a completed form for the organisational survey.

24/25 Centres (96%) have a dedicated paediatric pre-assessment service.

8/25 Centres (32%) do not have a policy for pre-operative investigation in paediatrics.

All Centres responding to the question (23/23) reported having a specific paediatric blood transfusion policy, and 15 of these 23 (65%) specifically include paediatric transfusion triggers.

23/25 Centres (92%) have capacity for cell salvage in paediatrics, though 11 (47.8%) of these do not have a dedicated paediatric cell salvage protocol.

The median number of machines for those Centres with cell salvage capacity is 3.

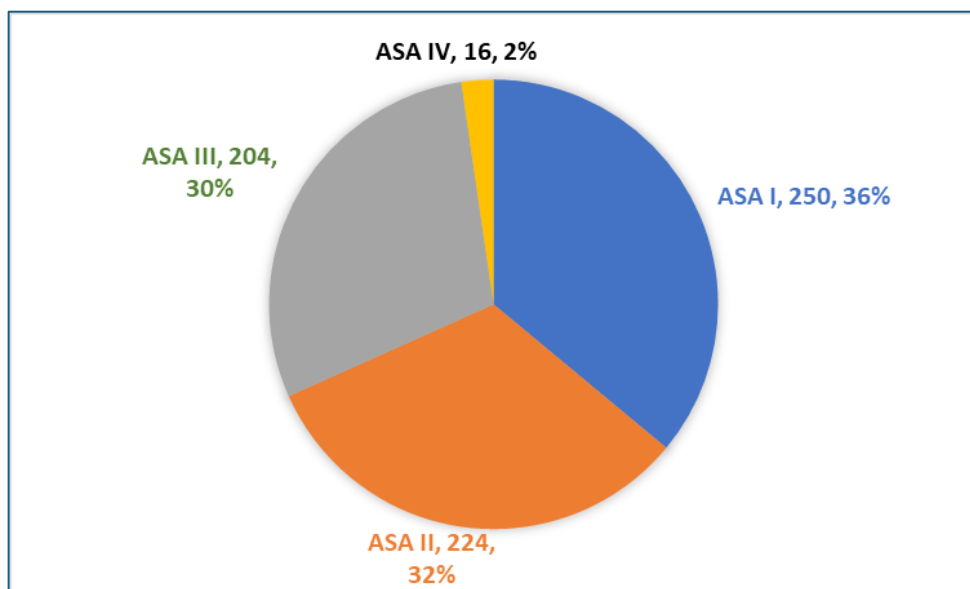
Patient Characteristics

30 Centres (see Appendix 3) participated and contributed data on 735 children meeting the inclusion criteria, aged between 1 month up to 18 years, with a median age of 10 years. 419 (57.0%) were female, 303 (41.2%) male (not recorded for 13 (1.8%) children). 295/735 (40.1%) children had comorbidities, ranging from 1 to 6 comorbidities.

Table 1 - Children with comorbidities

Number with comorbidities (n=295/735, 40.1%)	N	%
No comorbidities	440	59.9
1-2 comorbidities	254	34.6
3 or more comorbidities	41	5.5
Comorbidities (295 children - some children had more than one comorbidity)		
Respiratory problems	116	39.3
Cardiac problems	37	12.5
Liver disorder	3	1.0
Metabolic condition	21	7.1
Neuromuscular disorder	71	24.1
Renal disorder	51	17.3
Cerebral palsy	83	28.1
Epilepsy	62	21.0
Haematological conditions	17	5.8

Figure 1: Comorbidities were reflected by the children's ASA Score:



Of the 250 children given an ASA score of I (equating to a normal, healthy patient) 11 were reported to have a comorbidity. It is well recognised that the ASA scoring system can be subjective. 440 children were reported to not have any comorbidity, yet 175 (40%) of these were given ASA scores indicating that they had either mild, severe or life-threatening comorbidities. This may be explained the surgical condition not being reported as a comorbidity by clinicians.

A wide range of specialties were included. The majority were admitted under orthopaedics and spines.

Table 2 - Admitting specialty (n=735)

	N	%
Spine	218	29.7
Orthopaedics	261	35.5
Neurosurgery	51	6.9
Craniofacial	92	12.5
General surgery	55	7.5
Urology	45	6.1
Maxillofacial	1	0.1
Plastics	2	0.3
ENT	2	0.3
Nephrology	2	0.1
Gastroenterology	1	0.1
Oncology	2	0.3
Missing	3	0.4

Most children waited a significant amount of time for their procedure, median 114 days (IQR 48-239), range 1 to 1103 days.

Clinical Audit Results

Standard 1: All children undergoing major elective surgery with risk of bleeding have a pre-operative full blood count performed at least 6 weeks prior to the planned date of surgery.

Rationale

Taking a full blood count (FBC) at least 6 weeks prior to the planned date of surgery allows time for the detection and treatment of correctable anaemia before surgery. Raising the Hb increases the patient's reserve in the event of anticipated bleeding during surgery reducing the need for allogeneic red blood cell transfusion, particularly when accompanied by other PBM measures.

Results

The majority of children (668/735 (90.9%)) had a preoperative FBC measured and documented before surgery.

Table 3 - Preoperative FBC requested

	National (n=735)	
	N	%
Yes	668	90.9
No	56	7.6
Missing	11	1.5
<i>When the FBC was requested*</i> <i>n = 668</i>		
At booking	52	7.8
In pre-operative clinic	444	66.5
On admission	79	11.8
At induction of anaesthetic	56	8.4
Other	65	9.7
Not stated	23	3.4

*NB: 48 children had their Hb checked on more than one occasion so totals exceed more than 668 and 100%.

Table 3a – Number of weeks before surgery that last FBC was measured

Time period	N=735 children	%
Less than 1 week	326	44.4
1 week to less than 2 weeks	85	11.6
2 weeks to less than 4 weeks	88	12.0
4 weeks to less than 6 weeks	48	6.5
6 weeks to less than 12 weeks	60	8.2
12 weeks or more	67	9.1
Unknown	61	8.3

Commentary

551/735 (75.0%) children were confirmed to have attended a preoperative assessment for the major procedure. 668/735 (90.9%) children had a full blood count requested at some point preoperatively. The majority (547/735 (74%)) had a final pre-operative FBC taken within 6 weeks of surgery and 44% within 1 week of surgery.

With a median time on the waiting list of 114 days amongst the audited population, an FBC check at the booking appointment would provide ample time to identify and effectively treat iron deficiency anaemia, which could then be rechecked at pre-assessment. This was done in only 7.8% of cases. This has advantages over waiting for the pre-operative assessment clinic, which is closer to the procedure.

Standard 2: The pre-operative Hb is optimised by treating iron deficiency.

Rationale

A haemoglobin level below the age-appropriate normal range should be investigated. The most common cause of pre-operative anaemia is iron deficiency. Haematinic tests including ferritin and transferrin saturation (TSAT) help to guide treatment decisions.

Results

Pre-op FBC was requested for 668 children, as shown in Table 3. Of these, the Hb is known for 653 (97.8%) children.

In the children where haemoglobin prior to surgery was reported, 119 (18.3%) were anaemic on their last check prior to surgery. Under 5-year-olds had the highest prevalence of anaemia.

Table 4 Prevalence of anaemia at different age ranges (using age-related Hb thresholds)

Age range	National		
	Number of children	Number anaemic	Prevalence of anaemia in that age range (%)
Less than 5 years (Hb 110 g/L)	210	54	25.7
5 years to less than 12 years (Hb 115 g/L)	136	24	17.6
12 years to 15 years (Hb120 g/L)	221	27	12.2
Over 15 years up to 18 years (Female, Hb120 g/L)	46	5	10.9
Over 15 years up to 18 years (Male, Hb130 g/L)	38	4	10.5
Total	651	114	17.5

NB: Age is known for 651/653 children

81/735 (11.0%) children in total received iron therapy. In 43 cases this was given orally, in 3 it was given intravenously, and it was not stated for 35. As 57 of these children where the Hb results were reported were not anaemic on their last FBC before surgery, this may reflect successful pre-operative treatment of iron deficiency anaemia. However, in 15 of the 81 (18.5%) children, iron was started less than 6 weeks before surgery, which may provide insufficient time for response to oral supplements.

21 of the 119 known anaemic children (17.6%) on the last Hb prior the surgery received iron therapy. In most cases (17/21, 81%) this was given blindly, without haematinics to confirm iron deficiency.

22 of the 199 children (18.5%) classified as anaemic on their last check prior to surgery had been investigated with haematinics.

112/735 (15.2%) of all audited children had been investigated with ferritin, transferrin saturation or both.

Table 5 Timing of treatment of children with iron prior to surgery

Interval between the start of preoperative iron therapy and surgery	N=81	%
Less than 1 week	1	1.2
1 week to less than 2 weeks	3	3.7
2 weeks to less than 4 weeks	8	9.9
4 weeks to less than 6 weeks	3	3.7
6 weeks to less than 12 weeks	6	7.4
12 weeks or more	19	23.5
Not stated	41	50.6

Standard 3: A perioperative Hb transfusion trigger of 70 g/L should be used in stable children without major comorbidity or bleeding

Rationale

Guidelines state that surgical children without major co-morbidity or active bleeding should not be transfused peri-operatively if their Hb is 70g/L or more (excluding cardiac surgery).

Results

There were a total of 239 red cell transfusion episodes in 219 children, giving an overall peri-operative transfusion rate (including pre-operative, intra-operative and post-operative transfusions) of 29.8% (219/735).

12/735 (1.6%) children were transfused with red cells pre-operatively. 5 of these children had renal comorbidities and 3 were listed for solid tumour surgery. Only 1 child who received a preoperative blood transfusion had received iron pre-operatively. In 1 case the Hb was <70 g/L, and in 1 case it was <80 g/L. One child with a pre-operative Hb of 100 g/L was transfused two adult units pre scoliosis surgery. Respiratory problems were stated as a comorbidity for this child.

158/735 (21.5%) children received an allogeneic transfusion intraoperatively. This accounted for 66.1% of all transfusion episodes. Reasons for transfusion were provided for 143/158 (90.5%) children. See table 6 for details.

Table 6

Reason for intra-operative transfusion	National (n=158)*	
	n	%
Hb less than 70g/L	12	7.6
Ongoing blood loss	123	77.8
The child was clinically symptomatic	18	11.4
Hb less than 80 g/L in a child with major comorbidity	5	3.2
Other**	3	1.9
Not known	15	9.5

*NB: Totals exceed more than 158 and 100% because some children had multiple reasons for transfusion

** Other = Drop in Hb (2); Hb 78 (1);

69/735 (9.4%) children were given a postoperative transfusion.

13 children received transfusion both intra- and post-operatively.

In the postoperative setting, most transfusions appeared to have clinical justification. Reason for transfusion was stated for 59/69 (85.5%) children. See Table 7 below.

Table 7

Reason for post-operative transfusion	National (n=69)**	
	n	%
Hb less than 70g/L	27	39.1
Ongoing blood loss	14	20.3
The child was clinically symptomatic	20	29.0
Hb less than 80 g/L in a child with major comorbidity	9	13.0
Other	6	8.7
Not known	10	14.5

**NB: Totals exceed more than 69 and 100% because some children had multiple reasons for transfusion

Commentary

The transfusion rate of 29.8% children in this audit reflects the inclusion criteria of children undergoing surgery with a significant bleeding risk.

The 12 children given pre-operative transfusions included a high number with renal comorbidities and those listed for solid tumour resections. This is an area of practice which would benefit from further investigation, as anaemia is less likely to be due to iron deficiency and pre-operative anaemia management is more complex.

It is reassuring that the majority of post-operative transfusions were given due to Hb being below 70 g/L, or Hb below 80 g/L with major comorbidities, ongoing blood loss or clinical symptoms.

Standard 4: Tranexamic acid is given to all children undergoing surgery where there is risk of significant bleeding, unless contraindicated

Rationale

Tranexamic acid (TXA) is a synthetic analogue of the amino acid lysine which reduces bleeding by blocking the lysine binding sites of plasminogen, inhibiting plasminogen activation and thus reducing fibrinolysis. Large scale clinical trials and meta-analyses have demonstrated it to be efficacious in reducing blood loss and transfusion requirements in both trauma and elective surgery and its routine use in major orthopaedic surgery is included in NICE quality standards (NICE, 2015).

Tranexamic acid should be considered for all children undergoing surgery where there is a risk of significant bleeding and they have no contraindications to its use. The *British National Formulary* defines contra-indications as "Fibrinolytic conditions following disseminated intravascular coagulation (unless predominant activation of fibrinolytic system with severe bleeding); history of convulsions; thromboembolic disease".

Results

Tranexamic acid was given to 506/735 (68.8%) children. 190 (25.9%) children did not receive tranexamic acid. Not known for 39 (5.3%) children. See Table 8 below:

Table 8 - Use of tranexamic acid

	National (n=735)	
	n	%
Bolus only	239	32.5
Bolus & Infusion	237	32.2
Infusion only	30	4.1
Not given	190	25.9
Not known	39	5.3
Children NOT receiving tranexamic acid	n	%
Contraindicated	8/190	4.2
Other reason	46/190	24.2
Unknown	136/190	71.6

Table 8a - Reasons why tranexamic acid was not given

Reason	n
Did not anticipate much blood loss	1
Did not consider it	1
Felt not necessary	5
Low risk of bleeding	2
Minimal blood loss	16
Not indicated	1
Not required	2
Not usual practice	16
Surgeon prefer not to give	1
Tourniquet	1
TOTAL	46

It is noteworthy that 16 respondents stated that use of tranexamic acid was 'not usual practice' and 19 anticipated minimal bleeding (despite the inclusion criteria of the audit).

Commentary

Tranexamic acid was not given to 190 children, of whom only 8 had a contraindication. This suggests an on-going need to reinforce the administration of tranexamic acid for all children undergoing surgery where there is risk of significant bleeding.

Of the 506 children who were given tranexamic acid, most received this as a bolus alone (239/506, 47.2%) or bolus and infusion (237/506 children (46.8%).

In this audit, the median bolus dose administered was 15 mg/kg (IQR 11-17) and median infusion rate was 9 mg/kg/hr (IQR 5-10). The updated guidance may help standardise dosing regimens in future.

Standard 5: Red cell salvage is considered in all children undergoing surgery at risk of significant bleeding and where transfusion may be required, providing there are appropriately trained staff

Cell salvage can significantly reduce allogeneic blood transfusion in adults and with the development of small collection reservoirs, is feasible in infants as well as older children. Contraindications include sickle cell disease and other conditions characterized by red cell fragility.

Cell salvage was used in 322/735 (43.8%) cases. There were only 3% of cases where cell salvage was felt to be contraindicated or appropriate equipment not available. See Table 9 below:

Table 9 - Use of intraoperative cell salvage

Was cell salvage blood collected?	National (n = 735)	
	n	%
Yes	322	43.8
No	348	47.3
Unknown/ not stated	65	8.8
<i>If not collected – what was the reason? (n=348)</i>		
Anticipated blood loss too low: Child’s weight	43	12.4
Anticipated blood loss too low: Procedure	78	22.4
Machine not available	2	0.6
Contraindicated	25	7.2
Only adult machine available	1	0.3
Unknown/Missing	199	57.2

Of those cases who had cell salvaged blood collected, reinfusion occurred in 257/322 (79.8%) children. In the majority of cases where blood was not reinfused this was due to insufficient amounts to infuse.

There were 84 cases where cell salvage was not used but the patient received an allogeneic transfusion.

Commentary

Intraoperative cell salvage should be considered for all children weighing 10kg or more where blood loss of greater than 8 ml / kg or >10% of calculated total blood volume is anticipated (Klein, 2018). Although low weight was given as the reason for not using cell salvage in 39 children, the data for these children show a range of weights from 3.2 kg up to 82.0 kg. The weights of those in whom cell salvage was not used but who received an allogeneic transfusion were 3.2 – 15.3 kg. Wider routine use of cell salvage in smaller children might avoid exposure to allogeneic blood.

Standard 6: All families of children who undergo surgery with a risk of blood loss are given information pre-operatively regarding blood transfusion.

Rationale

NICE Quality Standard QS138 requires that anyone likely to receive a red cell transfusion is given both verbal and written information allowing them to understand the risks, benefits and alternatives to transfusion. Informed consent for transfusion is one the basic tenets of good healthcare.

Results

Table 10 – Provision of information about transfusion

	National (n=735)	
	n	%
<i>Evidence exists that family was informed of possible need for transfusion</i>		
Yes	572	77.8
No	155	21.1
Not stated	8	1.1
<i>Evidence exists that written/digital information was given</i>	n	%
Yes	122	16.6
No	605	82.3
Not stated	8	1.1

Commentary

These poor rates of providing information about transfusion (or of documenting this) mirror the results of national audits in adults. The 2023 audit of NICE QS138 in adults showed that only 35% of children receiving a transfusion received both verbal and written information. The Infected Blood Inquiry report emphasised the importance of consent and information-giving around transfusion, and the need to evidence this. NHS Trusts should ensure that this is built into pre-operative processes, with clarity over who is responsible. Consideration should also be given to documenting any discussion electronically in such a way that it can be readily audited. Families may find it convenient to be provided links to written information in an electronic format, for example by incorporating QR codes for national transfusion resources into local patient leaflets.

Red cell ordering in advance of surgery

Units are typically requested for crossmatch in advance of elective surgery carrying a significant risk of bleeding, to reduce the risk of any delay providing blood intraoperatively when it is needed. It is recommended that a Maximum Blood Ordering Schedule (MSBOS) be agreed between the laboratory and clinical teams, based on audits of local practice, which specifies the number of units that should be reserved for standard procedures (RCOA 2024).

The overall ratio of adult units crossmatched in advance to units transfused intraoperatively, (crossmatch to transfusion (C/T) ratio) in this dataset was 1.69 (data was not available regarding paediatric units). However, in spinal surgery this ratio was 2.27, suggesting a tendency for over-ordering in this patient group. This can impact on laboratory workload and stock management and might potentially lead to increased red cell wastage. Ideally, the C/T ratio should be 1.0, but a ratio of 2.5 and below was suggested to be indicative of acceptable blood usage (Waheed 2022).

Centres should use their individual crossmatch:transfusion ratio results from this audit, along with any other local analysis, to review their own MSBOS.

Table 11 – Ratio of adult units requested in advance to number of units transfused intraoperatively

*Number of adult units crossmatched divided by number of units transfused intraoperatively (mean average of pairs in each specialty)

Specialty	Number of children transfused intraoperatively	Number of children where both crossmatch and transfusion data available	Mean crossmatch: transfusion ratio*
Craniofacial	64	58	1.59
ENT	0	0	.
General surgery	11	8	1.44
Maxillofacial	0	0	.
Nephrology	0	0	.
Neurosurgery	8	4	1.13
Orthopaedics	19	8	1.63
Plastics	1	0	.
Renal transplant	3	3	1.33
Spine	41	25	2.27
Urology	10	8	1.25
TOTAL	157	114	1.69

Organisational Survey

26/30 (86.7%) centres provided information on their arrangements for managing children for whom there is a planned admission. This section provides details for information only, so readers can understand the context in which care is given. Only national data is provided – centres will be able to compare and contrast their own arrangements.

Paediatric pre-assessment service

21/26 (80.8%) centres provide this service

Referral pathways

	n	%
Children booked under certain specialties are screened and triaged	14	53.8%
Referred by booking clinician	15	57.7%
Children are screened and triaged face to face (one stop shop)	7	26.9%
Children are screened and triaged virtually or by telephone	11	42.3%

Pre-operative anaemia and policies

	n	%
Paediatric preoperative investigation policy for elective surgery	8	30.8%
Paediatric preoperative investigation policy for elective surgery which include haematinics	4	15.4%
Paediatric preoperative iron deficiency guideline	4	15.4%
Paediatric preoperative blood ordering policy	16	61.5%

Intra-operative measures

	n	%
Paediatric blood transfusion policy	8	61.5%
Paediatric blood transfusion policy including transfusion triggers	4	50.0%
Paediatric tranexamic acid administration policy	4	42.3%

Cell salvage

21 centres have paediatric cell salvage capability and of those 10 have a paediatric cell salvage protocol. 11 centres require a dedicated practitioner to operate the cell salvage.

Point of care testing

	N	%
AGB machine in theatre	18	69.2%
AGB machine not in theatre	9	34.6%
Haemocue in theatre	16	61.5%
Non-invasive Hb monitoring in theatre	3	11.5%

Discussion

This audit indicates the need for stronger and timely pathways of pre-operative anaemia management including more systematic detection, investigation and treatment in the paediatric surgical setting. It is important that there is clarity about which staff are responsible for checking results, arranging treatment and for follow-up testing to ensure its efficacy.

A number of recommendations are provided. These messages are aligned with those provided more generally in the UK Infected Blood Inquiry and with the Association of Paediatric Anaesthetists (APAGBI) "[Best practice guidance](#)" published in partnership with the Royal College of Anaesthetists (RCOA) to support development of pre-assessment services for children. The Centre of Perioperative Care (CPOC) [anaemia guidance](#) has a paediatric section to help guide centres to develop robust perioperative pathways.

Local policies with input from surgical, anaesthetic, haematology and laboratory teams may help address all aspects of these children's care and create pathways that are most likely to be workable and effective in day to day practice. Pathways for testing for and treating anaemia need to be developed with the inclusion of haematinics in anaemic children. Reflex testing may reduce delays in diagnosis and avoid the need for repeat visits and additional blood tests. Blood tests could be done at the time of booking, so treatment can be started and effectiveness checked at preassessment clinic.

While tranexamic acid was widely used, the updates to national guidance issued since this audit was performed mean that it should be considered for all children undergoing inpatient surgery, unless there is a clear contraindication. Centres should ensure that the latest recommendations are incorporated into their local policies. In October 2022, during the audit period, the Joint Royal Colleges Tranexamic Acid in Surgery Implementation Group issued guidance, following the publication of the POISE-3 (Peri-Operative Ischemic Evaluation-3) trial which reported that tranexamic acid reduces major bleeding by 25% and reduces the need for blood transfusion, without increasing the risk of thromboembolic events. They recommended a dose of 15mg/kg tranexamic acid loading dose (max 1g) over 10 minutes followed by 2mg/kg per hour. This dosing regimen should also be suitable for paediatric surgery with the maintenance dose discontinued at the end of surgery. This guidance states there is no evidence of any increased risk of seizures with the doses recommended. The Royal College of Paediatrics and Child Health (RCPCH) recommended that children over 12 years old should receive the adult dose.

Cell salvage is a valuable resource but may be under-utilised, despite Centres having the technology available. It is notable that half of Centres lack a specific cell salvage policy for paediatrics, which might be a barrier to its routine uptake, or contribute to some eligible children (e.g. young children >10 kg) missing out.

Centres should regularly review their MSBOS for individual surgical procedures, to ensure these accurately reflect the anticipated blood requirements.

Only a small number of families were documented to have received written/digital information about the potential need and risks of blood transfusion. Following the Infected Blood Inquiry we are likely to see greater scrutiny around consent and information-giving for transfusion, and the need to evidence this. Centres should give a clear plan about where in the patient's pre-operative journey transfusion will be discussed, and whose responsibility this is. Having electronic documentation of this step, for example, as a code or a searchable field in pre-operative proformas, will help Centres demonstrate compliance with this standard.

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Your service

1 -How many children under the age of 18 in total were anaesthetised in your centre in the calendar year 2021?

2 -Do you have a paediatric pre-assessment service?

- Yes (now answer questions 3 to 21a)
 No (Now go to Q6)

3 -Are children seen in a dedicated paediatric Preassessment clinic?

- Yes
 No

4 -How many children were seen in your pre assessment clinics (include all nurse/anaesthetic in telephone/video/F2F clinics) in the calendar year 2021?

5 -Please indicate all referral pathway sources which apply to your preassessment service:

- Paediatric children booked for elective procedures under certain specialties are screened and triaged (List specialties in the box at the end of this question)
 Children referred by booking clinician
 Paediatric children booked for elective procedures are screened and triaged face to face (one stop shop)
 Paediatric children booked for elective procedures are screened and triaged virtually/telephone

5a -Please list the specialties

Please indicate all specialties that are provided by your hospital:

6 -Spine Provided **Now complete 6a**

6a -Type of assessment

- Anaesthetic led pre-assessment
 Surgical led pre-assessment
 No pre-assessment

7 -Orthopaedics Provided **Now complete 7a**

7a -Type of assessment

- Anaesthetic led pre-assessment
 Surgical led pre-assessment
 No pre-assessment

8 -Neurosurgery Provided **Now complete 8a**

8a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

9 -Craniofacial Provided **Now complete 9a**

9a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

10 -General Surgery Provided **Now complete 10a**

10a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

11 -Urology Provided **Now complete 11a**

11a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

12 -Maxillofacial Provided **Now complete 12a**

12a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

13 -Dental Provided **Now complete 13a**

13a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

14 -Gastroenterology Provided **Now complete 14a**

14a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

15 -Plastics Provided **Now complete 15a**

15a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

16 -ENT Provided **Now complete 16a**

16a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

17 -Respiratory Provided **Now complete 17a**

17a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

18 -Radiology Provided **Now complete 18a**

18a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

19 -Oncology Provided **Now complete 19a**

19a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

20 -Cardiac Provided **Now complete 20a**

20a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

21 -Thoracic Provided **Now complete 21a**

21a -Type of assessment

- Anaesthetic led pre-assessment
- Surgical led pre-assessment
- No pre-assessment

Pre-operative anaemia and policies

22 -Please indicate which apply:

- Our hospital has a Paediatric preoperative investigation policy for elective surgery
- Our hospital has a Paediatric preoperative investigation policy for elective surgery which include haematinics
- Our hospital has a paediatric Preoperative iron deficiency guideline
- Our hospital has a paediatric preoperative blood ordering policy

23 -Who is responsible for checking results of FBC and haematinics? (Tick as many as apply)

- Surgical team
- Pre-assessment team
- Other (please state)

23a -Other details

Intra-operative measures

24 -Please indicate which apply:

- Our hospital has a paediatric blood transfusion policy
- Our hospital has a paediatric blood transfusion policy including transfusion triggers
- Our hospital has a paediatric tranexamic acid administration policy

25 -Our hospital has paediatric cell salvage capability

- Yes **Now complete Q25a to Q25d**
- No **Now complete Q26**

25a -Our hospital has a paediatric cell salvage protocol

- Yes
- No

25b -Our hospital requires a dedicated practitioner to operate cell salvage

- Yes
- No

25c -How many cell salvage machines do you have?

25d -Give details of the type of cell salvage machines you have

26 -Please tell us about Point of Care testing in your hospital:

- Our hospital has a ABG machine in theatre complex
- Our hospital has a ABG machine not in theatre complex
- Our hospital has a Haemocue available in theatre complex
- Our hospital has non invasive haemoglobin monitoring available in theatre
- None of the above

About this patient

DEMOGRAPHICS

1 -Child's year of birth

1a -If child is less than 1 year old, please state their age in months

1b -If child is less than 1 year old, please state their gestational age at birth (Please state to the nearest week)

2 -What is the child's biological sex?

Female

Male

3 -Nearest to the time of the procedure, what was the weight of the child on admission (Kg)?

3a -Weight not recorded

Ticked

4 -What was the American Society of Anaesthesiologists (ASA) score?

I

II

III

IV

V

Not stated

5 -What comorbidities does the child have?

Respiratory problems

Cardiac problems

Diabetes (type 1 or 2)

Liver disorder

Metabolic condition

Neuromuscular disorder

Renal disorder

Cerebral palsy – please record the GMFCS score at Q5a

Epilepsy

Haematological conditions

5a -What was the GMFCS score

I II III IV V Not stated

5b -Details of other syndrome or condition not listed above

6 -Please list any medication prior to admission

Planned procedure

7 -What is the planned procedure?

8 -Under which specialty was the child admitted?

Spine
Orthopaedics
Neurosurgery
Craniofacial
General surgery
Urology
Maxillofacial
Plastics
ENT
Thoracic
Other please state

9 -When was the patient added to the waiting list for the procedure?

DD MM YYYY 2019 to 2022

Pre-admission

10 -Was this patient seen in a pre-assessment clinic for this procedure?

Yes No

10a -Which type?

Nurse telephone
Nurse video
Nurse Face-to-face
Anaesthetic telephone
Anaesthetic video
Anaesthetic Face-to-face

11 -Was an FBC requested preoperatively?

Yes No

11a -When was it done?

At booking
At preoperative clinic
At induction
Other please state

12 -How many weeks before surgery was the last FBC measured?

Less than 1 week
1 week to less than 2 weeks
2 weeks to less than 4 weeks
4 weeks to less than 6 weeks
6 weeks to less than 12 weeks
12 weeks or more
Not stated

13 -What was the Hb? (g/L)

14 -What was the HCT? (%)

15 -What was the MCV? (fL)

16 -What was the MCH? (Pg)

17 -Were haematinics ordered?

Yes No

17a -Which tests were ordered?

Ferritin
TSAT

18 -Was iron therapy started before surgery?

Yes No

18a -How many weeks prior to surgery was iron therapy started?

Less than 1 week
1 week to less than 2 weeks
2 weeks to less than 4 weeks
4 weeks to less than 6 weeks
6 weeks to less than 12 weeks
12 weeks or more
Not stated

18b -Was the iron therapy:

Oral
IV
Not stated

18c -Why was the patient on IV therapy?

Intolerance to oral iron now or in the past
Too short a time for oral iron to be effective before surgery
Other
Not stated

19 -Is there evidence that the family was informed of the possible need for transfusion?

Yes No

20 -Is there evidence that written information was given?

Yes No

Blood ordering

21 -Was G&S sample sent?

Yes No

22 -Was blood crossmatched preoperatively?

Yes No

22a -Was the blood crossmatched as . . .

Adult units

Paedipacks

22b -How many adult units were cross matched in total Preoperatively?

22c -How many paedipacks were cross matched in total Preoperatively?

Preoperative transfusion

23 -Did the child have any red cells transfusions before they had their operation?

Yes No

23a -What was the date of transfusion of the first unit?

DD MM YYYY

24 -What was the reason for transfusion?

Ongoing blood loss

Hb was less than 70 g/L

Hb was less than 80 g/L in a child with major comorbidity

The child was clinically symptomatic

Other please state

24a -Other reason for transfusion

25 -What was the pre-transfusion Hb in g/L?

25a -Not done

Ticked

26 -Was the blood given as . . .

Adult units

Paedipacks

26a -How many adult units were given in total before the patient went to theatre?

26b -How many paedipacks were given in total before the patient went to theatre?

26c -How many mls were given in total before the patient went to theatre?

26d -Don't know

Ticked

Intraoperative

27 -What was the date of the procedure?

DD MM YYYY

28 -Was a tranexamic acid bolus given on induction?

Yes No

28a -What was the dose? (mg)

29 -Was a Tranexamic acid infusion given?

Yes No

29a -What was the dose? (mg/Hr)

30 -Why was tranexamic acid not given?

Contraindicated
Other please state

30a -Other details

31 -Was cell salvage blood collected?

Yes No Don't know

31a -Was salvaged blood reinfused?

Yes No

31b -If no, why not?

Insufficient amount to reinfuse
Contaminated
Contraindicated

31c -What volume was reinfused? (ml)

31d -What best describes the reason for not using cell salvage?

Unknown reason

Not available on the day of surgery due to lack of trained staff

Not available on the day of surgery due to lack of machine

Anticipated blood loss too low: Procedure

Anticipated blood loss too low: Child's weight

Not considered due to contraindication (please state)

31e -Please state contraindication

32 -What was the estimated total volume of intraoperative blood loss? (Please state in mls)

33 -Was there intraoperative allogeneic red cell transfusion?

Yes No

33a -Was the transfusion given in . . .

Adult units

Paedipacks

33b -How many adult units were given in total intraoperatively?

33c -How many paedipacks were given in total intraoperatively?

33d -How many mls were given in total intraoperatively?

33e -Don't know

Ticked

34 -What was the reason for transfusion?

Ongoing blood loss

Hb was less than 70 g/L

Hb was less than 80 g/L in a child with major comorbidity

The child was clinically symptomatic

Other please state

34a -Other reason for transfusion

35 -What was the lowest intra-operative Hb? (g/L)

35a -Hb not done

Ticked

36 -How was this intraoperative Hb measured?

FBC

ABG

Non-invasive Hb monitor (Massimo)

Haemocue

Postoperative

37 -Was there postoperative allogeneic red cell transfusion?

Yes No

38 -Date of first unit transfused

DD MM YYYY

39 -Was the transfused blood . . .

Adult units

Paedipacks

39a -How many adult units were given in total postoperatively?

39b -How many paedipacks were given in total postoperatively?

39c -How many mls were given in total postoperatively?

39d -Don't know

Ticked

40 -Was the reason for transfusion documented?

Yes No

41 -What was the reason for transfusion?

Ongoing blood loss

Hb was less than 70g/L

Hb was less than 80 g/L in a child with major comorbidity

The child was clinically symptomatic

Other please state

41a -Other reason for transfusion

42 -What was the lowest post-operative Hb? (g/L)

42a -Not done

Ticked

43 -What was the date of this lowest Hb?

44 -Was iron prescribed post-operatively?

Yes No

44a -What was the intended route of administration?

Oral

IV

Appendix 3 – List of participating Centres

Centres	Consultant	Trainee
Addenbrooke's Hospital	Johanne Lynch	Dr Mohamed Younis
Alder Hey Children's Hospital	Philip Arnold	Tamryn Miller
Birmingham Children's Hospital	Barry Lambert	Clare Pedley (TP)
Bristol Royal Hospital for Children	Tom Cope	Hannah Gill
Chelsea Children's Hospital	Ami Kotecha	
Children's Health Ireland at Temple Street	Sheila Duggan	
County Hospital Lincoln	Shivan Kanani	
Derbyshire Children's Hospital	Stefan Valdinger	
Derriford Hospital Children's Inpatient Unit	Laurence Hulatt	Eimear Blunnie
Evelina London Children's Hospital	Bernd Thiessen	
Great North Children's Hospital	Tom Hardy	Clare Watkinson
Great Ormond Street Hospital	Katherine Brooks	Rachel Moss (TP)
Hull Royal Infirmary	Subhashini Naik	
Leeds Children's Hospital	Irfan Mohammad Omar	Gillian Davies
Leicester Children's Hospital	Jamie McDonald	
Maidstone Hospital	Benjamin Rudge	
Noah's Ark Children's Hospital for Wales	Julia Parnell	
Nottingham Children's Hospital**	Suzanne Wake	
Oxford Children's Hospital	Sarah Jones	
Robert Jones & Agnes Hunt Children's Unit	Nicola Wilson	
Royal Hospital for Children & Young People	Jon McCormack	
Royal Hospital for Children Glasgow	Aarti Shah	
Royal London Hospital	Megan Griffiths	Shylesh Aravindan
Royal Manchester Children's Hospital	Khairi Shah	
Royal National Orthopaedic Hospital	Ben Clevenger	Jackline Nkhoma
Sheffield Children's NHS Foundation Trust	Nadia Ladak	James Nicolas & Lynsey Brown
Southampton Children's Hospital	Olivia Shields	Ming Fung
St. George's Hospital	Shammi Kakad	Caroline Stevens
Staffordshire Children's Hospital	Maggie Babb	Prashanth Reddy
The James Cook University Hospital	Amy Norrington	
University Hospital Coventry & Warwickshire	Carol Bradbury	

** Participated only in the pilot stage of the audit. No data is included in this report