

**Major haemorrhage in paediatric surgery**

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\*Correspondence Email: [stevebree@gmail.com](mailto:stevebree@gmail.com)**SUMMARY**

Major haemorrhage is the commonest cause of cardiac arrest during surgery in children. Problems include:

- underestimate of blood loss
- inadequate venous access
- insufficient help
- electrolyte imbalance (hyperkalaemia, hypocalcaemia)
- coagulopathy
- hypothermia

We consider a practical approach to management of major haemorrhage in a child from both a clinical and logistical point of view.

Effective teamwork and communication is essential.

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**INTRODUCTION**

Major haemorrhage is the single most common cause of cardiac arrest during surgery in children.<sup>1</sup> Problems arise as blood loss is often underestimated, venous access is inadequate, there is not enough help, or the child develops electrolyte imbalance (hyperkalaemia, hypocalcaemia) or coagulopathy.<sup>1</sup> Hypothermia is a particular challenge in major haemorrhage in children.

This article will consider a practical approach to management of major haemorrhage in a child from both a clinical and logistical point of view. Effective teamwork and communication is an essential part of this process.<sup>2</sup>

**CLINICAL ASPECTS**

Major haemorrhage may be seen in children in the following situations:<sup>1,2,3,4</sup>

- Road traffic accidents
- Civil conflict or war (penetrating injuries, typically gunshot wounds)
- Major surgery (neurosurgery, spinal, cardiac or tumour surgery)
- Associated with an underlying disorder of coagulation.

The magnitude of blood loss is typically underestimated in smaller children. All sources of blood loss must be estimated by direct observation, also from the clinical signs and symptoms displayed by the child.

There are a number of definitions of major haemorrhage; a pragmatic definition is when 1-1.5 times the blood volume needs to be infused acutely, or within a 24-hour period.<sup>1</sup> The estimated blood volume of the child must be calculated.

The blood volume of a child can be estimated using the following formulae:

- Neonate 90 ml.kg<sup>-1</sup>
- Child 80 ml.kg<sup>-1</sup>
- Adult 70 ml.kg<sup>-1</sup>

The weight of the child will be known already in a child undergoing elective surgery; in the case of trauma the weight of the child can be estimated using a Broselow tape, paediatric growth chart (use the 50th centile for age); or using the following formula:

- Weight = (age +4) x 2

It is recommended that each hospital develop a major haemorrhage protocol for adults and for children; as soon as a diagnosis of major haemorrhage has been made, the child should be treated according to the major haemorrhage protocol as outlined below:<sup>2,4</sup>

**Immediate actions for a child presenting to the hospital with a diagnosis of major haemorrhage after trauma:**

- Stop the bleeding by applying direct pressure, a tourniquet or by packing the wound.
- Give oxygen.
- Obtain IV access; ideally two large bore IV cannulae, the size depending on the age of the child, or central access (femoral vein or internal jugular). Intra-osseous access is effective and can be used to help establish perfusion but the IO needle is likely to become dislodged, so should only be used as a temporary measure. Do not repeat IO access at the same site, as there is a risk of extravasation. Do not attempt sternal IO access in children.

- Take blood for cross match. Call for group compatible, non-cross matched blood if required.
- Avoid crystalloid infusions if the need for early blood transfusion is obvious.
- Order 1 unit of packed red cells and 1 unit of fresh frozen plasma (FFP) per 20kg weight of the child. A 25kg child will need 2 units of blood and 2 units of FFP.
- 4ml.kg<sup>-1</sup> of packed cells in a child is equivalent to one unit of blood in an adult, and will raise the haemoglobin by approximately 1g.dl<sup>-1</sup>
- Volumes of blood products may seem high to those not experienced in major haemorrhage in children, but be reassured that cardiovascular parameters provide an excellent guide to effectiveness of ongoing resuscitation.
- Once the bleeding has been controlled, it is important to aim for a normal blood pressure, treat acidosis and to keep the patient warm. Avoid vasopressors if possible. Be aware of over transfusion once stability has been achieved.

### Assess the child

- Baseline observations – heart rate, blood pressure, capillary refill, CVP.
- Blood tests – haemoglobin, platelet count; blood gases, coagulation profile (PT, APTT, fibrinogen), lactate if available.
- Near patient coagulation testing if available (TEG/ROTEM).

### On-going management

- Transfuse blood – use blood Group O negative if immediate transfusion is required; or group specific blood if there is time. Full cross match may take up to 45 minutes. O Positive blood may be given to males if there are insufficient stocks of O Negative blood.
- Transfuse 5ml.kg<sup>-1</sup> packed red cells alternating with 5ml.kg<sup>-1</sup> FFP, to a total of 15ml.kg<sup>-1</sup> of each if required. Ongoing transfusion will be required if there is continued bleeding and/or the cardiovascular targets are not achieved.
- Monitor the temperature. The blood and fluids MUST be warmed. The patient must be covered, and actively warmed if possible.
- Monitor the ECG. Watch for hypothermia, hyperkalaemia, hypocalcaemia, hypomagnesaemia.
- Give tranexamic acid as early as possible (but do not give more than 3 hours after the acute injury).
- Consider imaging/definitive management of the bleeding (surgery). Alert the theatre teams.

### On-going assessment

- Continuous assessment and reassessment of the clinical signs (HR, BP, capillary refill; blood gasses if possible). Is the blood pressure adequate? If the child is in the emergency department and is talking and you can feel a peripheral pulse, the blood pressure is adequate. It is not necessary to achieve a normal blood pressure at this stage.

### Coagulation problems

- Dilutional coagulopathy is likely if packed cells are used without FFP; whole blood contains platelets and coagulation factors, so coagulopathy is not so much of a problem if whole blood is used.
- If blood loss of one blood volume is expected, give FFP early to prevent dilutional coagulopathy, rather than waiting for coagulopathy to occur.
- Continue transfusion as required, alternating 5ml.kg<sup>-1</sup> packed red cells with 5ml.kg<sup>-1</sup> FFP, to a total of 15ml.kg<sup>-1</sup> of each if required. Keep an accurate record of blood products and volume given.
- Consider platelets 5ml.kg<sup>-1</sup> and cryoprecipitate 5 ml.kg<sup>-1</sup> if there is on-going bleeding or signs of coagulopathy.
- Recheck blood tests – haemoglobin, platelet count; blood gases, coagulation profile (PT, APTT, fibrinogen), lactate if possible.
- Near patient coagulation testing if possible (TEG/ROTEM).
- Coagulation factor concentrates may be required for patients with inherited abnormalities of clotting (haemophilia, von Willibrands disease).

### Targets

- Aim to maintain fibrinogen >1.5 g.l<sup>-1</sup> and platelet count > 75 x10<sup>9</sup>.l<sup>-1</sup>
- Aim for ionised calcium greater than 1mmol.l<sup>-1</sup>. If measurement of calcium is difficult, consider giving 10% CaCl 0.2ml.kg<sup>-1</sup> slow IV bolus for every 20ml.kg<sup>-1</sup> of blood given.
- Monitor potassium levels. If there are ‘tented’ T waves on the ECG, or K<sup>+</sup> is greater than 5.5mmol.l<sup>-1</sup>, consider 10% CaCl 0.2ml.kg<sup>-1</sup> or insulin/dextrose infusion.
- Aim for haematocrit greater than 0.3 (Hb >10 g.dl<sup>-1</sup>) once a steady state is achieved.
- PT and APTT are not very sensitive in the context of bleeding (the values may be relatively normal, but the patient is still bleeding). Aim to maintain PT and APTT <1.5x normal value.

- Repeat coagulations tests, if possible, every hour.
- Repeat this cycle if necessary.

### Tranexamic acid

- There is good evidence to support the use of tranexamic acid in trauma. It is also frequently used in major haemorrhage after elective surgery. It should be given within 3 hours of the haemorrhagic insult.
- Give a loading dose of 15mg.kg<sup>-1</sup> slow IV bolus (consider an additional infusion of 15 mg.kg<sup>-1</sup> over 8 hours).
- Tranexamic acid is excreted in the kidney; it should be used with caution in patients with renal failure.

### ORGANISATIONAL ASPECTS

Organisational aspects of management of major haemorrhage are important to consider. Good leadership is essential, with clear allocation of tasks. Make sure the phone numbers of key personnel are readily available in the event of a major haemorrhage being called.

- Identify a team leader to be 'in charge' and to coordinate care. This is usually the senior surgeon or anaesthetist, and ideally someone who can stand back and direct as a non-hands on leader.
- Communicate early with the laboratory so that they understand the gravity of the situation.
- Identify someone to take blood samples to the lab or to collect the blood.
- Make sure all blood is checked properly before it is given; put two name bands on the patient (in case one is taken off); use this to check the blood. It is the responsibility of the person administering the blood to check that the correct blood is being given to the correct patient.
- All blood should be given through a blood giving set with filter; a special filter is not required for platelets, but they should be given through a clean giving set to avoid the platelets sticking to the blood in the giving set.
- A "scribe" should be designated early on to record all interventions and products / drugs given until the tempo has settled down.

### CONCLUSION

The management of major blood loss in children can be a daunting prospect in any facility due to the limited physiological reserve of the patients and the technical difficulties of dealing with a small child in shock. The emotional component can also add to the stresses involved but it is essential that simple basic resuscitation principles are applied, as they would be for an adult. Calm strong leadership adds to positive outcomes in these circumstances.

Recent experiences in conflict zones have emphasised the importance of applying the above principles to the most severely injured and shocked children.<sup>4</sup> Early blood gas results can demonstrate extremely deranged physiology, which corrects rapidly when resuscitation is adequate. Volumes of products used may often seem excessive for those new to these circumstances but careful monitoring of clinical parameters, bedside clotting, Hb, electrolytes and blood gases will support and aid in decision making with respect to ongoing blood product requirements. Acute transfusion of many multiples of the patient's blood volume is not unusual.

The switch from the unstable to stable patient will be achieved once surgeons have gained control of the bleeding and coagulopathy is managed. Until this is achieved, the outcome will be determined by the ability to follow and apply the above guidelines in a methodical way, as well as clear leadership and teamwork.

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