apls
Advanced Paediatric Life Support

Massive transfusion in paediatric trauma

Definition

Various definitions exist, including

- replacement (or anticipation of replacement) of one or more blood volumes within the first 24 hours of resuscitation
- a transfusion of more than 40ml/kg blood (child blood volume approximately 80ml/kg)

Rationale for Massive Transfusion Protocols

- Haemorrhage is a leading cause of death in paediatric trauma patients. Predefined massive transfusion protocols (MTP) have the potential to significantly reduce mortality by treating haemorrhagic shock and coagulopathy, in adhering to the principles of haemostatic resuscitation with rapid administration of balanced ratios of packed red blood cells (RBC), fresh frozen plasma (FFP) and platelets (PLT).

- Trauma-induced coagulopathy is a multi-factorial process. Tissue damage results in the release of tissue factor and subsequent activation of the coagulation cascade. Hypoperfusion that occurs after massive blood loss causes increased expression of thrombomodulin in turn binding to thrombin and activating protein C. Activated protein C inhibits cofactors V and VIII and in excess also depletes plasminogen activator inhibitor-1 (PAI-1), reducing tissue plasminogen activator inhibition and accelerating the formation of plasmin and fibrinolysis. Similar pathophysiological changes can occur during major surgery with massive blood loss.

- MTPs are designed to provide the right amount and balance of blood products, mimicking 'whole blood', to critically injured patients in order to prevent and treat haemorrhagic shock and coagulopathy. Not only does MTP guide resuscitation; it facilitates communication and logistical support between treating clinicians, blood bank and support staff.

Activation Criteria for a Paediatric Massive Transfusion Protocol (PMTP)

- Critical bleeding with coagulopathy
- Anticipated, or estimated blood loss > ½ blood volume
- Critical bleeding continuing after transfusion of ½ blood volume
- Any child requiring more than 20mL/kg of packed red blood cells (PRBC) in 2 hours and/or anticipated ongoing blood loss
- Any child requiring more than 40mL/kg of PRBC in a 24 hour period with ongoing blood

(OR Blood Bank may activate protocol if:

i. > 2 units of PRBC issued within 1 hour for child < 5 years old, OR
ii. > 4 units PRBC issued within 1 hour for child ≥ 5 years old, OR
iii. The Blood Bank technician anticipates likelihood of additional component needs.

In this situation, the Blood Bank technician contacts the Haematologist to activate the protocol), OR

Use of intravenous tranexamic acid (Cyclokapron) in trauma

The use of intravenous tranexamic acid in trauma has been established for adult patients (CRASH-2 trial) and administration is likely to be beneficial in children as well:

- **Tranexamic acid at a dose of 15 mg/kg (dose range 10-20 mg/kg; max 1g) by slow intravenous infusion over 10-15 minutes; ideally within the first 3 hours of trauma**

- Follow up doses can be given at the decision of the treating team and can be as IV boluses or continuous infusion

Precautions:

- Avoid rapid infusion or push injection as it may cause hypotension.
- Tranexamic acid should be used with caution in patients with haematuria, renal haemorrhage and bleeding into other bodies cavities (e.g. pleural space, joints) as inhibition of fibrinolysis may result in retention of blood clots in those spaces.
- Dose/interval adjustments for subsequent doses are required in renal impairment
- Do not use in conjunction with factor IX complex concentrates

Examples of MTPs

Weight of child	
< 15kg	1 unit PRBC+ 1 unit FFP* 1 unit pooled platelets
15 – 30kg	2 unit PRBC 2 unit FFP 1 unit pooled platelets
30 – 50kg	3 unit PRBC 3 unit FFP 1 unit pooled platelets
> 50kg	4 unit PRBC 4 unit FFP 1 unit pooled platelets

Second Dispatch Upon request for a second lot of blood products, the following will be issued according to weight:

Weight of child	
< 15kg	1 unit PRBC 1 unit FFP 2 units cryoprecipitate
15 – 30kg	2 unit PRBC 2 unit FFP 3 units cryoprecipitate
30 – 50kg	3 unit PRBC 3 unit FFP 5 units cryoprecipitate
> 50kg	4 unit PRBC 4 unit FFP 8 units cryoprecipitate

Baseline tests

Full blood count, rotational thromboelastometry (ROTEM®) X-match, biochemistry (EUC, S.Cr, S. E, Ca, Ca++) extended coags including D-Dimer, arterial blood gases (if arterial line). Cryoprecipitate should be added to second and subsequent packs. Consider treatment based on ROTEM results or extended coagulation testing.

ROTEM® provides information on the cause of bleeding, allows flexible screening of whole blood coagulation property, and ROTEM®-guided therapy can optimise blood products usage, avoiding unnecessary risks by minimising blood transfusions. Unlike conventional clotting assays, ROTEM® assesses the coagulation system as a dynamic process by determining not only the clotting time, but also the dynamics of clot formation, the mechanical clot stability and its lysis over time.

Time for Blood Product Availability

Product Time Until Despatch from Blood Bank

O negative PRBC	Immediate
ABO specific PRBC - uncrossmatched	5 – 10 minutes
- crossmatched PRBC	40 minutes
Frozen products	20 – 30 minutes

Laboratory Criteria

As a general guideline in massive transfusion, the following target values are reasonable to aim for:

Test Target Value

Haemoglobin (Hb)	> 70g/L
Platelets (or if Neurological injury)	> 50 x 109 /L > 100 x 109 /L
Activated Partial Thromboplastin Time (APTT)	< 40 seconds
Prothrombin Time	< 20 seconds
Fibrinogen	> 1 g/L

Acidosis and hypothermia should also be vigorously corrected, as these exacerbate coagulopathy

Conclusions

Haemorrhage is a leading cause of death in paediatric trauma patients. Predefined Massive Transfusion Protocols have the potential to significantly reduce mortality by treating haemorrhagic shock and coagulopathy, thereby ensuring adequate oxygen delivery and haemostasis in massively bleeding paediatric trauma patients, especially considering the high prevalence of early coagulopathy in this population. The triggers for MTP activation in paediatric trauma patients and the optimal blood product ratio that will increase survival in massively bleeding paediatric trauma patients still have to be determined. Despite not yet having been tested in paediatric populations, MTP with increased PLT to FFP to RBC ratios combined with thromboelastometry (ROTEM®) guided component therapy seem promising, based on results in adult patients. Prospective randomized trials investigating this therapeutic approach in paediatric trauma populations are highly warranted.

References:

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