Pediatric Massive Hemorrhage Protocol

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SIMULATION NURSE EDUCATOR, CHEO

Conflicts of interest

No conflicts of interest to declare

Question # 1 Pre-knowledge

What vital patient information does Transfusion Medicine need when you activate a pediatric Massive Hemorrhage Protocol (MHP)?

A) Name and age

B) Sex and age

C) Sex and weight

D) Name and weight

Question # 2 Pre-knowledge

What is the volume of RBCs a pediatric patient should receive per dose?

A) 20 ml/kg
B) 5 ml/kg
C) Half a unit
D) 1 unit

Question # 3 Pre-knowledge

What is a late and ominous sign for a pediatric patient with hypovolemic shock?

A) Tachycardia
B) Mottled skin
C) Cap refill > 3 seconds
D) Decreased blood pressure

Objectives

- Understand some key physiological differences in pediatrics
- Understand pediatric massive hemorrhage activation parameters
- Understand the flow of ORBCON's Massive Hemorrhage Protocol with pediatric considerations

Important Peds Anatomy and Physiology

- Proportionally larger solid intra-abdominal organs that are not well protected
  - Liver and kidney
- Increased vascular supply to the duodenum
- Large head, underdeveloped neck muscles, decreased CSF and smaller arachnoid space
  - Higher likely hood of a traumatic brain injury (TBI)
  - Fontanels don't close until 18 months
- Less body fat
- HGB levels reach adult levels by 12 weeks
- Platelet function immature
- Variable and larger blood volumes to weight ratios

Hazinski, M.F. (1999). *Manual of Pediatric Critical Care.* Mosby Inc.
Zazzera, E. S. (2020). Special Populations: The Pediatric Trauma Patient. In *TNCC: Trauma nursing core course: Provider manual* (8th ed.). Jones & Bartlett Learning.

Do we need a Massive Hemorrhage Protocol (MHP) for peds?

- YES!
  - Massive hemorrhage is the leading cause of preventable death in children
  - Leading cause of cardiac arrest in children in the OR
- Rates of MH similar in adults and children
  - Downside, literature isn't as fulsome for peds MH
- Many non-tertiary care hospitals do not have MHPs

Ontario Regional Blood Coordinating Network. (2022, July 1). *Provincial massive hemorrhage toolkit - transfusion Ontario*. Retrieved November 5, 2022, from https://transfusionontario.org/wp-content/uploads/2021/10/MHP_Toolkit_v1_Oct2021.pdf

Poll Question

If you work in a community hospital, does your center have a MHP?

A) Yes

B) No

Meet Rosie

- You are in ED and a mom and dad rush in holding their 2 m/o, 5kg baby girl named Rosie. Mom is holding a towel on Rosie's leg that has blood soaking through from a dog bite.

- How would we know if we should activate the MHP?

Definition of MH

- 50% of total blood volume lost in 3 hours ***or*** 100% in 24 hours
  - 40 ml/kg of total blood products delivered in 24 hours is a good predictor for mortality
- Problem with this definition:
  - Events are often acute
  - Blood volumes vary with age/weight

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Poll Question

What do you think Rosie's total blood circulating volume is?

A) 400 ml

B) 800 ml

C) 1000 ml

D) 1500 ml

A little more about blood volumes

- Babies: 80-90 ml/kg
- Child: 70 ml/kg
- Adults: 65-70 ml/kg
- Rosie weighs 5 kg
  - Her total blood volume is only about 425 ml!!
    - For Rosie, 50 % of her blood volume is only 212 mls
- 50 kg adult
  - Total blood volume is 3500 mls
  - 50% of their volume would be 1750 mls

Peds Pearl

- Even a seemingly small amount of blood can trigger a MHP activation

Hazinski, M.F. (1999). *Manual of Pediatric Critical Care.* Mosby Inc.

Back to Rosie

- Rosie is brought to the Trauma Bay and is hooked up to a monitor, initial VS:
  - HR 185
  - BP 78/47
  - RR 65
  - Sp02 97%

Peds Pearl

- Ensure you have the right sized equipment, especially BP cuff
- Ensure your monitor has appropriate pediatric alarm parameters
- Use Broselow tape for weight and equipment size if needed

POLL Question

Which VS worries you the most?

A) HR 185

B) BP 78/47

C) RR 65

D) Sp02 97%

Back to Rosie

- HR 185
- BP 78/47
- RR 65
- Sp02 97%

Peds Pearl

- CO=HR x SV
- Children compensate very well by increasing their heart rate
- Vasoconstrict peripherally which leads to mottled, cool extremities
- Hypotension is a ***late*** sign of shock
- Tachycardia and poor perfusion in a pediatric patient are **red flags**

Parameters to Trigger MHP

- The question remains for Rosie, how can we quickly determine if we should activate a MHP?
- Shock index adjusted for pediatric age
  - HR/systolic BP
- ORBCON's triggers to activate a MHP are:
  1) Poor response to fluids ***or***
  2) Obvious bleeding ***or***
  3) Hypotension

  - In Rosie's case, based on the visual of blood soaking through the towel and her high hear rate, we should activate before her blood pressure drops

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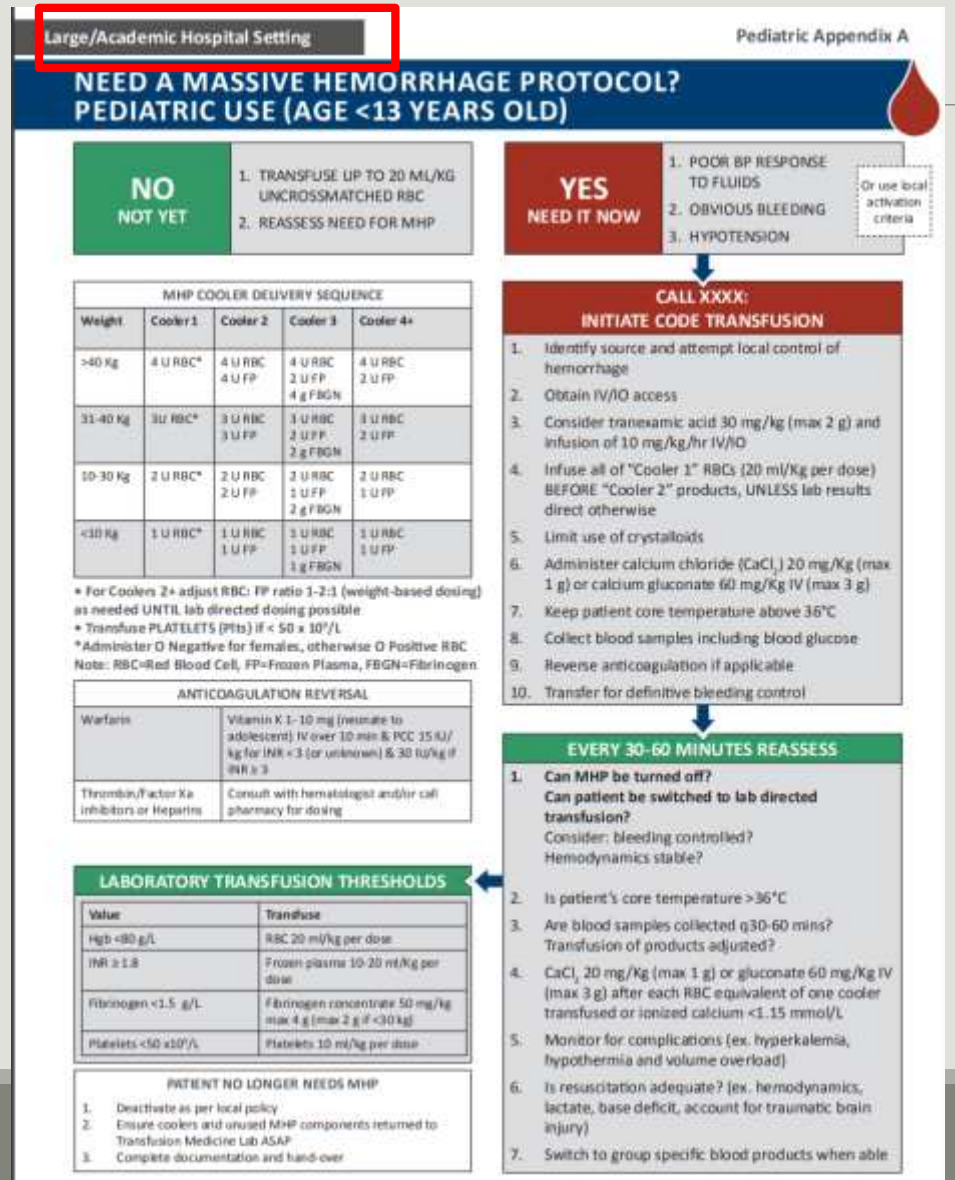
Let's Activate!



Large/Academic Hospital Setting

Pediatric Appendix A

NEED A MASSIVE HEMORRHAGE PROTOCOL? PEDIATRIC USE (AGE <13 YEARS OLD)

NO NOT YET
1. TRANSFUSE UP TO 20 ML/KG UNCROSSMATCHED RBC
2. REASSESS NEED FOR MHP

YES NEED IT NOW
1. POOR BP RESPONSE TO FLUIDS
2. OBVIOUS BLEEDING
3. HYPOTENSION

Or use local activation criteria

MHP COOLER DELIVERY SEQUENCE

Weight	Cooler 1	Cooler 2	Cooler 3	Cooler 4+
>40 Kg	4 U RBC*	4 U RBC 4 U FP	4 U RBC 2 U FP 4 g FBGN	4 U RBC 2 U FP
31-40 Kg	3U RBC*	3 U RBC 3 U FP	3 U RBC 2 U FP 2 g FBGN	3 U RBC 2 U FP
10-30 Kg	2 U RBC*	2 U RBC 2 U FP	2 U RBC 1 U FP 2 g FBGN	2 U RBC 1 U FP
<10 Kg	1 U RBC*	1 U RBC 1 U FP	1 U RBC 1 U FP 1 g FBGN	1 U RBC 1 U FP

• For Coolers 2+ adjust RBC: FP ratio 1-2:1 (weight-based dosing) as needed UNTIL lab directed dosing possible
• Transfuse PLATELETS (Plts) if < 50 x 10^9/L
*Administer O Negative for females, otherwise O Positive RBC
Note: RBC=Red Blood Cell, FP=Frozen Plasma, FBGN=Fibrinogen

ANTICOAGULATION REVERSAL

Warfarin	Vitamin K 1- 10 mg (neonate to adolescent) IV over 10 min & PCC 15 IU/kg for INR < 3 (or unknown) & 30 IU/kg if INR ≥ 3
Thrombin/Factor Xa inhibitors or Heparins	Consult with hematologist and/or call pharmacy for dosing

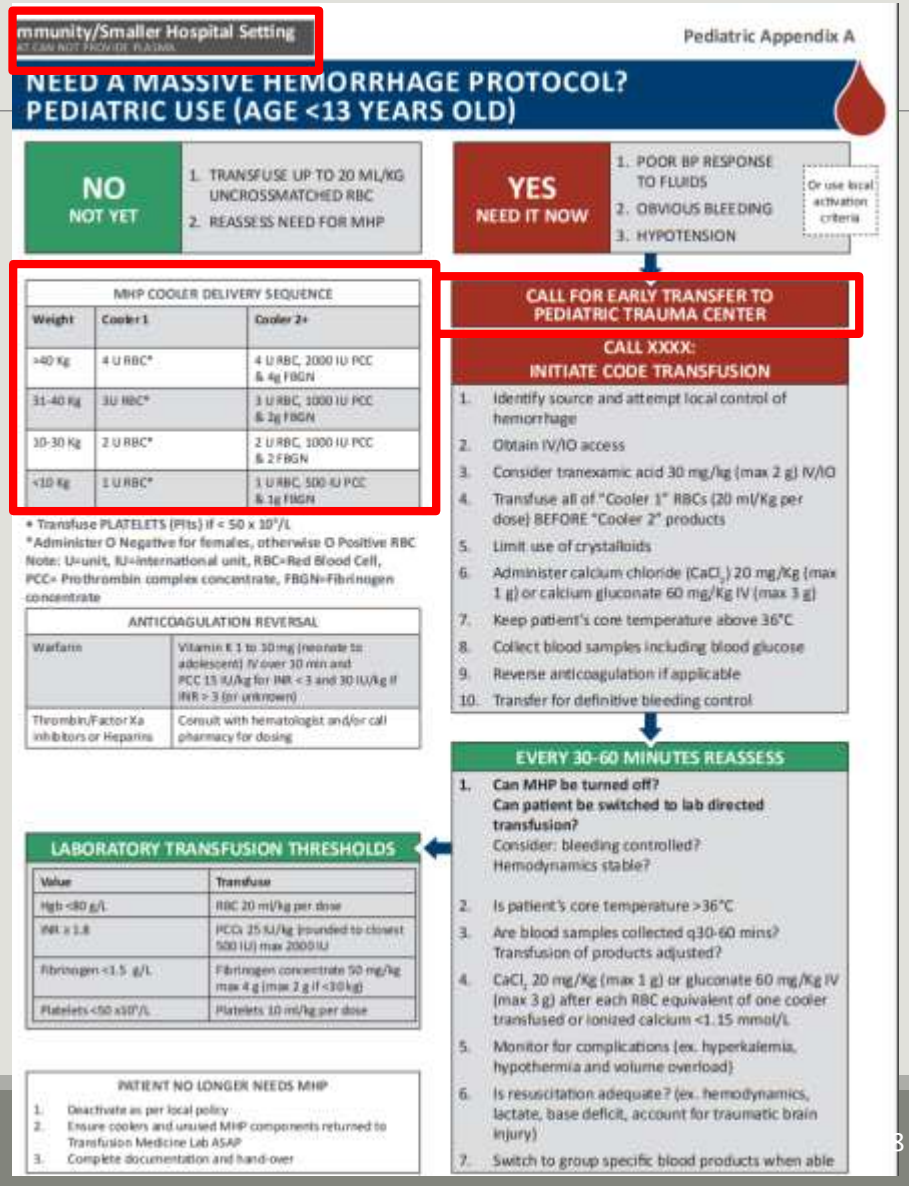
CALL XXXX: INITIATE CODE TRANSFUSION
1. Identify source and attempt local control of hemorrhage
2. Obtain IV/IO access
3. Consider tranexamic acid 30 mg/kg (max 2 g) and infusion of 10 mg/kg/hr IV/IO
4. Infuse all of "Cooler 1" RBCs (20 ml/Kg per dose) BEFORE "Cooler 2" products, UNLESS lab results direct otherwise
5. Limit use of crystalloids
6. Administer calcium chloride ($CaCl_2$) 20 mg/Kg (max 1 g) or calcium gluconate 60 mg/Kg IV (max 3 g)
7. Keep patient core temperature above 36°C
8. Collect blood samples including blood glucose
9. Reverse anticoagulation if applicable
10. Transfer for definitive bleeding control

EVERY 30-60 MINUTES REASSESS
1. **Can MHP be turned off? Can patient be switched to lab directed transfusion?** Consider: bleeding controlled? Hemodynamics stable?
2. Is patient's core temperature >36°C
3. Are blood samples collected q30-60 mins? Transfusion of products adjusted?
4. $CaCl_2$ 20 mg/Kg (max 1 g) or gluconate 60 mg/Kg IV (max 3 g) after each RBC equivalent of one cooler transfused or ionized calcium <1.15 mmol/L
5. Monitor for complications (ex. hyperkalemia, hypothermia and volume overload)
6. Is resuscitation adequate? (ex. hemodynamics, lactate, base deficit, account for traumatic brain injury)
7. Switch to group specific blood products when able

LABORATORY TRANSFUSION THRESHOLDS

Value	Transfuse
Hgb <80 g/L	RBC 20 ml/kg per dose
INR ≥ 1.8	Frozen plasma 10-20 ml/Kg per dose
Fibrinogen <1.5 g/L	Fibrinogen concentrate 50 mg/kg max 4 g (max 2 g if <30 kg)
Platelets <50 x10^9/L	Platelets 10 ml/kg per dose

PATIENT NO LONGER NEEDS MHP
1. Deactivate as per local policy
2. Ensure coolers and unused MHP components returned to Transfusion Medicine Lab ASAP
3. Complete documentation and hand-over



mmunity/Smaller Hospital Setting
AT CAN NOT PROVIDE PLASMA

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Or use local activation criteria

MHP COOLER DELIVERY SEQUENCE

Weight	Cooler 1	Cooler 2+
>40 Kg	4 U RBC*	4 U RBC, 2000 IU PCC & 4g FBGN
31-40 Kg	3U RBC*	3 U RBC, 1000 IU PCC & 2g FBGN
10-30 Kg	2 U RBC*	2 U RBC, 1000 IU PCC & 2 FBGN
<10 Kg	1 U RBC*	1 U RBC, 500 IU PCC & 1g FBGN

• Transfuse PLATELETS (Plts) if < 50 x 10^9/L
*Administer O Negative for females, otherwise O Positive RBC
Note: U=unit, IU=international unit, RBC=Red Blood Cell, PCC= Prothrombin complex concentrate, FBGN=Fibrinogen concentrate

ANTICOAGULATION REVERSAL

Warfarin	Vitamin K 1 to 10 mg (neonate to adolescent) IV over 10 min and PCC 15 IU/kg for INR < 3 and 30 IU/kg if INR > 3 (or unknown)
Thrombin/Factor Xa inhibitors or Heparins	Consult with hematologist and/or call pharmacy for dosing

CALL FOR EARLY TRANSFER TO PEDIATRIC TRAUMA CENTER

CALL XXXX: INITIATE CODE TRANSFUSION
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2. Obtain IV/IO access
3. Consider tranexamic acid 30 mg/kg (max 2 g) IV/IO
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5. Limit use of crystalloids
6. Administer calcium chloride ($CaCl_2$) 20 mg/Kg (max 1 g) or calcium gluconate 60 mg/Kg IV (max 3 g)
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INR ≥ 1.8	PCCs 25 IU/kg (rounded to closest 500 IU) max 2000 IU
Fibrinogen <1.5 g/L	Fibrinogen concentrate 50 mg/kg max 4 g (max 2 g if <30 kg)
Platelets <50 x10^9/L	Platelets 10 ml/kg per dose

PATIENT NO LONGER NEEDS MHP
1. Deactivate as per local policy
2. Ensure coolers and unused MHP components returned to Transfusion Medicine Lab ASAP
3. Complete documentation and hand-over

MHP Activated

- Next steps:
  - Control the hemorrhage
    - Torniquet??
  - Obtain IV access
    - Biggest possible PIV
    - Move to IO quickly
  - Crystalloid fluid bolus
    - 20 ml/kg before switching to blood

Peds Pearl

- TM must know the sex and ***weight*** of patient
- Everything in peds is weight based, get a weight ASAP
- Use Broselow Tape if needed

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Blood Sampling

- Should be done with IV access if possible
- IO samples can be used for type and screen
  - Alert TM it's an IO sample
- CBC and group/screen are the priority
- Check a sugar
  - Can be hypo or hyper glycemic

Peds Pearl

- Batch blood work together
- Capillary blood samples can be used for group and screen, cap gas
- Microcontainers available

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Consider TXA

- Awaiting more data
  - Current recommendation, within 3 hours of injury
    - 15 mg/kg/dose, MAX 1 g, slow IV push
      - Followed by infusion 2-5mg/kg/hr until bleeding stops
  - Higher doses
    - 30 mg/kg/dose, MAX 2 g
    - Followed by 5-10 mg/kg/hr

Peds Pearl

- Safety data unavailable at this time for TBI patients, caution with use
- If IV pump has library, ensure peds TXA doses are appropriate
- Can very low infusion rates be programmed into your infusion pumps?

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Continuing Down the Algorithm

CALL XXXX:
INITIATE CODE TRANSFUSION

- ✓ Identify source and attempt local control of hemorrhage
- ✓ Obtain IV/IO access
- ✓ Consider tranexamic acid 30 mg/kg (max 2 g) and infusion of 10 mg/kg/hr IV/IO
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- ✓ Limit use of crystalloids
6. Administer calcium chloride ($CaCl_2$) 20 mg/Kg (max 1 g) or calcium gluconate 60 mg/Kg IV (max 3 g)
7. Keep patient core temperature above 36°C
- ✓ Collect blood samples including blood glucose
9. Reverse anticoagulation if applicable
10. Transfer for definitive bleeding control

Keep Your Patient Warm

- Pediatric patients are at a higher risk for hypothermia
- Check temperature within 15 min of MHP activation
  - Continue to check temp q 30 min or continuous
    - Rectal probe, urinary cath with temp probe, if not contraindicated
    - Low temp reading thermometer
  - Ways to warm
    - Remove wet clothing
    - Increase temp in trauma bay/OR
    - Overhead heaters
    - Convective warming device
      - Bair hugger
  - Warm IV fluids

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[Photograph of Bair Hugger Model 555]. Retrieved November 6, 2020, fromhttps://bairhugger.blogspot.com/2016/06/.

First MH Cooler Arrives

- Contains enough blood for 20ml/kg RBC bolus

Peds Pearl

- Full units come in the cooler, you need to draw out the 20 ml/kg
  - 1 unit = 350 mls RBCs
- Rosie weighs 5 kg, she only needs 100 ml of blood, the bag has 350 mls in it

CAUTION! PEDIATRIC USE (age < 13 years old)
DOSE BY WEIGHT & LIMIT CRYSTALLOIDS
"CODE TRANSFUSION" Cooler #1

Weight	Content of Cooler #1 Units (U)	RBC Dose	Goals
>40 Kg	4 U RBC	20 mL/Kg per dose	Hgb > 80 g/L INR < 1.8 PLTs>50 x 10^9/L Fibrinogen> 1.5 g/L
31-40 Kg	3 U RBC		
10-30 Kg	2 U RBC		
< 10 Kg	1 U RBC		

Note: Infuse all of "Cooler #1" RBCs **BEFORE** starting "Cooler # 2" products, **UNLESS** lab results guide otherwise.

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Warming IV fluids/blood

- Hotline, Level 1 rapid infuser etc.
  - Know their limitations
- Blood products should not be placed in warming cupboard
- IV fluid/blood should not be microwaved

Peds Pearl

- Rosie will only need 100 mls of blood
  - How do you deliver small amounts of ***warmed*** blood?
- Find solution for what your institution supplies

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Second Cooler

- Community/smaller hospitals might differ from tertiary centers

MHP COOLER DELIVERY SEQUENCE				
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>40 Kg	4 U RBC*	4 U RBC 4 U FP	4 U RBC 2 U FP 4 g FBGN	4 U RBC 2 U FP
31-40 Kg	3U RBC*	3 U RBC 3 U FP	3 U RBC 2 U FP 2 g FBGN	3 U RBC 2 U FP
10-30 Kg	2 U RBC*	2 U RBC 2 U FP	2 U RBC 1 U FP 2 g FBGN	2 U RBC 1 U FP
<10 Kg	1 U RBC*	1 U RBC 1 U FP	1 U RBC 1 U FP 1 g FBGN	1 U RBC 1 U FP

MHP COOLER DELIVERY SEQUENCE		
Weight	**Cooler 1**	**Cooler 2+**
>40 Kg	4 U RBC*	4 U RBC, 2000 IU PCC & 4g FBGN
31-40 Kg	3U RBC*	3 U RBC, 1000 IU PCC & 2g FBGN
10-30 Kg	2 U RBC*	2 U RBC, 1000 IU PCC & 2 FBGN
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And More Coolers

- Use all contents of previous coolers keeping a RBC/FP =1-2:1
- Switch to lab guided transfusions ***ASAP*** to ensure patient is receiving the appropriate blood products
  - This is why q 30 min blood work is needed

MHP COOLER DELIVERY SEQUENCE				
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10-30 Kg	2 U RBC*	2 U RBC 2 U FP	2 U RBC 1 U FP 2 g FBGN	2 U RBC 1 U FP
<10 Kg	1 U RBC*	1 U RBC 1 U FP	1 U RBC 1 U FP 1 g FBGN	1 U RBC 1 U FP

LABORATORY TRANSFUSION THRESHOLDS	
Value	**Transfuse**
Hgb <80 g/L	RBC 20 ml/kg per dose
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Further Assessment and Management

- Similar to adults
  - Hypocalcemia
    - Citrate and calcium chelation
    - Caution with calcium chloride, can cause severe extravasation
    - Check concentration, may have to dilute
  - Hypomagnesia
    - May drop blood pressure if given too quickly
  - Hyperkalemia
    - ECG and electrolyte monitoring
    - Cell should not be irradiated
    - Avoid hemolysis
      - Choose shortest possible PIV, avoid CVLs

Peds Pearl

Fresher units should be used to help prevent hyperkalemia

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TBI and Peds

- TBI common injury in children
- Delicate balance to give the right amount of fluids
  - Too much will increase ICP
  - Too little will lower cerebral perfusion pressure (CPP)
- Permissive hypotension
  - Not widely accepted in peds, especially if child has TBI
  - Will decrease the CPP (MAP-ICP) as MAP will be lower
- No evidence for therapeutic hypothermia
- Monitor for hypo or hyper glycemia

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A Few More Tidbits

- Keep accurate account of products and IV solution given
- Transfer to tertiary care center ASAP
- Documentation and handover tool on ORBCON's website
- Parenteral presence
- Therapeutic endpoints include base deficit and lactate
- Ensure entire team, including TM, knows if patient is transferred
  - i.e., ED to OR

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Calling Off a MHP

- Just as important!
- Ensure Transfusion Medicine knows you have called off the code
- Return coolers and any unused products ASAP

Final Notes

- Know your institutions policy, equipment etc.
- Weight is everything in peds
- ORCON's Website
  - Peds simulation video and case

Question # 1 Post-knowledge

What vital patient information does Transfusion Medicine need when you activate the Massive Hemorrhage Protocol (MHP)?

A) Name and age

B) Sex and age

C) Sex and weight

D) Name and weight

Correct Answer

C: sex and weight

Sex of the patient is needed to determine if O positive or negative blood can be given.
All medication and blood product dosing in pediatrics is calculated based on weight. Weight is needed so TM knows how many units of each product to prepare.

Question # 2 Post-knowledge

What is the volume of RBCs a pediatric patient should receive per dose?

A) 20 ml/kg
B) 5 ml/kg
C) Half a unit
D) 1 unit

Correct Answer

A) 20 ml/kg

Everything in pediatrics is weight based. The dose for RBCs per kg is the same as a fluid bolus, 20 ml/kg

Question # 3 Post-knowledge

What is a late and ominous sign for a pediatric patient with hypovolemic shock?

A) Tachycardia
B) Mottled skin
C) Cap refill > 3 seconds
D) Decreased blood pressure

Correct Answer

D) Decreased blood pressure

To maintain cardiac output, children increase their HR to meet demands and vasoconstrict peripherally which leads to poor peripheral perfusion. When the blood pressure falls it is because the child has exhausted all compensatory mechanisms