Hemorrhagic Shock and Massive Transfusion Protocol (MTP)

EIIC
EMSC Innovation and Improvement Center

Patient presents with traumatic injury

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Standard ATLS Primary and Secondary Survey

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Concern for Hemorrhagic Shock:

- **Evaluate vital signs**
  - **Tachycardia** is the **first sign**
  - **Hypotension** is a **late sign**
- **Other later signs include:**
  - **Tachypnea**
  - **Decreased responsiveness**
  - **Decreased urine output**
  - **Increased base deficit**
- **Assess hemorrhage source/mechanism of injury**
  - External bleeding
  - Hemothorax
  - Abdominal or retroperitoneal hemorrhage (FAST exam is considered unreliable in children). See **EIIC Pediatric Trauma Imaging Key Considerations.**
  - Pelvic pain and/or instability
  - Open fractures of the long bones

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Initial Treatment:

- 2 large bore IVs or consider IO access early
- Consider obtaining baseline labs (e.g., type and cross, CBC, INR, fibrinogen, TEG) to allow for goal-directed resuscitation
- Stop the bleeding (e.g., apply pressure, pelvic binder, tourniquet use, if appropriate)
- **Early blood product administration (10mL/kg bolus)**
- 20mL/kg for crystalloid bolus if blood products are initially not available
- **Prevent Hypothermia**
  - Remove cold/wet clothing
  - Cover with warm blankets, hats, and socks
  - Initiate active warming measures as needed (e.g., forced air warming systems, radiant warmers, warmed IV and blood products, circulating water mattresses) as needed.
- Support Airway/Breathing to improve oxygenation

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Considerations for Massive Transfusion Protocol (MTP):

- (ABC-D Criteria) **2 or more** of the following positive findings:
  - **Penetrating injury**
  - **Positive FAST exam**
  - **Tachycardia AND hypotension**
  - **Lactate > 3.5 mmol/L**
  - **Base deficit >= -8.8 mmol/L**

OR

- **> 20mL/kg of blood product**
- **Persistent hemodynamic instability**
- **Active visible bleeding**

> Initiate pediatric Massive Transfusion Protocol (see page 3)
  - Continue efforts to obtain hemorrhage control

Ongoing Management

- Continue to find appropriate hemorrhage control
- Early discussion with PTC
- Urine output goal: 1-2mL/kg/hr

Hemorrhagic Shock Management continued

Normal Heart Rates			Respiratory Rate (breaths/min)	
Age	**Awake Rate (/min)**	**Sleeping Rate (/min)**	**Age**	**Normal**
Neonate	100-205	90-160		
Infant	100-180	90-160	Infant	30-53
Toddler	98-140	80-120	Toddler	22-37
Preschooler	80-120	65-100	Preschooler	20-28
School-age child	75-118	58-90	School-age child	18-25
Adolescent	60-100	50-90	Adolescent	12-20

Normal Blood Pressures (mm Hg)				
Age		**Systolic**	**Diastolic**	**Mean Arterial**
Birth (12 hours)	<1 kg	39-59	16-36	28-42
	3 kg	60-76	31-45	48-57
Neonate (96 hours)		67-84	35-53	45-60
Infant (1-12 months)		72-104	37-56	50-62
Toddler (1-2 years)		86-106	42-63	49-62
Preschooler (3-5 years)		89-112	46-72	58-69
School-age child (6-9 years)		97-115	57-76	66-72
Preadolescent (10-12 years)		102-120	61-80	71-79
Adolescent (12-15 years)		110-131	64-83	73-84

Definition of Hypertension by Systolic Blood Pressure and Age	
Age	**Awake Rate (/min)**
Term Neonates (0-28 days)	<60
Infants (1-12 months)	<70
Children (1-10 years)	<70 + (age in years x2) This estimates systolic blood pressure that is less than the fifth blood pressure percentile for age.
Children (>10 years)	<90

American Heart Association. (2020). Pediatric Advanced Life Support Provider Manual (6th ed.). https://ebooks.heart.org

PEAK Pediatric Education and Advocacy Kits

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Massive Transfusion Protocol (MTP)

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Blood Product Administration Guidance

Balanced Resuscitation: 1:1:1 (pRBC:FFP:PLT) to mimic whole blood and optimize hemostasis.

- Packed Red Blood Cells (pRBC): 10mL/kg bolus
- Fresh Frozen Plasma (FFP): 10mL/kg bolus
- Platelets (PLT): 10mL/kg bolus
- Cryo: 10mL/kg bolus
- Whole Blood: 10mL/kg bolus if available

Total Blood Volume (mL/kg)

- Neonates 85-90 | Infants 75-80 | Children 70-75

Massive Transfusion Protocol Phased Packs

The volume of blood products administered is typically calculated using the child's weight measured in kilograms.

< 20 Kg	
PACK 1	
pRBC	1 unit
FFP	1 unit
PLT	0 unit
PACK 2	
pRBC	1 unit
FFP	1 unit
PLT	1 unit
CRYO	2 units
PACK 3	
pRBC	1 unit
FFP	1 unit
PLT	1 unit
CRYO	As needed
PACK 4	
pRBC	1 unit
FFP	1 unit
PLT	0 unit
CRYO	As needed

For subsequent packs, alternate between Packs 3 and 4 continuously

21-50 Kg	
PACK 1	
pRBC	2 units
FFP	2 units
PLT	1 unit
PACK 2	
pRBC	2 units
FFP	2 units
PLT	1 unit
CRYO	5 units
PACK 3	
pRBC	2 units
FFP	2 units
PLT	1 unit
CRYO	As needed

Repeat Pack 3 for subsequent packs

> 50 Kg	
PACK 1	
pRBC	4 units
FFP	4 units
PLT	1 unit
PACK 2	
pRBC	4 units
FFP	4 units
PLT	1 unit
CRYO	5 units
PACK 3	
pRBC	4 units
FFP	4 units
PLT	1 unit
CRYO	As needed

Repeat Pack 3 for subsequent packs

Adjunct Therapies

- Consider **Tranexamic acid (TXA) if within 3 hours of injury:**
  - Age ≥ 12: 1g IV over 10 min, second dose 1g IV over 8 hours or until bleeding stops
  - Age < 12: 15 mg/kg IV over 10 min, infuse 2mg/kg/hr over 8 hours or until bleeding stops
- Thromboelastography (TEG) – driven resuscitation if available
- Calcium administration after 2 rounds of MTP, check Q1H during MTP:
  - Calcium gluconate (preferred) 100 to 200 mg/kg/dose (MAX 3 g/dose) IV over 5 to 10 minutes with cardiac monitoring
  - Calcium chloride 20 mg/kg/dose (MAX 1 g/dose) IV can alternatively be given if central access is available and with cardiac monitoring

Adapted from Arkansas Children's Hospital, Little Rock, AR. Arkansas Children's Massive Transfusion Protocol. Updated June 16, 2022