BOTTOM LINE RECOMMENDATIONS:

Croup

» Croup is the most common cause of upper airway obstruction in children. The typical age of presentation is between 6 months and 5 years with a peak around 2 years of age. Consider other causes of upper airway obstruction such as bacterial tracheitis, epiglottitis, and retropharyngeal abscess in children who present with severe symptoms with a transient or lack of response to croup treatment.

» Presence of acute onset barky cough strongly suggests croup.

» X-rays are rarely necessary to confirm the diagnosis of croup.

» Because croup symptoms are triggered by a viral infection, antibiotics are **not** effective.

» Oral dexamethasone **(1 dose of 0.15 to 0.6 mg/kg, max dose 12 mg)** should be given to **ALL** children who present to the emergency department with croup.

AT INITIAL ASSESSMENT, CHILDREN WITH:

» **MILD** croup (no inspiratory stridor at rest or indrawing) can be safely discharged home after dose of dexamethasone without any further observation.

» **MODERATE** croup (inspiratory stridor at rest and mild to moderate indrawing) should be observed after dose of dexamethasone until both stridor at rest and indrawing resolve (usually a few hours).

» **SEVERE** croup [stridor (often biphasic), severe chest wall indrawing, agitation] should be treated with **5 mL of 1 mg/mL (1:1,000) epinephrine via nebulization and oral dexamethasone.**

» More than one dose of nebulized epinephrine may be required in the treatment of severe croup.

If children are treated with epinephrine, they should be observed for a minimum of **2 hours** before being discharged from medical care.

CRITERIA FOR SAFE DISCHARGE HOME

» Absence of inspiratory stridor at rest and respiratory distress (suprasternal, intercostal and chest wall indrawing).

» Croup resources to share with parents can be accessed at https://trekk.ca/patientsandfamilies.

CRITERIA FOR HOSPITAL ADMISSION

» Persistence of stridor at rest and respiratory distress (defined above) **4 hours or more after treatment with dexamethasone** and repeated doses of nebulized epinephrine.

CRITERIA FOR TRANSFER TO CHILDREN'S HOSPITAL INTENSIVE CARE

» Persistent severe croup [stridor (often biphasic), severe chest wall indrawing, agitation] despite treatment with two doses of nebulized epinephrine and oral dexamethasone within first two hours of assessment and treatment.

The purpose of this document is to provide healthcare professionals with key facts and recommendations for the diagnosis and treatment of croup in children. This summary was produced by the croup content advisor for the TREKK Network, Dr. David Johnson of the Alberta Children's Hospital Research Institute, and uses the best available knowledge at the time of publication. However, healthcare professionals should continue to use their own judgment and take into consideration context, resources and other relevant factors. The TREKK Network is not liable for any damages, claims, liabilities, costs or obligations arising from the use of this document including loss or damages arising from any claims made by a third party. The TREKK Network also assumes no responsibility or liability for changes made to this document without its consent. This summary is based on:

1) Alberta Medical Association. Diagnosis and Management of Croup, Summary of the Alberta Clinical Practice Guideline, Update 2014. (Accessed online December 1 2016).

2) Bjornson et al. The Cochrane Library and the Treatment of Croup in Children: An Overview of Reviews. Evidence-based Child Health 2012; 5:1555-65

BOTTOM LINE RECOMMENDATIONS:

Asthma

Asthma is the most common chronic disease in children. Acute exacerbations of asthma are one of the most common reasons for children to seek emergency care and require urgent hospitalization. Up to two-thirds of children with asthma who seek emergency care can be classified as having **mild** respiratory distress, between 2 and 5% have **severe** respiratory distress, and the remainder have **moderate** respiratory distress.

OVERVIEW OF MANAGEMENT

» Evidence-based management of children with acute asthma exacerbations (including repeated doses of salbutamol and ipratropium, and oral corticosteroids in the first 60 minutes of care) reduces hospitalization rates substantially.

NOTE: *While Canadian pediatric emergency departments (EDs) have similar approaches to treating children with asthma, there are some regional differences. Depending on where in Canada you practice, please see the following clinical pathways for more detailed guidance (including dosing of bronchodilators) or the TREKK Asthma PedsPac:*

Quebec (Sainte-Justine) *Ontario* *Alberta* *British Columbia*

CLASSIFYING ASTHMA SEVERITY

» Use of a standardized, validated clinical score (the Pediatric Respiratory Assessment Measure or PRAM) to classify the severity of respiratory distress in children with asthma exacerbations results in improved use of evidence-based medications and lower rates of hospitalization.[1,2]

» Cut-off scores for categorizing patients as having mild, moderate, or severe respiratory distress differ between provincial pathways. *See pathways listed above for specific details.*

MILD

» Salbutamol should be delivered with metered dose inhalers (MDIs) and spacers rather than nebulization.[3]

» While oral corticosteroids are frequently administered to children with mild respiratory distress, clear evidence of benefit in those with mild symptoms is lacking.

MODERATE

» Treat with salbutamol delivered via MDI and spacers every 20 minutes, for a total of three doses.

» Methods for adjusting the dose of salbutamol for children of different ages vary between pediatric emergency departments. Some adjust based on age in years and others adjust based on broad weight cut-offs. *See provincial pathways listed above for specific adjustments.*

» Administration of **oral corticosteroids** just before or immediately after initiating bronchodilator therapy substantially decreases respiratory distress within 2-6 hours of treatment and substantially decreases hospitalization rates.

» **Oral dexamethasone** or **prednisone/prednisolone** are likely to be comparably effective;[4] in some studies, dexamethasone was reported to result in substantially lower rates of vomiting.

- **Liquid parenteral form of dexamethasone** administered orally is used preferentially in most Canadian pediatric emergency departments.
- **Standard dosing:** dexamethasone 0.15 to 0.6 mg/kg, or prednisone/prednisolone 1-2 mg/kg. *See provincial pathways above for specific dosing and maximum doses.*

» Multiple doses of **ipratropium** (two or three) added to salbutamol aerosols and oral corticosteroids in the first 60 minutes of treatment yield greater improvement and lower hospitalization rates.[5] *See provincial pathways for specific dosing.*

- Benefits appear to be greatest in those with severe respiratory distress; it is less certain in those children with moderate distress.

SEVERE

» There is good evidence that patients with severe respiratory distress improve more rapidly when **bronchodilators** are delivered continuously **via aerosol** over 60 to 180 minutes as compared with intermittently (i.e.: every 20 minutes).[6] Some provincial pathways suggest use of continuous nebulization in place of intermittent MDI and spacers for children with severe respiratory distress.

» Although delivery via MDIs/spacers is more efficient than nebulization, it is much more convenient to deliver aerosols continuously via nebulization than via MDIs/spacers.

» **Large volume nebulizers**[7] allow administration of bronchodilators continuously over 60 or more minutes, and should be used in preference to standard-sized nebulizers, which can only accommodate doses administered over shorter times.

- Mix: three 5 mg (child weight >20 kg) or 2.5 mg (child weight <20 kg) salbutamol nebules with three 250 mcg ipratropium nebules and enough normal saline to make a total volume of 20 ml.
- Nebulize over 60 minutes at 8L/min.

» **Magnesium Sulfate:** Children with severe initial respiratory distress who do **not** respond to repeated or continuous bronchodilators and early corticosteroids have been shown to have greater subsequent improvement if treated with intravenous magnesium sulfate (in addition to repeated or continuous bronchodilator therapy). While the dose studied has varied, **40-50 mg/kg** appears to be as effective as higher doses.[8, 9]

CRITERIA FOR SAFE DISCHARGE HOME

» General consensus among Canadian pediatric emergency physicians for safe discharge includes:

- No significant intercostal and/or suprasternal indrawing at least 1 to 2 hours after the last bronchodilator treatment;
- Good air movement on auscultation with at most mild expiratory wheezes; and
- Oxygen saturations on room air greater than 90%.
- The above equates to PRAM score ≤ 3.

CRITERIA FOR HOSPITAL ADMISSION OR PROLONGED OBSERVATION

» Continue therapy as per provincial pathway for those not yet ready for discharge.

» Consider admission to hospital if persistent moderate/severe respiratory distress more than 4-6 hours after corticosteroids given.

» Consult PICU/transport team regarding transfer is persistent severe respiratory distress after initial 1-2 hours of therapy.

This summary is based on:

1) Ducharme FM, Chalut D, Plotnick L, Savdie C, Kudirka D, Zhang X, Meng L, McGillvary D. The pediatric respiratory assessment measure: A valid clinical score for assessing acute asthma severity from toddlers to teenagers. *J Pediatr*. 2008 Apr; 152(4):476-80.
2) Chalut DS et al. The preschool respiratory assessment measure (PRAM): a responsive index of acute asthma severity. *J Pediatr*. 2000 Dec; 137(6): 762-8.
3) Cates CJ, Crilly JA, Rowe BH. Holding chambers (spacers) versus nebulisers for beta-agonist treatment of acute asthma. *Cochrane Database Syst Rev.* 2013 Sep 13;(9):CD000052. doi: 10.1002/14651858.CD000052.pub3.
4) Keeney GE et al. Dexamethasone for acute asthma exacerbations in children: A meta-analysis. *Pediatrics.* 2014 Mar 1;133(3):493-9.
5) Griffiths B, Ducharme FM. Combined inhaled anticholinergics and short-acting beta2-agonists for initial treatment of acute asthma in children. *Cochrane Database Syst Rev.* 2013 Aug 21;(8):CD000060. doi: 10.1002/14651858.CD000060.pub2.
6) Camargo CA Jr et al. Continuous versus intermittent beta-agonists in the treatment of acute asthma. *Cochrane Database Syst Rev.* 2003;(4):CD001115.
7) Order information for MiniHEART Hi-Flo®, Westmed HEART Continuous Nebulizers (large-volume nebulizer used in RCTs)
8) Cheuk DK, Chau TC, Lee SL. A meta-analysis on intravenous magnesium sulphate for treating acute asthma. *Arch Dis Child.* 2005 Jan;74-7.
9) Griffiths B, Kew KM. Intravenous magnesium sulfate for treating children with acute asthma in the emergency department. *Cochrane Database Syst Rev.* 2016; (4):CD011050.

Pediatric Severe Sepsis Algorithm

For children >28 days of age

Recognition of Severe Sepsis:

- Fever (>38.0°C) or hypothermia (<36.0°C)
- High Risk Conditions*
- Signs of infection*

And signs of impaired perfusion:

- Tachycardia, cap refill >2 sec, cold extremities, ↓urine output, SpO_2 <94%, mottled skin
- Mental status changes (confusion, lethargy, inconsolability)

** See Sepsis Screener in Drug Dosing Binder*

Initial Management:

- Assess ABCs, cardiorespiratory monitoring
- O_2 10-15 L/min non-rebreather mask
- IV access x2; IO access if 2 failed IV attempts
- May use IO for blood tests, fluids & medications in lieu of IV
- Investigations:
  - Bedside glucose (If glucose ≤2.6 mmol/L, give 5 mL/kg D10W IV push, then start D10NS infusion @ 5 mL/kg/hr (MAX 250 mL/hr). Recheck glucose in 5 min)
  - CBC and diff, blood C&S, electrolytes, venous gas, glucose, urea, creatinine, lactate, PT/PTT, ALT, blood type & screen
  - CXR
  - Urinalysis and C&S (consider indwelling urinary catheter)

Alert Pediatric Referral Centre

10 min

1st Bolus - NS 20 mL/kg IV rapid push over 5 – 10 min

Give Antibiotics

- Ceftriaxone (100 mg/kg/dose, MAX 2g/dose) IV q24h
- Vancomycin if suspect meningitis (15 mg/kg/dose, MAX 1 g/dose) IV q6h

! Reassess HR, RR, BP, Perfusion, SpO_2
If remain abnormal:

20 min

2nd Bolus - NS 20 mL/kg IV rapid push over 5 – 10 min

- Alert Pediatric Referral Centre, if not already done

! Reassess HR, RR, BP, Perfusion, SpO_2
If remain abnormal:

30 min

3rd Bolus - NS 20 mL/kg IV rapid push over 5 – 10 min

- Prepare inotrope infusion
- Alert Pediatric Referral Centre, if not already done

! Reassess HR, RR, BP, Perfusion, SpO_2
If remain abnormal:

40 min

If "Cold Shock"
(↓ perfusion, ↓ peripheral pulses)
Epinephrine 0.05 mcg/kg/min IV,
titrate up by 0.02 mcg/kg/min to effect

! Reassess HR, RR, BP, Perfusion, SpO_2
If remain abnormal:

Ongoing

If "Warm Shock"
(↑ pulse pressure, bounding pulses)
Norepinephrine 0.05 mcg/kg/min IV,
titrate up by 0.02 mcg/kg/min to effect

CAUTION!

- **Assess for fluid overload after each bolus (palpate for hepatomegaly, auscultate for crackles)**
- **Consider cardiogenic shock if deterioration after fluid boluses**

Pediatric Referral Centre Discussion

CONSIDERATION OF:

- Intubation
  - Be prepared for clinical deterioration
  - Ensure adequate fluid resuscitation

BOTTOM LINE RECOMMENDATIONS:

Sepsis

Sepsis is a systemic response to infection; it is a leading cause of morbidity and mortality worldwide[1]. Early recognition, aggressive resuscitation (fluids, metabolic correction, antibiotics) and escalation of care (vasoactive medications) are key to improving patient outcomes.

See the **TREKK Sepsis PedsPac** for bedside tools to aid in recognition and management of pediatric severe sepsis.

EARLY RECOGNITION OF SEVERE SEPSIS

- Clinical triad: temperature change (hypo/hyperthermia), altered mental status and impaired perfusion (capillary refill >2 sec, SpO2 <92%, mottled skin, cold extremities) in the setting of suspected/proven infection.
- A triage screening poster is available to identify patients with possible sepsis.
- Sepsis is a clinical diagnosis; laboratory investigations are supportive and should not delay treatment initiation.
- Hypotension is a late finding in pediatric sepsis and a sign of decompensated shock.
- Alert your pediatric referral centre if you have a patient with suspected severe sepsis.

MANAGEMENT PRIORITIES FOR SEVERE SEPSIS/SEPTIC SHOCK

EARLY VASCULAR ACCESS

- Secure two vascular access sites.
- Intraosseous (IO) access should be secured when intravenous (IV) access has not been achieved after two attempts. In situations where rapid IV access may be difficult, IO access should occur concurrently with IV attempts to minimize delay to vascular access.

EARLY AGGRESSIVE FLUID RESUSCITATION

- Rapid administration of normal saline boluses of **20 mL/kg** over 5-10 minutes.
- Give boluses via push-pull technique (i.e. filling large syringe with normal saline from IV bag and pushing through IV tubing) or rapid/Level 1 infuser (patient must be ≥ 20 kg with large bore IV, at least 22 gauge or larger to use rapid infuser)[2].

A regular IV pump is NOT sufficient.

- Boluses may need to be repeated up to **60 mL/kg or more**.
- Titrate fluids to therapeutic endpoints (see Page 2).
- Carefully monitor for signs of fluid overload (i.e. crackles on auscultation, hepatomegaly) or signs of cardiogenic shock (i.e. murmur, persistent shock despite fluid resuscitation).

EARLY METABOLIC CORRECTION

- High flow O2 using 10-15 Lpm via non-rebreather mask.
- Check for and correct low glucose (common in infants) and low calcium (see your PedsPac Dosing Binder or contact your local pediatric referral centre for guidance). If glucose ≤ 2.6 mmol/L, give 5mL/kg D10W rapid push IV, then start D10W IV @ 5mL/kg/hr (MAX 250 mL/hr). Recheck bedside glucose in 5 minutes.

EARLY ANTIBIOTIC THERAPY

- Broad spectrum antibiotics should be administered **within 1 hour of recognition of sepsis.**
- Antibiotics should **NEVER** be delayed to obtain cultures.
- Children < 3 months - **Ampicillin (75 mg/kg/dose) + Cefotaxime (100 mg/kg/dose, MAX 2 g/dose).**
- Children > 3 months - **Ceftriaxone (100 mg/kg/dose, MAX 2 g/dose) IV q24h + Vancomycin if suspect meningitis (15 mg/kg/dose, MAX 1 g/dose) IV q6h.**

EARLY DISCUSSION WITH PEDIATRIC REFERRAL CENTRE REGARDING:

- Initiation and selection of vasoactive medications.
- Considerations for intubation and ventilation.
- Administration of blood products.
- Steroid (catecholamine resistant shock)

EARLY ESCALATION OF CARE

- If signs of shock persist (abnormal perfusion and/or hypotension) despite resuscitation with 40 mL/kg of isotonic fluids, prepare inotrope infusion, as indicated below, and administer if no improvement after total 60 mL/kg of fluids.
  - For cold shock (↓ perfusion, ↓ pulses): **epinephrine** (0.05 mcg/kg/min IV, titrate up by 0.02 mcg/kg/min to effect).
  - For warm shock (↑ pulse pressure, bounding pulses): **norepinephrine** (0.05 mcg/kg/min IV, titrate up by 0.02 mcg/kg/min to effect).
  - **Dopamine** (10 mcg/kg/min IV) may be started initially if readily available and there is any delay with administering epinephrine or norepinephrine.

THERAPEUTIC ENDPOINTS

- Normalization of capillary refill (< 2 seconds), pulses, pulse pressure (diastolic BP should be 2/3 systolic BP), mental status, urine output **(>1 mL/kg/hr).**

SOURCE IDENTIFICATION

- Identification of the source of infection should **NEVER** delay resuscitation and administration of antibiotics.
- Blood culture, urine culture (via catheter) and chest x-ray are standard investigations.
- CSF culture may be considered in patients who are hemodynamically stable with no altered LOC or focal neurological signs that may suggest the need for head imaging prior to lumbar puncture.

The purpose of this document is to provide healthcare professionals with key facts and recommendations for the diagnosis and treatment of sepsis in children. This summary was produced by the sepsis content advisors for the TREKK Network, Dr. Graham Thompson of the Alberta Children's Hospital Research Institute and Dr. Mona Jabbour of the Children's Hospital of Eastern Ontario, and uses the best available knowledge at the time of publication. However, healthcare professionals should continue to use their own judgment and take into consideration context, resources and other relevant factors. The TREKK Network is not liable for any damages, claims, liabilities, costs or obligations arising from the use of this document including loss or damages arising from any claims made by a third party. The TREKK Network also assumes no responsibility or liability for changes made to this document without its consent. This summary is based on:

1. Thompson G & Kissoon, N. Sepsis in Canadian children: A national analysis using administrative data. *Clin Epidemiol.* 2014;6:461–9.
2. Parker MJ & Manan A. Translating Resuscitation Guidelines into Practice: Health Care Provider Attitudes, Preferences and Beliefs Regarding Pediatric Fluid Resuscitation Performance. *PLoSOne*. 2013;8(3).
3. Rhodes A, Evans LE, Alhazzani W, et al. Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016. *Crit Care Med*. 2017;45(3):486-552.
4. Davis AL, Carcillo JA, Aneja RK, et al. American College of Critical Care Medicine Clinical Practice Parameters for Hemodynamic Support of Pediatric and Neonatal Septic Shock. *Crit Care Med.* 2017;45(6):1061-93.
5. Goldestein B, Giroir B, Randolph A. International pediatric sepsis consensus conference: Definitions for sepsis and organ dysfunction in pediatrics. *Pediatr Crit Care Med.* 2005;60(1):2-8.

BOTTOM LINE RECOMMENDATIONS:

Multisystem Trauma

Trauma is the leading case of morbidity and mortality in children[1]. Children have unique injury patterns and substantial differences in their response to trauma when compared with adults; this requires special consideration when addressing the assessment and management of pediatric trauma.

PEDIATRIC CONSIDERATIONS

ANATOMICAL

- Small body mass with large surface area, results in increased heat loss and greater external force per body unit area.
- Proportionally larger and less protected solid organs increase chance of intra-abdominal injury (IAI).
- Pliable ribcage with less musculature and more mobile mediastinum allows for major thoracic injury without obvious external signs of trauma.
- Larger head-to-body ratio results in a higher proportion of head injuries and age-related differences in cervical spine injury patterns.

PHYSIOLOGICAL

- Higher metabolic rate leads to increased oxygen and glucose demands, increased respiratory rate, and insensible fluid losses.
- Compensated shock is prevalent and often unrecognized as blood pressure remains normal until child displays rapid decompensation and arrest.

DEVELOPMENTAL

- Normal curiosity in young children and increased risk-taking amongst adolescents put children and youth at risk of injury.
- Children are often fearful with trauma assessments, and providers have difficulty with communication & examination, especially in young, preverbal children.

PEDIATRIC ATLS ASSESSMENT (KEY POINTS FOR PRIMARY SURVEY IN CHILDREN)

AIRWAY WITH CERVICAL SPINE CONTROL

- Have pediatric equipment available (1/2 size higher and lower)
- Blocks or sandbags with tape across the forehead are better than an ill-fitting cervical collar.

BREATHING

- Children have short tracheas & are often intubated too deeply; as well, endotracheal tubes are easily dislodged in transport (secure equipment well).
- Pulmonary contusions and pneumothoraces can occur even *without* external or radiological signs of chest wall trauma.
- Children desaturate quickly and modified rapid sequence intubation protocols may be necessary to avoid hypoxia.
- Deflating the stomach with an NG/OG tube can improve respiratory status by relieving abdominal distention that impairs breathing.

CIRCULATION

- Be wary of tachycardia and signs of peripheral vasoconstriction (delayed capillary refill, cool extremities, thready peripheral pulses).
- **DO NOT wait for blood pressure to fall.** Compensated shock can quickly lead to rapid decompensation & arrest.
- Warmed isotonic fluids (NS or LR) should be administered at bolus doses of **10 or 20 ml/kg** based on severity of shock or presence of active bleeding. Between **10 – 40 ml/kg** preparation for giving blood products should occur if hemodynamic status remains compromised. In children with severe shock and active bleeding, minimize crystalloid and begin transfusing uncrossmatched blood (ideally group O-) ASAP.
- Place intraosseous lines early if intravenous access difficult (after 90 seconds or 2 attempts at intravenous placement).

DISABILITY

- In preverbal children, the Pediatric Glasgow Coma Scale is an accurate tool to assess and communicate mental status after trauma.
- Check blood glucose in infants and young children to ensure hypoglycemia is not contributing to an altered mental status.
- Address pain (appropriate analgesia) and distress (family presence, distraction techniques and calm person at head of bed).

EXPOSURE

- Keeping children warm after trauma is of critical importance. Methods include warm blankets, overhead heaters, forced air warmers (e.g. Bair Hugger), and warmed intravenous fluids (+/- blood).

FAMILY PRESENCE

- Standard in pediatric trauma centers across North America; must have dedicated personnel to remain with family.
- Evidence demonstrates reduced stress on the family and patient without compromising medical care or team dynamics.
- Communication between the medical team and the family is enhanced.

DIAGNOSTIC IMAGING FOR PEDIATRIC MULTIPLE TRAUMA

- ATLS 9th Edition recommends chest and pelvic radiography after blunt trauma prior to transport.
- CT imaging of the neck is **NOT** routine or warranted for all pediatric trauma patients, and is best done at a pediatric trauma center.
- For children whose cervical spines cannot be clinically cleared, a referring center may either maintain the child in proper cervical immobilization & forego imaging, or use radiography as a screening tool.
- Screening radiography in children <8 years is 2 views of the neck (AP and lateral); odontoid view recommended in children ≥ 8 years.
- Pelvic x-rays can be omitted in children at low risk for fracture with a normal GCS and hemodynamic status and **NONE** of the following: signs of abdominal trauma, abnormalities on pelvic exam, an associated femur fracture, or hematuria.

BOTTOM LINE FOR RADIOGRAPHY OF BLUNT PEDIATRIC TRAUMA PRIOR TO TRANSPORT

- **Chest x-ray:** Yes
- **Cervical spine x-rays:** May be done if unable to clinically clear, or may be deferred if child is left in cervical collar for transport.
- **Pelvic x-rays:** Yes, if suspicion of pelvic fracture or hemodynamic instability.
- **CT Imaging**: Should **NOT** delay transport; usually best decision is to allow pediatric trauma center to perform CT imaging.

FAST IN CHILDREN

- Currently, FAST scans have limited sensitivity on their own, and while helpful if positive, **are not adequate to rule out IAI.** Abdominal CT scan is currently necessary and best obtained at a pediatric trauma centre if concern exists for clinically important IAI.

PEDIATRIC TRAUMA SCORE

- Trauma triage scores have been developed to predict which children require trauma center-level care.
- The Pediatric Trauma Score (PTS) was developed to reflect children's vulnerability to traumatic injury, emphasizing the importance of the child's weight and airway.
- Several studies have confirmed that the PTS is a valid tool in predicting mortality of a traumatically injured child.
- As a guide, the score recommends that all children with a PTS < 8 (i.e. any child that is high risk or worrisome) should be transferred to a pediatric trauma center. Local resources and consultation with a pediatric trauma center early will help with transport and referral decision.

TRANSPORT CONSIDERATIONS AND CHECKLIST

- Life-threatening injuries identified and addressed
- Early communication with receiving center established
- Ongoing sedation +/- paralysis plan as needed
- Analgesia addressed, fractures splinted, antibiotics for open fractures
- IV or IO access in place and stabilized
- Airway controlled & equipment well-secured
- Gastric tubes & urinary catheters secured as needed
- Imaging, lab results & paperwork available to crew

- If pneumothorax is identified, a chest tube may need to be placed prior to transport; should definitely be placed for air transport.
- If child requires transfusion, consider administering tranexamic acid (TXA) if within 3 hours of injury. Initial dose for < 12 years is 15 mg/kg (max 1g), and for ≥ 12 years is 1g.
- Communication of key clinical information including patient status, weight (can be estimated with Broselow tape), age, identified injuries & interventions and estimated time of arrival.

MAJOR CAUSES OF INADEQUATE RESUSCITATION IN CHILDREN

1. Failure to support airway and breathing (compromise of oxygenation and ventilation is common).
2. Failure to recognize and respond to intra-abdominal hemorrhage (loss of perfusion is less common but potentially lethal).
3. Failure to adequately address cardiopulmonary resuscitation (points 1 and 2) in children with traumatic brain injury; this is the leading contribution to secondary brain injury.

The purpose of this document is to provide health care professionals with key facts and recommendations for the diagnosis and treatment of multisystem trauma in children in the emergency department. This summary was produced by the multisystem trauma content advisor for the TREKK Network, Dr. Suzanne Beno of the Hospital for Sick Children, and uses the best available knowledge at the time of publication. However, healthcare professionals should continue to use their own judgment and take into consideration context, resources and other relevant factors. The TREKK Network is not liable for any damages, claims, liabilities, costs or obligations arising from the use of this document including loss or damages arising from any claims made by a third party. The TREKK Network also assumes no responsibility or liability for changes made to this document without its consent. This summary is based on:

1. Yanchar NL, Warda LJ, Fuselli P; Canadian Pediatric Society Injury Prevention Committee. Child and youth injury prevention; a public health approach. Paediatr Child Health 2012;17(9): 511
2. ATLS Subcommittee; American College of Surgeons' Committee on Trauma; International ATLS working group. Advanced trauma life support (ATLS®): the ninth edition. J Trauma Acute Care Surg. 2013 May;74(5):1363-6.
3. Kenefake ME, Swarm M, Walthall J. Nuances in Pediatric Trauma. Emerg Med Clin N Am 31 (2013) 627-652.

BOTTOM LINE RECOMMENDATIONS:

Severe Head Trauma

HEAD TRAUMA is categorized as mild, moderate, or severe. Head trauma is considered **SEVERE** when children present with a Glasgow Coma Scale (GCS) **score of ≤ 8.** These children often have intracranial injury as seen by neuroimaging and all will have suffered traumatic brain injury (TBI), an alteration in brain function caused by external force. ***TBI is a critical public health issue*** with injury being the leading cause of death in children >1 year of age, and TBI is the most significant cause of death and disability in this group.[1]

PEDIATRIC CONSIDERATIONS

» Normal curiosity in young children and increased risk-taking behaviour among adolescents put children and youth at increased risk of injury. Smaller size and reduced awareness of environmental hazards can increase the likelihood and severity of injuries resulting as occupants in motor vehicle collisions or as pedestrians/cyclists.

» Anatomically, children have larger head-to-body size ratios (higher incidence of head trauma), thinner cranial bones (increased likelihood of skull fractures), and unfused sutures (better tolerance of increased intracranial pressure).

» Pediatric brains have increased water content and decreased myelinisation. **Children are therefore more susceptible to shear injuries such as diffuse axonal injury (DAI), and are at higher risk for cerebral swelling.**

» Practitioners should be alert for abusive head trauma, particularly in infants and young children (see TREKK suspected physical child maltreatment recommendations).

ASSESSMENT PRINCIPLES

» Children with severe head trauma should be stabilized as per the principles of advanced trauma life support (ATLS) with special attention to the unique differences in childhood anatomy and physiology (see TREKK multisystem trauma recommendations). Appropriate cervical immobilization should occur. **Once the need for advanced trauma care is identified, early referral and organization of transport after stabilization is important for optimizing outcomes.**

» When children present with significant head trauma, assume multisystem injury due to the mechanisms of injury with which children commonly present and their smaller size and unique anatomy. **It is critical to identify and treat shock; unrecognized hypotension significantly increases secondary brain injury.**

» The modified Glasgow Coma Scale (GCS) for Infants and Children should be used to assess and document neurological status in preverbal children. Alternatively, the AVPU Scale (Alert, Voice, Pain, Unresponsive) can be used; a child who is responsive only to pain or completely unresponsive can be assumed to have a GCS of ≤ 8 and will need to be managed accordingly.

» Children with severe head trauma will need to have their airway managed prior to transport. **Hypoxia significantly increases secondary brain injury; children should be well-oxygenated pre- and post-intubation.**

» Cerebral herniation is a **life-threatening emergency** recognized by symptoms such as:

1. Progressive obtundation
2. Unilateral pupillary dilatation
3. Cushing's triad (hypertension, bradycardia, abnormal respirations)

» Children requiring referral and transport to a pediatric trauma center should **NOT** undergo CT imaging prior to transport unless the decision to do so is made with the Trauma Team Leader. Decision rules such as CATCH2 help determine the need for CT imaging. However, CT imaging should **NOT** delay transport, and additional scans may result in increased radiation to the patient.

TREATMENT

» After severe head injury, the main goal of treatment is to **prevent secondary brain injury and minimize increased intracranial pressure.**

» The foundation of treatment for TBI is excellent cardiopulmonary resuscitation. It is imperative that every effort is made to **avoid hypoxia and hypotension** with effective airway support and appropriate attention to shock. These 2 factors play the largest role in contributing to secondary brain injury.

Cerebral Perfusion Pressure (CPP) = Mean Arterial Pressure (MAP) – Intracranial Pressure (ICP)

» Pain and sedation should be addressed to reduce intracranial hypertension. Choices include fentanyl [1-2 microgram/kg administered intravenously (IV); max dose 100 micrograms] and/or midazolam (0.1 mg/kg IV; max dose 10 mg). Close vital sign monitoring, especially respiratory rate and blood pressure, is recommended for all patients before and after analgesia/sedation administration since apnea and hypotension may occur with administration of these medications.

» Rapid sequence intubation (RSI) agents for pediatric head trauma include the following:
  - » **PRE-INDUCTION:** Consider having atropine 0.02 mg/kg (max 0.5 mg) available for potential bradycardia. **Note:** Lidocaine 1.5 mg/kg or fentanyl 2-5 microgram/kg may be used 3-5 minutes prior to induction to theoretically reduce an increased intracranial pressure response with endotracheal intubation.
  - » **INDUCTION:** Ketamine 2 mg/kg **or** etomidate 0.3 mg/kg **or** propofol 1-4 mg/kg (if blood pressure stable) **Note:** Sedative and induction doses may need to be lowered if patient is hemodynamically unstable.
  - » **PARALYTICS:** Rocuronium 1 mg/kg **or** succinylcholine 1-2 mg/kg.

» "Non-value added time" in pediatric TBI has been shown to worsen outcomes. Streamline resuscitation as much as possible and transfer early.

MANAGEMENT OF CEREBRAL HERNIATION

» This includes STAT (immediate) reduction of intracranial pressure.
1. Hyperventilation to pupillary response (watch for constriction).
2. Raise head of bed to 30 degrees (reverse Trendelenburg).
3. Hyperosmolar agents (**3% hypertonic saline 3 mL/kg** and repeat as needed, and/or **mannitol 0.25-1 g/kg**). Note: hyperosmolar therapy is generally used only for patients showing signs of clinical herniation.
4. Airway protection with RSI while cervical spine immobilization is maintained.
5. Neurosurgical intervention for hematoma evacuation or decompressive craniectomy.

» Aim for **euthermia and normocapnia (end tidal CO_2 35-40). Hyperventilation should be reserved for herniation.** Inadvertent hyperventilation with low or moderate $paCO_2$ contributes to cerebral ischemia and should be avoided.

» Seizures should be controlled with **benzodiazepines** (lorazepam or midazolam 0.1 mg/kg IV) and consideration of phenytoin or fosphenytoin [PE (phenytoin equivalents)] 20 mg/kg IV for further prophylaxis.

The purpose of this document is to provide healthcare professionals with key facts and recommendations for the diagnosis and treatment of severe head trauma in children in the emergency department. This summary was produced by the severe head trauma content advisor for the TREKK Network, Dr. Suzanne Beno of the Hospital for Sick Children, and uses the best available knowledge at the time of publication. However, healthcare professionals should continue to use their own judgment and take into consideration context, resources and other relevant factors. The TREKK Network is not liable for any damages, claims, liabilities, costs or obligations arising from the use of this document including loss or damages arising from any claims made by a third party. The TREKK Network also assumes no responsibility or liability for changes made to this document without its consent.

This summary is based on:

1) Catherine A Farrell; Canadian Paediatric Society, Acute Care Committee. Management of the paediatric patient with acute head trauma. Paediatr Child Health 2013; 18 (5); 253-8.
2) Kochanek, PM et al. Guidelines for the acute medical management of severe traumatic brain injury in infants, children and adolescents - 2nd edition. Pediatr Crit Care Med 2012; 13(1).
3) Zebrack, M, Dandoy, C, Hansen, K, Scaife, E, Mann, NC, Bratton, SL. Early resuscitation of children with moderate-to-severe traumatic brain injury. Pediatrics 2009; 124 (1); 56-64.