Clinical Guidelines

Septic Shock

Document Control Information

<table>
<thead>
<tr>
<th>Author</th>
<th>Claire Fraser</th>
<th>Author Position</th>
<th>TANP CATS Consultant</th>
</tr>
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<tbody>
<tr>
<td>Document Owner</td>
<td>E. Polke</td>
<td>Document Owner Position</td>
<td>Service Coordinator</td>
</tr>
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Septic Shock

Septic shock is suspected when children have a change in mental status manifested as irritability, inappropriate crying, drowsiness, confusion, poor interaction with parents, lethargy, or becoming unrousable, along with additional features such as tachypnoea and reduced urine output.

Recognition

- Suspected infection
- Hypo or hyperthermia (temp <36° or >38.5°)
- Tachycardia
- Tachypnoea
- Altered mental status
- Decreased urine output (<1 ml/kg/hr)
- Other end organ dysfunction
- Signs of either cold or warm shock

For recognition of a child at risk refer to the Amber and Red signs on the Paediatric Sepsis 6 trigger bundle at the end of this guideline

<table>
<thead>
<tr>
<th>Cold Shock</th>
<th>Warm Shock</th>
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<tbody>
<tr>
<td>Capillary Refill &gt;2s</td>
<td>Flash Capillary Refill</td>
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<tr>
<td>Reduced Peripheral Pulses</td>
<td>Bounding Peripheral Pulses</td>
</tr>
<tr>
<td>Cool Mottled Extremities</td>
<td>Warm to edges</td>
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<tr>
<td>Narrow Pulse Pressure</td>
<td>Wide Pulse Pressure</td>
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Hypotension is not required for the clinical diagnosis of shock; however once it is present in a child with a suspected infection the diagnosis is confirmed.

Early signs and symptoms of shock are as a result of the body’s compensatory mechanisms, while late signs are indicative of decompensation.

Normal ranges for age (APLS)

<table>
<thead>
<tr>
<th>Age(years)</th>
<th>Respiratory rate</th>
<th>Heart rate</th>
<th>Systolic BP (mmHg)</th>
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<tbody>
<tr>
<td>&lt; 1</td>
<td>30 - 40</td>
<td>110 - 160</td>
<td>80 - 90</td>
</tr>
<tr>
<td>1 - 2</td>
<td>25 - 35</td>
<td>100 - 150</td>
<td>85 - 95</td>
</tr>
<tr>
<td>2 - 5</td>
<td>25 - 30</td>
<td>95 - 140</td>
<td>85 - 100</td>
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<tr>
<td>5 - 12</td>
<td>20 - 25</td>
<td>80 - 120</td>
<td>90 - 110</td>
</tr>
<tr>
<td>&gt; 12</td>
<td>15 - 20</td>
<td>60 -100</td>
<td>100 - 120</td>
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Children’s Acute Transport Service provides paediatric intensive care retrieval for Great Ormond Street, The Royal Brompton and St Mary’s NHS Trusts. Funded and accountable to the North Thames Paediatric Intensive Care Commissioning Group through Great Great Ormond Street Hospital
There is evidence showing that aggressive optimisation of the haemodynamic status within the first few hours of critical illness reduces subsequent organ failure and improves overall survival.

Paediatric septic shock is typically associated with severe hypovolemia and children frequently respond well to aggressive volume resuscitation. Children are consistently under-resuscitated in the first few hours. For every hour that a child remains in septic shock the mortality risk double.

The First Hour of Resuscitation – GOALS to restore

- Normal perfusion
- No difference in quality between central & peripheral pulses
- Warm extremities
- Capillary refill time <2s
- Normal range for age heart rate, blood pressure & respiratory rate for age (this may not be possible if the underlying cause is pneumonia)
- Normal mental status
- Urine output >1ml/kg/hr
- Serum lactate < 2
- ScvO2 sats (where available) >70%
- Normal glucose and ionized calcium concentrations

Actions in the 1st Hour

- Maintain or restore a patent airway
- High flow oxygen to achieve saturations >95% - intubate if indicated.
- Obtain secure intravenous or intraosseus access x2 quickly.
- Give high dose broad spectrum antibiotics- try to avoid Ceftriaxone (<1yr) due to risk of precipitation with calcium administration, use cefotaxime.

Do not waste valuable time - if difficult IV access, site an intraosseous (IO) needle. More than one is frequently required.

Resuscitate

Signs of shock should be immediately treated

- 20 mls/kg over 5 minutes. Rapid infusion bolus administered either by push or pressure bag
- Use 0.9% Saline or Human Albumin Solution 4.5% (HAS).
- Correct hypoglycaemia, give 2 mls/kg of 10% Glucose

Reassess - What are the effects of every fluid bolus?

- Have the heart rate, quality of peripheral pulses, CRT, mental state, blood pressure responded? Multiple fluid boluses may be necessary.
- Large fluid deficits often exist & initial fluid volumes of 40-60 ml/kg are quite usual, volumes of 80-100mls/kg may be necessary.
Is there evidence of volume overload? (hepatomegaly, crackles, increased work of breathing or gallop rhythm), fluid is not recommended when rales or hepatomegaly are present – commence inotropic support

If after 15 minutes of optimal fluid resuscitation (40-60 mls/kg) and there is still evidence of end organ dysfunction start peripheral or IO Adrenaline at 0.1mcg/kg/min up to 0.5mcg/kg/min

Please REFER to CATS at this point if not already done so.

Inotrope choice:
- Use Adrenaline for COLD SHOCK
- Use Noradrenaline for WARM SHOCK

Hydrocortisone Therapy
- If a child is at risk of adrenal failure or has purpura fulminans and is in catecholamine resistant shock then intravenous hydrocortisone should be administered at 1mg/kg qds. for children (2.5mg/kg for neonates).

Obtain Central Access
Insert an Arterial line for haemodynamic monitoring.

Indications for Intubation
- Impending cardiovascular collapse
- Poor airway reflexes
- Depressed level of consciousness - Glasgow Coma Score (GCS) ≤ 8 or AVPU ≤ P Worsening tachypnoea or oxygen requirement
- Fluid refractory shock (≥ 40 mls/kg fluid resuscitation in the first 30 minutes without reversal of shock)

Cardiovascular instability around intubation can be minimised by
- Optimal volume replacement prior to intubation.
- Fluid bolus attached.
- Adrenaline or Dopamine infusion drawn up and attached if not running.
- Pre oxygenation with 100% O2.
- A “good fit” ETT. This is necessary to ventilate in the presence of pulmonary oedema.
- Use of a cuffed ETT is preferred.
- Ensuring the most experienced team members perform the intubation Anaesthetic / ICU Consultant with Paediatric Consultant support.
- Use of optimal drugs for induction:
  - Ketamine 0.5-2.0 mg/kg +/- Fentanyl 2-5mcg/kg
  - Suxamethonium 1-2 mg/kg (Unless contraindicated)
- Modified rapid sequence induction (Cricoid pressure).

Inhalational anaesthetics present a significant risk of cardiovascular depression. They should only be used if the risk of a difficult airway outweighs this.

Thiopentone, propofol & benzodiazepines all carry a similar risk of significant cardiovascular depression.
Once Intubated

- End tidal CO₂ monitoring is mandatory
- Secure ETT – do not cut the ETT
- Check appropriate position with CXR (Tip at T2-T3)
- Sedate & muscle relax as per CATS guidelines
- These children are at risk of acute respiratory distress syndrome (ARDS). A low tidal volume strategy of 4-7 ml/kg with an initial PEEP of 5 cm/H₂O should be used. PEEP can be titrated up depending on blood gases & evidence of pulmonary oedema.

ACTIONS: The First 6 hours: STABILISATION

Coagulopathy

- Consider treatment with 10-20 mls/kg of Fresh Frozen Plasma (FFP)
- Low platelet counts in the absence of active bleeding should not be supplemented unless < 20 x 10⁶/microlitre
- Low fibrinogen is suggestive of DIC give 5-10mls/kg of Cryoprecipitate.

Electrolytes

- Treat Hypocalcaemia (0.5 mls/kg 10% calcium gluconate).
- Treat Hypomagnesaemia 0.5 ml/kg 20% magnesium sulphate (or 1ml/kg 10% magnesium sulphate).

(This can cause hypotension, give slowly over 30 minutes with additional fluid bolus if necessary)

Ongoing Fluid Resuscitation

Fluid shift and hypotension secondary to capillary leak can continue for several days.

Continued fluid administration should be titrated against clinical end points such as, heart rate, perfusion pressure, cardiac output, urine output, serum lactate and ScvO₂ saturations.

If Hb >10g/dl use crystalloid.
Consider packed red cells if Hb <10g/dl
Consider Fresh Frozen Plasma for coagulopathy.

Indicators of disease severity regardless of “how good they look”

- Low neutrophils
- Low platelets
- Rapid onset (<6 hours)
- Rapidly spreading rash
- High volume requirement

References:

Children’s Acute Transport Service provides paediatric intensive care retrieval for Great Ormond Street, The Royal Brompton and St Mary’s NHS Trusts. Funded and accountable to the North Thames Paediatric Intensive Care Commissioning Group through Great Ormond Street Hospital.
1. Recognize decreased mental status and perfusion. Begin high flow O₂ and establish IO/IV access according to PALS.

If no hepatomegaly or rales / crackles then push 20 mL/kg isotonic saline boluses and reassess after each bolus up to 60 mL/kg until improved perfusion. Stop for rales, crackles or hepatomegaly. Correct hypoglycemia and hypocalcemia. Begin antibiotics.

### Fluid refractory shock?

Begin peripheral IV/IO inotrope infusion, preferably Epinephrine 0.05 – 0.3 µg/kg/min
Use Atropine / Ketamine IV/IO/IM if needed for Central Vein or Airway Access

Titrated Epinephrine 0.05 – 0.3 µg/kg/min for Cold Shock.
(Titrated central Dopamine 5 – 9 µg/kg/min if Epinephrine not available)
Rate central Norepinephrine from 0.05 µg/kg/min and upward to reverse Warm Shock.
(Titrated Central Dopamine ≥ 10 µg/kg/min if Norepinephrine not available)

### Catecholamine-resistant shock?

If at risk for Absolute Adrenal Insufficiency consider Hydrocortisone.
Doppler US, PICCO, FATD or PAC to Direct Fluid, Inotrope, Vasopressor, Vasodilators
Goal is normal MAP-CVP, ScvO₂ > 70%* and CI 3.3 – 6.0 L/min/m²

<table>
<thead>
<tr>
<th>Normal Blood Pressure</th>
<th>Low Blood Pressure</th>
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<tbody>
<tr>
<td>Cold Shock</td>
<td>Cold Shock</td>
<td>Warm Shock</td>
</tr>
<tr>
<td>ScvO₂ &lt; 70%* / Hgb &gt; 10g/dL on Epinephrine?</td>
<td>ScvO₂ &lt; 70%* / Hgb &gt; 10g/dL on Epinephrine?</td>
<td>ScvO₂ &gt; 70%* on Norepinephrine?</td>
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</tbody>
</table>

- **Begin Milrinone infusion.**
  - Add Nitroso-vasodilator if CI < 3.3 L/min/m² with High SVRI and/or poor skin perfusion.
  - Consider Levosimendan if unsuccessful.

- **Add Norepinephrine to Epinephrine to attain normal diastolic blood pressure.** If CI < 3.3 L/min/m² add Dobutamine, Enoximone, Levosimendan, or Milrinone.

If euvoletic, add Vasopressin, Terlipressin, or Angiotensin. But, if CI decreases below 3.3 L/min/m² add Epinephrine, Dobutamine, Enoximone, Levosimendan.

### Persistent Catecholamine-resistant shock? Refractory Shock?

Evaluate Pericardial Effusion or Pneumothorax, Maintain IAP < 12mmHg

**ECMO**