CATS Clinical guideline

Septic shock

The inflammatory triad of fever, tachycardia & abnormal perfusion is very common in children with benign infections. Septic shock should be considered in children who manifest this triad with additional features such as tachypnoea, reduced urine output, irritability & lethargy / drowsiness.

Recognition

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

<table>
<thead>
<tr>
<th>Cold Shock</th>
<th>Warm Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capillary Refill &gt;3s</td>
<td>Flash Capillary Refill</td>
</tr>
<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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</tbody>
</table>

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.

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>
</tr>
</thead>
<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>
</tr>
<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>
</tr>
</tbody>
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There is now a large body of evidence showing that aggressive optimisation of the haemodynamic status within the first fews hours of critical illness has a profound effect in reducing subsequent organ failure and improving over all survival.

Children in septic shock are consistently under-resuscitated in the first few hours.

For every hour that a child remains in Septic Shock the mortality risk doubles.
The First Hour of Resuscitation - GOALS

To restore

1. Normal perfusion
   a. No difference in quality between central & peripheral pulses
   b. Warm extremities
   c. Capillary refill time <3s
2. Normal range for age heart rate, blood pressure & respiratory rate (this may not be possible if the underlying cause is pneumonia)
3. Normal mental status
4. Urine output >1ml/kg/hr
5. Serum lactate < 2
6. ScvO₂ sats (where available) >70%

ACTIONS - 1st Hour
1. Maintain or restore a patent airway
2. High flow oxygen to achieve sats >95% - intubate if indicated.
3. Obtain secure intravenous access x2 quickly. Do not waste valuable time - if difficult site an intra osseous (IO) needle.
4. Signs of shock should be immediately treated with 20 mls/kg over 5 mins.
   - Human Albumin Solution 4.5%(HAS) is the fluid of choice. If sourcing this will delay fluid administration then use 0.9% Saline until HAS is available.
5. REASSESS
   - What are the effects on heart rate, quality of peripheral pulses, CRT, mental state
   - Is there evidence of volume overload? (hepatomegaly, crackles, increased work of breathing or gallop rhythm)
6. Multiple fluid boluses may be necessary.
   - Large fluid deficits often exist & initial fluid volumes of 40-60 ml/kg are quite usual, much larger volumes may be necessary.
7. Repeated assessment after each bolus is required
8. If volume overloaded do no give further fluids - commence inotropes
9. Give high dose broad spectrum antibiotics
   - Try to avoid Ceftriaxone (<1yr) due to risk of precipitation with calcium administration
10. Correct hypoglycaemia
    - 2 mls/kg 10% dextrose
11. If after 15 minutes of optimal fluid resuscitation (40-60 mls/kg) there is still evidence of end organ dysfunction start peripheral or IO dopamine
    - Up to 15 mcg/kg/min
    - Watch tissue integrity
12. Use ketamine, fentanyl + suxamethonium to intubate & gain central access.
13. The 1st choice for central access is FEMORAL.
15. Add Adrenaline for COLD SHOCK
16. Add Noradrenaline for WARM SHOCK
17. Transfer to PICU

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 (≥ 60 mls/kg fluid resuscitation in the first hour without reversal of shock)
Induction of anaesthesia presents a significant risk of hypoxia, myocardial depression & afterload reduction.

This can be minimised by
1. Optimal volume replacement prior to intubation.
2. Having volume running with a bolus attached.
3. Pre oxygenation with 100% O₂
4. A “good fit” ETT is necessary to ventilate in the face of pulmonary oedema.
   ▪ Use a cuffed ETT if available.
5. Get the most experienced person you can find. (eg. Local Anaesthetic / ICU Consultant)
6. Use of optimal drugs for induction.
   ▪ Ketamine 0.5-2.0 mg/kg
   ▪ Fentanyl 2-5 mcg/kg
   ▪ Suxamethonium 1-2 mg/kg (Unless contraindicated)
7. Rapid sequence induction should be used (NGT + Cricoid pressure).

Inhalational anaesthetics present a significant risk of cardiovascular depression.
They should only be used if the risk of a difficult airway out weighs this. Thiopentone, propofol & benzodiazepines all carry a similar risk.

ONCE INTUBATED
1. End tidal CO₂ monitoring is mandatory
2. Secure ETT – do not cut length down.
3. Check appropriate position with CXR (Tip at T2-T3)
4. Sedate & muscle relax as per CATS induction of anaesthesia guidelines
5. 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.

Ventilation provides cardiovascular support.
Up to 40% of CO may be required to support the work of breathing. This can be reduced by mechanical assistance allowing blood flow to be diverted to other vital organs. Increased intra thoracic pressure reduces Left ventricular afterload which is particularly helpful in patients with Low CI & high SVR. Mechanical support also aids patients with increased pulmonary vascular resistance (if ventilated at or around the functional residual capacity (FRC).

OTHER ISSUES
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 10⁹/microlitre
Low fibrinogen is suggestive of DIC give 5-10mls/kg of Cryoprecipitate.

Electrolytes
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 volume if necessary)
Treat Hypocalcaemia
• 0.5 mls/kg 10% calcium gluconate
Stabilisation: The First 6 hours

Keep reassessing the adequacy of resuscitation—many cases have persistent “cryptic shock”. Treating this reduces mortality rates dramatically.

Target ALL of the following
1. Normal perfusion
   - No difference in quality between central & peripheral pulses
   - Warm extremities
   - Capillary refill time <3s
2. Normal range for age heart rate, blood pressure & respiratory rate (this may not be possible if the underlying cause is pneumonia)
3. Normal mental status
4. Urine output >1ml/kg/hr
5. Serum lactate < 2
6. \( \text{ScvO}_2 \) sats (where available) >70%

ONGOING FLUID RESUSCITATION

Fluid shift & hypotension secondary to capillary leak can continue for several days. Continued fluid administration should be titrated against clinical end points such as \( \text{ScvO}_2 \) sats, serum lactate, urine output, heart rate, perfusion pressure & cardiac output.

If remains clinically unstable
- If Hb >10g/dl the fluid of choice (if readily available) is Human Albumin Solution 4.5%
- Consider packed red cells if Hb <10g/dl
- Consider Fresh Frozen Plasma for coagulopathy

Potential Pitfalls

Failure to rapidly establish vascular access in the severely shocked child
Do not persist in peripheral access if difficult - use an intraosseous needle

Inadequate fluid resuscitation
Give 20 mls/kg and reassess - these patients can require >100 mls/kg

Large volume requirements = severe disease

Failure to recognise volume overload
Increasing work of breathing with worsening oxygenation following fluid administration is suggestive of volume overload. Crackles on auscultation do not absolutely indicate pulmonary oedema as a pneumonic process may be the underlying source of sepsis. Hepatomegaly is highly suggestive of volume overload.

Delay in intubation
Children in comparison to adults delay a drop in blood pressure by vasoconstriction & elevation of heart rate. A “normal” blood pressure can be falsely reassuring. Once hypotension occurs there is usually a rapid progression to cardiovascular collapse.

False reassurance after initial response to resuscitation
Reassess, reassess, reassess

Indicators of disease severity regardless of “how good they look”
Low neutrophils
Low platelets
Rapid onset (<6 hours)
Rapidly spreading rash
High volume requirement
Recognise decreased mental status & perfusion.  
Begin high flow $O_2$.  
Establish IV/IO access.

**Initial Resuscitation**
Push boluses of 20 mls/kg HAS 4.5% (if not readily available use 0.9% saline) up to & over 60 ml/kg until perfusion improves OR hepatomegaly / crackles develop.  
Correct hypoglycaemia  
Start Antibiotics.

**Fluid Refractory Shock**
Start dopamine up to 15 mcg/kg/min IV/IO  
Intubate & gain central access.

For COLD SHOCK  
add in central adrenaline if dopamine resistant.  

For WARM SHOCK  
add in central noradrenaline.

Catecholamine resistant shock  
Begin hydrocortisone IF at risk for *absolute* adrenal insufficiency.

Monitor in PICU

**Cold Shock with normal blood pressure**
1. Titrate volume & adrenaline, $ScvO_2^*$>70%, Hb >10g/dl  
2. If $ScvO_2$ remains <70% add vasodilator with volume loading. (eg. milrinone)

**Cold Shock with low blood pressure**
1. Titrate volume & adrenaline, $ScvO_2^*$>70%, Hb >10g/dl  
2. If remains hypotensive consider noradrenaline.  
3. If $ScvO_2$ still <70% add milrinone

**Warm shock with low blood inotropes**
1. Titrate volume & noradrenaline, $ScvO_2^*$>70%  
2. If remains hypotensive consider vasopressin, terlipressin or methylene blue.  
3. If $ScvO_2$ remains <70% consider low dose adrenaline.

**Persistent catecholamine resistant shock**
Rule out & correct pericardial effusion, pneumothorax & intra abdominal pressure >12 mmHg  
Consider cardiac output monitoring to guide fluid, inotropes, vasopressor, vasodilator & hormonal therapies.  
**GOAL Cardiac Index >3.3 & <6.0 l/min/m^2**

**Refractory shock**  
ECMO