Paediatric Advanced Life Support

CET- BALLARAT HEALTH SERVICES

VALID FROM 31ST JULY 2016 TO 30TH JUNE 2020
CONTENT IS CURRENT AT THE TIME OF PRODUCTION OF THIS POWER POINT
Pathways leading to cardiac arrest in childhood

Figure 1.1: Pathways leading to cardiac arrest in childhood

**FLUID LOSS**
- Blood Loss
- Gastroenteritis
- Burns

**FLUID MALDISTRIBUTION**
- Septic Shock
- Cardiac Disease
- Anaphylaxis
- Congenital Heart Malformations

**RESPIRATORY DISTRESS**
- Foreign Body
- Croup
- Asthma
- Bronchiolitis

**RESPIRATORY DEPRESSION**
- Convulsions (and drugs used to treat)
- Raised ICP
- Drugs

Inadequate Oxygen Delivery

Inadequate Oxygenation

Circulatory Failure

Respiratory Failure

CARDIAC ARREST

Age Groups

- Neonate: Newborn - 28 days
- Infant: 29 days - 1 year
- Child: 1-8 years
- Older children: >9 yrs (over 12 can be treated as per adults)
Rapid Estimation of Body Weight in Paeds

- **NEWBORN**: 3.5 KG
- **6 MONTHS**: 7KG
- **1 YEAR**: 10KG
- **9 YEARS & LESS**: $2 \times \text{age in years} + 8$
- **10 YEARS & OVER**: $\text{Age} \times 3.3 = \text{KG}$
- **Weight (in kg) = 2 \times \text{age in years} + 8**
<table>
<thead>
<tr>
<th>Age</th>
<th>Body Weight Kg (27yrs = ageX2 + 9) or ≥16yrs = ageX3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term</td>
<td>3mth</td>
</tr>
<tr>
<td>3.5kg</td>
<td>6.0kg</td>
</tr>
<tr>
<td>50cm</td>
<td>56cm</td>
</tr>
</tbody>
</table>

**Adrenaline** 1:100,000 (10 µg/mL) (10 micrograms/kg) for asystole, severe bradyarrhythmia, VF or PEA

<table>
<thead>
<tr>
<th>Amiodarone</th>
<th>mg 5 mg/kg (for VT/VF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.5mg</td>
<td>25mg</td>
</tr>
</tbody>
</table>

**Atropine** 100 µg/mL (2 micrograms/kg) (IV only)

<table>
<thead>
<tr>
<th>Magnesium Sulphate 50% solution</th>
<th>(0.5:2 mg/mL) (≤2 kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.175mg</td>
<td>0.261mg</td>
</tr>
</tbody>
</table>

**Sodium Bicarbonate 8.4%, 1 mEq/kg (IV or IO) (for severe metabolic acidosis, pH≤7.1, or prolonged arrest)**

<table>
<thead>
<tr>
<th>Glucose</th>
<th>0.5g/kg (IV or IO) (for hypoglycaemia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.75g</td>
<td>3g</td>
</tr>
</tbody>
</table>

**Fluid Volume mL 20mL/kg**

<table>
<thead>
<tr>
<th>Endotracheal Tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncuffed size: Age&lt;4 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cuff Volume mL</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Laryngeal Mask Airway Size</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Defibrillation (episodic or monophasic)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Heart Rate (beats per minute)</th>
</tr>
</thead>
</table>

| Systolic Blood Pressure Minimum | 50 |

<table>
<thead>
<tr>
<th>Respiratory Rate (breaths per minute)</th>
</tr>
</thead>
</table>

Adapted from Australian Resuscitation Council: Section 12.4: Paediatric Advanced Life Support and Royal Children's Hospital Clinical Practice Guidelines. Colour coding: uses the Broader-Luten System. Updated Dec 2011. MRCOX/CMHE/SHS
Anatomical differences - Airway

- Large head, short neck, large tongue, soft palate
- < 6 months nasal breathers, narrow nasal passages
- 3-8 yrs adenotonsillar hypertrophy
- Young children epiglottis is horseshoe shaped & projects posteriorly (intubation difficult)
- Larynx high & anterior
- Trachea short and soft
- Cricoid ring is the narrowest point of the paed airway
Anatomical differences - Breathing

- Upper & lower airways are relatively small
- Infants rely on diaphragmatic breathing, supported by abdominal muscles
- Ribs are more horizontal in infants
- The chest wall is highly compliant
  - therefore rib #’s must be the result of great force
  - this will result in severe pulmonary injury
  - flail chest is more common and poorly tolerated in comparison to adults
Anatomical differences - Breathing

- Upper and lower airways are small & more easily obstructed. They have an increased work of breathing.
- Muscles are more likely to fatigue as they have fewer type I fibres.
- Horizontal ribs contribute less to chest expansion.
- Compliant chest wall can equal serious pulmonary injury without rib #’s.
Anatomical differences - Circulation

- Circulating blood volume per kg of body weight is 70-80ml/kg
- Even small amounts of blood loss are critical

- Body surface area (BSA)
  - Small children have a greater BSA in relation to their physical size
  - The child will lose heat more rapidly & consequently be more prone to hypothermia
Physiological differences - Respiratory

- The increased respiratory rate results in a higher metabolic rate and higher $O_2$ consumption
- With an increase in work of breathing the compliant chest wall allows sternal recession & rib space indrawing
  - resulting in less negative intrathoracic pressure

**Paediatric Normal Respiratory Values**

<table>
<thead>
<tr>
<th>Age</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1yrs</td>
<td>30-40 breaths/min</td>
</tr>
<tr>
<td>1-2</td>
<td>25-35</td>
</tr>
<tr>
<td>2-5</td>
<td>25-30</td>
</tr>
<tr>
<td>5-12</td>
<td>20-25</td>
</tr>
<tr>
<td>&gt;12</td>
<td>15-20</td>
</tr>
</tbody>
</table>
Physiological differences - Respiratory

- Harder to generate negative pressures & Less negative pressure results in decreased lung volumes and small airway closure

- Respiratory insufficiency will lead to hypoxia, acidosis and eventually resp arrest
Physiological differences - Cardiovascular

Infants have a small and relatively fixed stroke volume; cardiac output is directly related to heart rate

<table>
<thead>
<tr>
<th>Age</th>
<th>Heart rate</th>
<th>Systolic bp</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1yr</td>
<td>110-160bpm</td>
<td>70-90sys</td>
</tr>
<tr>
<td>1-2</td>
<td>100-150</td>
<td>80-95</td>
</tr>
<tr>
<td>2-5</td>
<td>95-140</td>
<td>80-100</td>
</tr>
<tr>
<td>5-12</td>
<td>80-120</td>
<td>90-110</td>
</tr>
<tr>
<td>&gt;12</td>
<td>60-100</td>
<td>100-120</td>
</tr>
</tbody>
</table>

BP ~ 80 + ( age in yrs x 2)
Physiological differences - Cardiovascular

- Infants respond to fluids in a blunted manner
- Because stroke volume cannot increase greatly to improve CO
- By age 2 myocardial response to fluid are similar to adults
Circulation- insufficiency

By the time a child has a cardiac arrest from circulatory insufficiency, they have had a substantial period of hypoxia & acidosis resulting in myocardial depression and finally causing cardiac arrest.

- Hypotension is a late & preterminal sign
Circulation - insufficiency

- **Compensated shock**
  - tachycardia
  - cool extremities
  - prolonged capillary refill >2-3 secs
  - weak peripheral pulses compared with central
  - normal BP

- **As compensation fails**
  - depressed mental status
  - urine output < 1ml/kg child & < 2ml/kg infants
  - metabolic acidosis
  - tachypnoea
  - weak central pulses

- **Decompensated**
  - the above plus hypotension
Psychological

- Fear, distress and anxiety in a child will result in an increase HR & respiratory rate
- Parents should be kept closely informed of events
- Parents should given the opportunity to be present during the resuscitation of their child in consultation with staff (ARC 2016)
Important Points

- Smaller functional respiratory reserve = hypoxia develops earlier than in adults
- Higher metabolic rate = higher $O_2$ demand
- Smaller airways = increased WOB
- Compliant thoracic cage = the generation of negative intrathoracic pressure is more difficult

- **Respiratory arrest is the most common cause of arrest in children**
Airway Assessment

- The aim is to establish a clear and open airway

CLEARING the airway
- Visualise the nose and mouth
- Clear oral and nasal secretions with suction
- No blind finger sweeps in infants <1yr
- Magill’s forceps may be used to extract foreign body

OPEN the airway
- Head tilt-chin lift (no pressure on soft tissue) or
- Jaw thrust

Position
- Infant: neutral position avoid hyperextension
- Children: head tilt increases with age
Airway Management - Infant

- Clear and open the airway
- If airway not open tilt head back very slightly – Sniffing position
Airway Position - Child

Unrestricted Airflow

Airway / C-Spine Alignment

Appropriate Padding

Compromised Airflow

No Spinal or Occipital Support

No Padding / No Collar
Airway adjuncts

Oropharyngeal:

May be necessary to maintain an open airway when using bag-valve-mask ventilation in the unconscious patient with no cough or gag.

- Avoid due to potential oropharyngeal trauma
- Only use if no cough or gag reflex is present
- Measure centre of the lips to the angle of mandible
- In infants insert using a laryngoscope or tongue depressor and with the guedels airway the “right side up”
Breathing Assessment

- Once the airway has been cleared and opened

- If NO or inadequate respiratory effort commence rescue breathing (BVM) 2 breaths

- Then commence CPR
Breathing - Ventilation

- Use bag with volume at least 500ml infant & small children
- Older children (9-14yrs) adult bag
- Attach oxygen flow at 15L
- Use only the force & tidal volume to make chest rise
- Observe bilateral rise and fall
- Minimise gastric inflation
  - Avoid high inspiratory pressures
  - Insert nasal/orogastric tube as soon as possible
Advanced Airway-ETT

- secures a patent airway
- reduces risk of aspiration
- facilitates adequate ventilation with 100% O₂
- facilitates tracheal suctioning
- more practicable in prolonged resuscitation
- provides an alternative route for selected drugs – de-emphasised by the ARC
- Do not delay CPR to put in an ETT
Advanced Airway-ETT

- If intubation cannot be accomplished easily continue to ventilate with 100% oxygen via bag-valve mask

- Endo tracheal intubation should not be attempted at the expense of prolonging hypoxaemia
ETT

- Uncuffed are preferred up until 8-10 years
- During resus cuffed may be used (short term)
- Allow for a small air leak with cuffed & uncuffed ETT

**Uncuffed**
- Internal diameter (mm) = \((\text{Age}/4) + 4\)

**Cuffed**
- Internal diameter (mm) = \((\text{Age}/4) + 3\)

- Length (cm) = \((\text{Age}/2) + 12\) for an oral tube
- Length (cm) = \((\text{Age}/2) + 15\) for nasal tube

*Formula is suitable for ages over 1 year*
ETT

- Larynx circular in cross section & narrowest part at cricoid ring rather than vocal cords
- ETT should give a relatively gas-tight fit in the larynx but should not be so tight in the larynx that no leak is audible or it may cause damage to the mucosa at the level of the cricoid ring and subsequent oedema on extubation
- Post resus allow a small leak
- Cuffed may be preferred with poor lung compliance
ETT

- Oral intubation during resuscitation is preferred
  - quicker
  - less likely to cause trauma, haemorrhage
  - easier to replace than nasal tube

- Laryngoscopes
  - straight blade is easier to use for intubation as it lifts the epiglottis
  - straight blade may cause vagal stimulation
  - curved blade moves the epiglottis forward - this is a more difficult technique
Advanced Airway Adjunct

Laryngeal Mask Airway (LMA):
- generally not used in paed resuscitation
- can be life saving in the setting of “can’t intubate and can’t ventilate”
- does not provide definitive airway protection
- easily dislodged
- **Can NOT** be used as a route of drug administration

<table>
<thead>
<tr>
<th>Weight Range</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>5kg</td>
<td>size 1</td>
</tr>
<tr>
<td>5-10kg</td>
<td>size 1.5</td>
</tr>
<tr>
<td>10-20kg</td>
<td>size 2</td>
</tr>
<tr>
<td>&gt; 20kg</td>
<td>size 2.5</td>
</tr>
</tbody>
</table>
Circulation - Assessment

- absent signs of life, pallor and or cyanosis are suggestive of inadequate circulation

- if a pulse is not palpable or cannot be identified within 10 secs or is
  - < 60 bpm in an infant
  - < 40 bpm in children

- Start immediate chest compressions at a minimal speed of 100 chest compressions per minute
Advanced Paediatric CPR ratio

- In the hospital setting – BHS Acute site
- Two Health Care Providers
- 100% Oxygen with a Bag-Valve-Mask

2:15 – 2 ventilations / 15 compressions

- Aiming for a minimum speed of 100 chest compressions per minute
- Compressions pause for 2 ventilations
Advanced Paed CPR

- When an advanced airway is insitu (ETT) CPR is no longer delivered in cycles
- Compressions are continuous at a minimal speed of 100 chest compressions per minute with no pauses for ventilation
- Deliver about 10 breaths per min
- Avoid hyperventilation

*Minimise interruptions to compressions*
Circulation - management

- Continue to assess circulation & attach cardiac monitor
- Gain IV/IO (intra-osseous) access, attempt to obtain 2 sites
  - If IV access is not obtained within 60 seconds an IO route should be used for drug administration

- collect blood while getting IV/IO access
Circulation - management

Fluid Management

- If hypovolaemia is suspected as the cause of the arrest; administer 20mls/kg bolus crystalloid
- Additional boluses should be titrated against response
- Fluid bolus-if more than 40mls/kg needed significant haemodilution may result equal to half the circulating volume
Advanced Life Support for Infants and Children

**Start CPR**
2 breaths :15 Compressions
Minimise Interruptions

**Attach**
Defibrillator / Monitor

**Assess Rhythm**

- **Shockable**
  - Shock (4 J/kg)
  - CPR for 2 minutes

- **Non Shockable**
  - Return of Spontaneous Circulation?
  - CPR for 2 minutes

**Post Resuscitation Care**

**During CPR**
- Airway adjuncts (LMA / ETT)
- Oxygen
- Waveform capnography
- IV / IO access
- Plan actions before interrupting compressions (e.g. charge manual defibrillator to 4 J/kg)

**Drugs**
- **Shockable**
  - * Adrenaline 10 mcg/kg after 2nd shock (then every 2nd loop)
  - * Amiodarone 5mg/kg after 3 shocks
- **Non Shockable**
  - * Adrenaline 10 mcg/kg immediately (then every 2nd loop)

**Consider and Correct**
- Hypoxia
- Hypovolaemia
- Hyper / hypokalaemia / metabolic disorders
- Hypothermia / hyperthermia
- Tension pneumothorax
- Tamponade
- Toxins
- Thrombosis (pulmonary / coronary)

**Post Resuscitation Care**
- Re-evaluate ABCDE
- 12 lead ECG
- Treat precipitating causes
- Re-evaluate oxygenation and ventilation
- Targeted Temperature Management

January 2016
Paediatric Cardiac Arrest Algorithm Management Non-Shockable
Asystole/Symptomatic Bradycardia

Heart rate <60 infant, <40 children
- If unresponsive to ventilation with O₂
- CPR up to 2 mins, **Adrenaline 10mcg/kg** IV / IO initial & repeat dose every 4 mins
- ETT adrenaline 100mcg/kg (as a last resort)
- IV Adrenaline infusion 0.1-0.2 mcg/kg/min or higher
- Seek causes & correct
Asystole / Symptomatic Bradycardia continued

- Continue with adrenaline every 4mins
- Minimal interruptions to chest compressions
- Maintain adequate oxygenation
- Consider external pacing
- Correct reversible causes (as per adult)
Pulseless Electrical Activity (PEA)

- CPR - uninterrupted
- Adrenaline every 4 mins
- seek causes consider all H’s & T’s
  - esp hypovolaemia, acidosis, dynamic hyperinflation & if trauma related:- tension pneumothorax & pericardial tamponade
  - IV or IO bolus of crystalloid or colloid solution
- Consider external pacing
Paediatric Cardiac Arrest Algorithm Management

Shockable
VF/Pulseless VT

- **Unwitnessed / non-monitored arrest** -
  - Single **shock 4j/kg**
  - Immediately followed by **2 mins** CPR
  - **shock 4j/kg**
  - **2mins** CPR & **adrenaline 10mcg/kg** every 4 mins
  - **shock 4j/kg** & all subsequent shocks after each sequence of 2 mins of CPR

- **Witnessed / monitored arrest**
  - No stacked shocks. All shocks 4 j/kg
  - all subsequent shocks 4j/kg after each sequence of 2 mins of CPR and adrenaline
VF/Pulseless VT continued

- Persistent or refractory VF
- Continue with uninterrupted CPR, with one DC shock every 2mins (if indicated by rhythm) and repeated adrenaline every 4mins

Consider

- Amiodarone - 5mg/kg IV/IO after 3rd shock
- MgSO₄ - 0.1 - 0.2mmol/kg IV/IO
- KCl - 0.05mmol/kg IV/IO
- Consider Reversible Causes
- Establish advanced airway management
SVT

- If severe hypotension immediate *synchronised DC shock* 0.5 - 1.0 J/kg
- If circulation adequate
  - vagal stimulation;
    - infant & young child: ice water in plastic bag to face or carotid sinus massage
    - older children perform valsala e.g. blowing through a narrow straw/ into a 10ml syringe or carotid sinus massage

- Adenosine 0.1mg/kg (max 6mg) + 0.2mg/kg (max 12mg) – IV/IO
- Amiodarone 5mg/kg over one hour followed by 5mcg/kg/min for the next 4 hours
SVT

- Most common non-arrest arrhythmia in children
- Typically occurs in infancy or in children with congenital heart disease
- Infant rate >= 220-300
- Children rate >= 180
- SVT may be undetected in infants for a long period of time until they develop a low cardiac output
- Procainamide 15mg/kg may cause hypotension by vasodilation
- Ca channel blockers should not be used to treat SVT in infants & avoid in children as it may induce hypotension & cardiac depression
Pulsatile Ventricular Tachycardia

- Haemodynamically stable VT
  - antiarrhythmic: amiodarone 5mg/kg IV over 20-60mins

- Pulse present, hypotensive & poor circulation
  - synchronised DC shock 0.5-1j/kg
  - sedate if conscious
ETT administration of Drugs

- Only if IV/IO not available
- Adrenaline / Atropine / Lignocaine only
  ALS drugs suitable for ETT administration

- Infant - make up to 1 - 2ml
- Child - make up to 2 - 5ml
- Large child - make up to 5 - 10ml

- Dilute with water for injection to increase the drug absorption
- Administration as per adult
Intraosseous injection of drugs and infusion of fluids

- Bone marrow has a rich blood supply & forms part of the peripheral circulation
- Drugs administered fast & at same concentrations as those administered IV
- IV fluids need to be administered under pressure (gravity sets are ineffective)
- Inject via a syringe
Intraosseous injection continued

- The antero-medial surface of the proximal or distal tibia are suitable puncture sites.
- Iliac crest is suitable in older children, but rarely used.
- Can be left insitu for up to 72 hours.
EZI-IO
ALS drug therapy - Summary

- **Adrenaline**
  - asystole, severe bradycardia, VF, pulseless VT & PEA
  - 10mcg/kg IV/IO intervals 4 mins
  - ETT 100mcg/kg
  - infusion 0.1-0.2mcg/kg/min or higher

- **Atropine**
  - Bradycardia
  - 20mcg/kg IV/IO or 30mcg/kg ETT
ALS drug therapy - Summary

- **Amiodarone**
  - shock resistant VF & pulseless VT
  - 5mg/kg IV which may be repeated

- Can be used in the management of atrial tachycardias, SVT, stable VT
ALS drug therapy - Summary

- **NaHCO$_3$**
  - limited and unproven
  - Some evidence that it causes intracellular acidosis – level of evidence for use in an arrest is very low
ALS drug therapy – Bolus Dosages

- Magnesium 0.1 - 0.2mmol/kg IV/IO
- 10% Calcium Gluconate 0.7 ml/kg IV/IO
- 10% Calcium Chloride 0.2ml/kg IV/IO
- Glucose 0.5 g/kg IV/IO (5ml/kg of 10% glucose)
- Potassium 0.05 mmols/kg slow injection IV /IO
- FLUIDS – crystalloid / colloid 20ml/kg IV/IO
Post Resuscitation

Aims

- Preserve brain function, avoid secondary injury, diagnose & treat cause of arrest
- Avoid hyperventilation (aim for normocarbia)
- Hypothermia (32-34°C) 12-24hrs within 6hrs in children after cardiac arrest
- Normoglycaemia
- Treat seizures
Advanced Life Support for Infants and Children

Start CPR
2 breaths : 15 Compressions
Minimise Interruptions

Attach
Defibrillator / Monitor

Assess Rhythm

Shockable

Shock (4 J/kg)

CPR for 2 minutes

Non Shockable

Return of Spontaneous Circulation?

CPR for 2 minutes

Post Resuscitation Care

During CPR
Airway adjuncts (LMA / ETT)
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Plan actions before interrupting compressions (e.g. charge manual defibrillator to 4 J/kg)

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Hypovolaemia
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