



# ANZCOR Guideline 12.6 – Introduction to Paediatric Advanced Life Support Techniques in Paediatric Advanced Life Support

## Summary

### Who does this guideline apply to?

This guideline applies to infants and children.

### Who is the audience for this guideline?

This guideline is for health professionals and those who provide healthcare in environments where equipment and drugs are available.

### Recommendations

1. This guideline provides detailed advice regarding the use of specific techniques during infant and child CPR and post ROSC care.

## Guideline

### 1 Airway and Oxygen Therapy

Hypoxaemia and hyperoxaemia are both deleterious. A high concentration of oxygen should be administered during resuscitation regardless of any preceding condition. There is insufficient evidence for choosing any concentration of oxygen during acute resuscitation<sup>1</sup>. It is reasonable to use 100% oxygen initially for resuscitation [Class A, Expert Consensus Opinion]. After ROSC, the concentration of inspired oxygen should be reduced to a level which yields a satisfactory level of oxygen in arterial blood measured by arterial blood gas analysis (PaO<sub>2</sub> 80-100 mmHg) or by percutaneous oximetry (SpO<sub>2</sub> 94-98%). (CoSTR 2015 weak recommendation, very low quality evidence). ,

With cyanotic heart disease, appropriate PaO<sub>2</sub> and SpO<sub>2</sub> are approximately 40-50 mmHg and 75-85% respectively.

Oxygen may be delivered by mechanical ventilation and as a supplement to the spontaneously breathing patient by nasal cannulae, nasal prongs or face masks. In apnoeic patients the priority is to establish ventilation.

Self-inflating resuscitation bags should not be used to deliver oxygen to the self-ventilating patient because minimal and unreliable amounts of oxygen are released passively from the patient exit valve despite introduction of high flow oxygen into the resuscitation bag<sup>2</sup>. If used to deliver oxygen to the spontaneously-breathing victim, an air-tight seal of the mask on the face is required, the one way delivery valve must be observed to open and ideally the reservoir bag observed to deflate periodically with self ventilation. An alternative method of oxygen delivery is desirable for the spontaneously breathing victim.

#### 1.1 Airway Maintenance

##### Airway Opening Manoeuvres

Any of the basic airway opening manoeuvres (backward head tilt, chin lift [jaw support] or jaw thrust may be used) except if a neck injury is suspected, when only jaw thrust should be used [Class A, Expert Consensus Opinion]. Hyperextension of the neck, which may cause airway obstruction in small infants, should be avoided.

##### Oropharyngeal and nasopharyngeal airways

Airway adjuncts may be used by persons trained in selection and insertion [Class A, Expert Consensus Opinion]. Either oropharyngeal (Guedel) airways or nasopharyngeal airways may be used. A guide to the correct size of an oropharyngeal airway is the distance from the centre of the mouth to the angle of the mandible. A guide to the correct length of a nasopharyngeal airway is the distance from the tip of the nose to the tragus of the ear.

The diameter of a nasopharyngeal airway should approximate that of an endotracheal tube suitable for the child's age.

##### Facemasks

To administer ventilation and oxygen, a range of mask sizes should be available.

The correct sized facemask extends from the bridge of the nose to the space between the lower lip and point of the chin. Masks with inflatable or cushioned rims are preferable because they facilitate achievement of an airtight seal of the mask upon the face.

### **Laryngeal mask airway**

The laryngeal mask airway (LMA) has not been formally evaluated in paediatric resuscitation. They may be used to establish an airway and give ventilation instead of using a bag-valve-mask by persons trained in their use<sup>1</sup> [Class B, Expert Consensus Opinion]. They should not be used in semi-conscious patients or when the gag reflex is present. They are subject to dislodgment during transport. Their use should not replace mastery of bag-valve-mask ventilation. The LMA is a suitable means of providing ventilation in situations where bag-valve-mask ventilation has failed or is inadequate and ET intubation is not possible.

Laryngeal mask airway sizes to suit body weight (kg) of newborns, infants and children are: size 1 <5kg; size 1½ 5-10kg; size 2 10-20kg; size 2½ 20-30kg; size 3 30-50kg; size 4 50-70kg; size 5 70-100kg; size 6 >100kg.

### **Endotracheal intubation**

This technique is preferred for maintenance of the airway and provision of mechanical ventilation after initial ventilation with bag-valve-mask ventilation or LMA ventilation and to limit aspiration [Class A, Expert Consensus Opinion].

Although uncuffed tubes are routinely used in paediatrics to avoid tracheal stenosis, cuffed tubes may also be used short term since there is no difference in airway irritation or need to change the tube during anaesthesia (LOE II)<sup>1</sup> and no difference in airway irritation between uncuffed tubes and cuffed tubes when the cuff of the latter is monitored to allow a small leak at peak inspiratory pressure in the intensive care unit [LOE III-2]<sup>1</sup>.

With uncuffed tubes, a size 3mm (internal diameter) tube is used for a term newborn of 2000-3000 g BW, a size 3.0 mm or 3.5 mm for a term newborn >3000g. A size 3.5mm or 4 mm is used for an infant up to the age of 6 months, and a size 4 mm from 7 months to 1 year. For children over 1 year, the size is approximately determined by the formula: size (mm) = age (years) / 4 + 4.

With cuffed tubes, a size 3 mm is used for newborns ≥3 kg and ≤ 1 year of age, a size 3.5 mm for children 1-2 years of age and for older children according to the formula age (years)/4 + 3.5 mm. If insertion of a cuffed tube meets tracheal resistance, a tube 0.5 mm smaller should be used. If there is no leak around a tube with its cuff deflated, a 0.5 mm smaller tube should be inserted when the patient's condition is stable<sup>1</sup>.

Irrespective of formulae, the correct size should enable adequate lung inflation with escape of a small volume of gas around the tube on application of moderate pressure. However, cuffed tubes or closer fitting uncuffed tubes may be preferable when lung compliance is poor. Initial insertion of a cuffed tube obviates the need to change a tube when oxygenation is compromised by a leak around a tube which is too small.

The tube should be inserted to a specified length to avoid accidental extubation or endobronchial intubation. The approximate depth of insertion measured from the centre of the lips for an *oral* tube in a newborn is 9.0 cm, 11.5 cm for a 6 months old infant and 12 cm for a 1 year old. Thereafter, the approximate depth of oral insertion is given by the formula: age (years) / 2 + 12 cm. For *nasal* tubes, appropriate depths of insertion are: newborn 11 cm; 6 months 13 cm; 1 year 14 cm; thereafter age (years)/2 + 15 cm.

Although a guide, assessment of depth of intubation is not reliable during laryngoscopy because this is performed with the neck extended whereas on removal of the laryngoscope, the head assumes a position of neutrality or flexion thereby increasing depth of insertion. Initial intubation by the nasal route should not be attempted unless the oral route is obstructed. Use of cricoid pressure during intubation to prevent regurgitation should be released if it hinders intubation <sup>1</sup> (Class B).

Intubation by the oral route is invariably quicker, less likely to cause trauma and haemorrhage and the tube is more readily exchanged if the first choice is inappropriate. However, orally placed tubes are more likely than nasally-placed tubes to dislodge or intubate a bronchus. The tube may be secured with cotton tape tied around the neck or affixed to the face with adhesive tape.

Confirmation of correct placement must be undertaken immediately after insertion and frequently or continuously thereafter. In emergency conditions, the oesophagus or a bronchus may be mistakenly intubated. Moreover, displacement during resuscitation or transport may occur.

The tip of the tube should be visualised passing through the vocal cords at intubation. Bilateral lung inflation should be confirmed immediately by auscultation of breath sounds in the axillae, by observation of intermittent rise and fall of the chest observed with ventilation and by return and maintenance of oxygenation. Capnography or CO<sub>2</sub> detection after initial intubation is recommended (*infra*) <sup>1</sup> (Class A) to confirm tracheal placement with the realisation that CO<sub>2</sub> excretion cannot occur without pulmonary blood flow. Lack of CO<sub>2</sub> detection implies non-tracheal intubation or lack of pulmonary blood flow possibly due to excessive ventilation or inadequate chest compression or combinations. The position of the tube in the trachea should be checked immediately.

## 1.2 Delivery of Positive Pressure Ventilation

Mechanical ventilation during cardiorespiratory arrest may be given by either bag-valve-mask ventilation (BVM), laryngeal mask or by endotracheal tube depending on the training and expertise of the rescuers [Class A]. Studies of resuscitation at out-of-hospital paediatric arrest either favour BVM or show no advantage of endotracheal intubation when considering outcomes and complications <sup>1</sup>.

If endotracheal intubation for mechanical ventilation can be performed expediently and expertly it confers advantages over use of a bag-valve-mask system. The tube allows administration of 100% oxygen, better control of the airway, prevention of aspiration, ability for tracheal toilet and the route may be used to administer endotracheal drugs. BVM may be given by either self-inflating resuscitation bags or oxygen flow inflating (exemplified by Jackson-Rees modified Ayre's T-piece) bags. Self-inflating resuscitation bags are recommended for the occasional resuscitator because of ease of operation. High flow oxygen should be added.

Expired air resuscitation, bag-valve-mask ventilation or ventilation by laryngeal mask airway may allow gas to enter the stomach – which may compromise effective ventilation. The stomach should be deflated with passage of nasogastric tube after endotracheal intubation [Class A, Expert Consensus Opinion].

## 2 Vascular Access

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Any pre-existing functioning venous line can be used provided it does not contain any drug or electrolyte which caused the cardiopulmonary arrest.

### 2.1 Peripheral venous access

Peripheral veins are to be found on the dorsum of the hand, wrist, forearm, cubital fossa, foot and ankle (long saphenous). The external jugular is often distended during cardiopulmonary resuscitation but cannulation is impeded by performance of endotracheal intubation. Cannulation of the external jugular is facilitated when the patient is intubated and the head is turned to the opposite side. Cannulation of the femoral vein is an option facilitated by use of ultrasound. Surgical cut-down onto the long saphenous, saphenofemoral junction or basilic vein is a valuable skill sometimes required in traumatic exsanguination.

### 2.2 Intraosseous injection and infusion

The bone marrow has a rich blood supply and forms part of the peripheral circulation. The intraosseous route is an acceptable alternative to intravenous injection <sup>1</sup> (Class A). Injected drugs are distributed as fast and attain the same plasma concentrations as those injected intravenously. Although most commonly used for young children, it can be used for patients of any age including premature newborns and adults. Establishment of the intraosseous route is quicker to achieve than the intravenous route in severely dehydrated children and fluids administered by this route stabilize vital signs as quickly as fluids given intravenously. Any intravenous fluid or drug may be administered with the aid of gravity, infused under pressure or injected from a syringe. Although many sites may be used, the antero-medial surface of the proximal or distal tibia are the most suitable puncture sites during resuscitation of infants and children.

Intraosseous needles, bone marrow injection guns and drills are manufactured for this purpose. The needle is inserted perpendicularly to the bone surface. If a hand-held needle is used, a rotary action is used to traverse the cortex. A loss of resistance signals entry to marrow.

Correct positioning of the needle, confirmed by aspiration of bone marrow or injection of 0.9% sodium chloride without extravasation, is necessary to avoid compartment syndrome. Bone marrow may be used reliably for venous biochemical and haematological analysis but not for venous blood gas tensions. Contra-indications include local trauma, infection and bone disorders.

### 2.3 Central venous cannulation

Cannulation of subclavian, internal or external jugular veins are options. However, central cannulation is difficult in the setting of cardiorespiratory arrest and fraught with potential serious complications such as pneumothorax unless the operator is well practised. This technique is not routinely recommended at cardiac arrest.

### 2.4 Endotracheal administration of drugs

The endotracheal route is an alternative if intravenous and intraosseous access are not available.

It may be the first route to become available for drug administration at the commencement of resuscitation, in which case it can be used, particularly if adrenaline is indicated.

Although adrenaline, atropine and lignocaine are all absorbed from the respiratory tree into the circulation, their absorption is variable and optimal doses are unknown. The recommended doses are adrenaline 100 mcg/kg (no human studies), lignocaine 2-3 mg/kg [LOE III-3] and atropine 30 mcg/kg [LOE II] <sup>1,3</sup>.

Volumes of drug preparations, using water rather than saline as diluent [LOE III-3] if necessary, should be approximately 0.7mL for a newborn, 1 - 2mL for an infant, 2 - 5mL for a small child and 5 - 10mL for a large child [LOE III-2] <sup>3</sup>.

The preparation should be injected directly into the endotracheal tube and dispersed throughout the respiratory tree with vigorous bagging. Drug administration by intrabronchial instillation achieves less plasma concentration than by simple injection into the endotracheal tube.

## 2.5 Other techniques

Surgical cut-down onto a long saphenous, sapheno-femoral junction or basilic vein is a valuable skill sometimes required in traumatic exsanguination.

## 3 Defibrillation

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Defibrillators are manual or automated (AED's), and capable of delivering either biphasic or monophasic shocks and need to be able to deliver shocks in the range of 0.5-4 J / Kg. Shocks are delivered through either pads (preferred) or paddles, the ideal size is not known, but the largest size available that still enables good separation between the pads/ paddles should be chosen to enable good contact with the chest wall.

Since defibrillators have stepped energy levels, the exact energy may not be available to conform to the dosage recommendations. In this case, the closest level to the dose should be selected. To deliver a shock, one electrode (paddle or self-adhesive pad) is placed over the cardiac apex or in the left mid-axilla opposite the xiphoid, the other to the right of the upper sternum (antero-lateral positions). Alternatively, pads/paddles may be placed in antero-posterior positions (one over the left of the lower sternum and the other below the left scapula). Self-adhesive pads, or adequate conductive gel with firm pressure on the paddles are required to deliver optimum energy through the heart and to avoid skin burns. Conductive gel should be confined to the area beneath the paddles and gel pads not permitted to touch in order to avoid bridging and ineffective delivery.

Single shocks should be delivered followed by immediate chest compressions and ventilation for 2 minutes <sup>1</sup> [Class A, Expert Consensus Opinion]. Three stacked shocks may be given when the onset of a shockable rhythm is witnessed with monitoring in special circumstances such as:

- 1) In the cardiac catheter laboratory
- 2) In the intensive care unit or cardiac ward post cardiac surgery
- 3) In other circumstances when a defibrillator is already attached.

Every effort should be made to ensure that interruption to CPR is minimal. If an AED is used, single shocks only should be used followed immediately by resumption of CPR if a pulsatile rhythm is not restored.

Rescuers must be constantly alert to the possibility of accidental electrocution of themselves or fellow-rescuers. The defibrillator should be charged only when the paddles are in position on the patient's chest. When pads are being used the defibrillator can and should be charged while chest compressions are being carried out in order to minimise interruptions to CPR.

Two charged paddles should not be carried together in one hand. Precautions should be taken to ensure that no person is touching the patient or bed or trolley on which the patient is lying at the time of discharge. If after charging, the need for defibrillation dissipates, the charged paddles should be replaced in their holders and then discharged. Discharge should never be done in the air and never in the presence of air enriched with oxygen as there is a risk of fire.

The ideal energy dose for safe and effective paediatric defibrillation is unknown but present evidence supports a dose of 2-4 J/kg<sup>5</sup> For the sake of simplicity we continue to recommend 4 J/kg for the initial dose using a biphasic (preferable) or monophasic unsynchronised shock for VF and pulseless VT-followed immediately by 2 minutes of CPR without waiting to analyse the rhythm (CoSTR 2015, weak recommendation, very-low-quality evidence).

There is insufficient evidence from which to determine a dose for second and subsequent defibrillation energy doses<sup>5</sup>. We recommend a dose of 4J/kg for second and subsequent shocks.

The external energy dose for supraventricular tachycardia (SVT) is 0.5-1J/kg, but up to 2J/kg can be used using monophasic shock or biphasic shock<sup>7</sup> (LOE IV). Synchronised shocks are used. The internal energy dose is 0.5J/kg using biphasic shock<sup>6</sup> [Class A, LOE IV]. The energy dose for pulsatile VT is synchronised 0.5-2J/kg [Class A, Expert Consensus Opinion].

Either pads or paddles may be used<sup>1</sup> (Class A), however pads allow chest compression to continue while charging, probably permit faster resumption of chest compression after delivery of a shock, may be safer and may allow easier use of an antero-posterior position which may be more efficacious than the standard antero-lateral positions of paddles or pads. Dextrocardia may be present with congenital heart disease and the position of the paddles should be altered accordingly.

### **3.1 Automatic external defibrillation**

Although a variable dose manual defibrillator is preferred, a semi-automated external defibrillator (AED) may be used for infants and children (Class A)<sup>1</sup> provided it is able to differentiate shockable from non-shockable rapid paediatric rhythms. Institutions which manage infants or children should have a variable dose manual defibrillator (Class A; Expert Consensus Opinion).

If a manual defibrillator is not available for infants and small children (<8 years), use of an adult AED with dose attenuation (e.g., delivering 50J) is acceptable<sup>1</sup>. If that is not available, an adult AED machine and dose should be used<sup>1</sup>. For children older than 8 years, a standard AED machine (for adults) and dose may be used.

## 4 Monitoring

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### 4.1 Vital signs

Routine monitoring of heart rate, respiratory rate and blood pressure are essential for infants and children with critical illness. It is prudent to have ready access to or have displayed the normal age related values for rapid reference.

### 4.2 Oximetry

Transcutaneous oximetry (SpO<sub>2</sub>) is essential monitoring in all critically-ill patients. It equates well to arterial haemoglobin-oxygen saturation (SaO<sub>2</sub>) but not when the SaO<sub>2</sub> is below 70%. The relationship between haemoglobin-oxygen saturation and partial pressure of oxygen in arterial blood (PaO<sub>2</sub>) is not linear. It should be noted that a SpO<sub>2</sub> of 90%, although only 10% below normal haemoglobin-oxygen saturation, represents a partial pressure of oxygen in arterial blood (PaO<sub>2</sub>) of 60 mmHg which is 40 mmHg below normal.

### 4.3 End-tidal CO<sub>2</sub>

Studies of CO<sub>2</sub> detection during a perfusing cardiac rhythm and during resuscitation at cardiac arrest have a high level of sensitivity and specificity for tube position <sup>1</sup> (Class A).

End-tidal CO<sub>2</sub> (P<sub>et</sub>CO<sub>2</sub>, capnography) or colorimetric detection of CO<sub>2</sub> detection are recommended <sup>1</sup> (Class A) to confirm tube position at every tracheal intubation. Since no CO<sub>2</sub> is excreted unless there is pulmonary blood flow, undetectable CO<sub>2</sub> after intubation basically represents non-tracheal intubation or absence of circulation, or both. In this circumstance, tube position should be checked immediately by direct laryngoscopy. Low levels of end-tidal CO<sub>2</sub> during CPR may represent excessive positive pressure ventilation or inadequate chest compressions or both. In addition CO<sub>2</sub> detection during positive pressure ventilation may guard against inadvertent extubation, particularly when the intubated patient undergoes transport to, within or between hospitals. Small movements of the head and neck, as may occur for example on transfer from one trolley to another or to a bed, may easily dislodge an endotracheal tube.

### 4.4 Electrocardiograph (ECG)

The ECG should be displayed with either leads or paddles. Drug therapy or immediate direct current shock is administered according to the existing rhythm. Electrolyte status, especially that of potassium and calcium should be checked and may be indicated by ECG patterns.

## 5 Extracorporeal Life-Support (ECLS)

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Institution of extracorporeal circulatory support, that is extracorporeal membrane oxygenation (ECMO) during cardiopulmonary resuscitation may be considered for infants and children in cardiac arrest from cardiac diagnoses in hospitals that have expertise, resources and systems to optimise the use of ECMO during and after resuscitation<sup>5</sup>. The upper duration of cardiac arrest which precludes ECLS is unknown. (CoSTR 2015, weak recommendation, very-low-quality evidence).

ECLS may be considered in special circumstances for out-of-hospital arrest such as in severe hypothermic environments but institutions providing an ECLS service should specify qualifying conditions and the status of the victim. The latter might include such factors as witnessed arrest, high quality CPR, duration of CPR and clinical and satisfactory acid-base condition of the victim on arrival. (Expert Consensus Opinion)

## 6 Special Circumstances

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Infants and children with repaired or unrepaired congenital heart disease with single ventricle physiology (e.g., hypoplastic left heart syndrome), cavo-pulmonary shunts or pulmonary hypertension may require special considerations during resuscitation. However, standard CPR techniques should be used initially (Class A, Expert Consensus Opinion) pending advice from a specialist centre.

## 7 Chest Compression

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Refer to Guidelines 6 and 12.2.

## References

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