The seriously ill child presents a complex and challenging medical scenario. It is essential that the symptoms and signs of the illness are recognised and the basic manoeuvres of treatment carried out quickly and effectively if the child is to be prevented from progressing to a more serious state and even to cardio-respiratory arrest. Therefore in paediatric emergency medicine, recognition and prevention of continued deterioration are the key features of medical management.

The most common cause of death in children less than one year of age is due to congenital abnormalities. However this is followed by preventable causes such as cardiovascular and respiratory illnesses, infectious disease and trauma. In pre-school and school aged children, trauma is the most common cause of death and this trend is continued into teenage years. Trauma is avoidable and prevention schemes should be focussed on education, alteration of environmental hazards and the enforcement of safety legislation. Serious infectious diseases and the early stages of respiratory and cardiovascular illnesses can, if recognised by their early symptoms, also be prevented from progressing to a paediatric medical emergency.

The seriously ill child must be recognised early to prevent progression to cardio-respiratory arrest. Cardio-respiratory arrest has a poor outcome in children with survival rates quoted as below 7%. It is essential to recognise:

1. Respiratory Failure
2. Cardiovascular Failure
3. Shock

Respiratory failure is usually defined as the inability to maintain a PaO₂ >9kPa in 60% inspired oxygen or a PaCO₂ <9kPa. However blood gas analysis is not always available and may be difficult to obtain in a child. Therefore clinical evaluation in infants and children may be more effective. The initial signs of respiratory distress are:

- Use of accessory muscles
- Increased respiratory rate
- Increased heart rate

However if the situation continues to deteriorate then the signs will change to:

- Decreased level of consciousness
- Hypotonia
- Decreased respiratory effort
- Cyanosis or extreme pallor (despite oxygen therapy)
- Sweating
- Bradycardia

These are all warning signs of decompensation of the respiratory system and imminent respiratory failure. They must be acted on immediately to prevent cardio-respiratory arrest.
Cardiovascular failure and shock are closely associated. Shock, in infants and children can be difficult to recognise in its early stages. The blood pressure may well appear normal but there will be signs of poor skin perfusion, tachycardia, tachypnoea and oliguria (compensated shock). Children maintain their blood pressure well into the late stages of circulatory failure and therefore the occurrence of hypotension is a sign of physiological decompensation of the cardiovascular system and requires rapid and effective therapy as cardiac arrest is imminent.

The following are signs of imminent cardio-respiratory failure:

- Unusual behaviour
- Coma or altered conscious level
- Exhaustion from respiratory distress
- Cyanosis
- Tachypnoea
- Heart rate
  -  < 1 year  - >180 beats/min or <80 beats/min
  -  > 1 year  - > 160 beats/min or <60 beats/min
- Fever with petechiae
- Severe trauma or burns > 15% body surface area
- Seizure

and all require immediate intervention.

Immediate management follows the ABC protocol:

A - approach the child in a calm and gentle manner.
  - establish control of the airway if necessary.
B - administer high concentrations of inspired oxygen
  - establish controlled ventilation if necessary
C - establish vascular access
  - administer fluids in a controlled manner.
D - observe for changes in neurological function.

It is essential that the child is regularly reassessed during treatment and the management altered if there is continued deterioration of the child’s condition.

**CARDIO-RESPIRATORY ARREST**

Despite active, and often timely, intervention some infants and children progress to cardio-respiratory arrest. The management of paediatric cardio-respiratory arrest are described in detail in the European Resuscitation Council (ERC) Guidelines [1,2]. These were revised in 2005 following an international consensus on science on cardiopulmonary resuscitation and cardiovascular care (CoSTR) [3,4].

Resuscitation of infants and children is often not initiated for fear of doing harm as rescuers had not been taught or had forgotten the specific paediatric recommendations. The differences between adult and paediatric resuscitation were hindering resuscitation attempts and that bystanders and healthcare professionals were not performing ventilations or chest compressions. The new guidelines have, wherever possible recommended a simpler uniform approach and now recommends a virtually similar approach to paediatric or adult resuscitation. Furthermore there is good evidence that performing either chest compressions or expired air ventilation alone may result in a better outcome than doing nothing [5].
The following describes the major changes in the new guidelines.

**Figure 1. Paediatric Basic Life Support (BLS) Algorithm**

The initial assessment, airway manoeuvres and 5 expired air ventilations remain unchanged.

**COMPRESSION:VENTILATION RATIO**

The Consensus document recognised the importance of decreasing the number of interruptions to chest compressions during resuscitation. It was therefore recommended that lay rescuers (or single rescuers) should perform paediatric resuscitation using a ratio of 30 compressions to 2 ventilations (as per adult resuscitation). However if there are two or more rescuers with a duty to respond then they should perform resuscitation using a ratio of 15 compressions to 2 ventilations. Although there is no evidence to support any particular ratio in children, the previous ratio of 5:1 is no longer recommended as it delivers an inadequate number of compressions [6,7,8].

**AGE DEFINITIONS**

With the disappearance of the different compression:ventilation ratios that were based on age, it is no longer necessary to define the ages of children. In effect resuscitation of the child merges with adult resuscitation, the only difference being in terms of aetiology of the event. If the differentiation of child from adult is deemed necessary then it should be made in terms of the onset of puberty. However a detailed examination to formally determine the signs of the onset of puberty is considered inappropriate and unnecessary and if the rescuers believe the victim to be a child then paediatric resuscitation should be commenced. Any misjudgement is inconsequential, as studies have shown that the paediatric pattern of arrest continues into early adulthood [9].

**CHEST COMPRESSION TECHNIQUE**

The landmark for chest compressions is found from the xiphisternum (as in adults) and not from the internipple line. In older children the compression point is simply over the middle of the chest (as in adult resuscitation), thereby removing the complexity previously encountered of finding the correct chest compression position.

The technique of compression has also been simplified. It is recommended that the child’s chest be compressed between one-third and one-half of the resting diameter. The rescuer can use a two-finger, one-hand or two-hand technique, as appropriate in order to attain the necessary depth of compression. In small infants it is more efficacious to use the two-thumb encircling technique for two-rescuer resuscitation [10].

**AUTOMATED EXTERNAL DEFIBRILLATION (AED)**

AEDs are widely used in the management of ventricular fibrillation (VF) in adult cardiac arrest. However, in children VF is relatively uncommon. AEDs have been shown to be capable of identifying arrhythmias in children accurately and are unlikely to advise a shock inappropriately [11,12]. The new guidelines now recommend the use of AEDs for children aged greater than 1 year. There is currently insufficient evidence to support a recommendation for or against the use of AEDs in children below 1 year.
Some manufacturers supply paediatric attenuated pads that deliver between 50 – 75J. These devices are recommended; however if they are not available then an unmodified adult AED may be used in children.

**Figure 2. Paediatric Advanced Life Support (ALS) Algorithm**

**AIRWAY DEVICES**

Cuffed tracheal tubes are recommended for in-hospital intubation of the paediatric airway, especially where there is increased airway resistance, decreased lung compliance or an excessive glottic air leak [13]. The correct size of tube must be used, the cuff inflation pressure carefully monitored (< 20cmH₂O) and the tube position verified. End-tidal carbon dioxide monitoring should be used to verify the initial insertion and maintained position of the tracheal tube in the trachea. However, it should be remembered that during cardiac arrest there may be little or no carbon dioxide in the expired air, depending on pulmonary blood flow.

**DRUG ADMINISTRATION**

The preferred route for drug administration is by direct venous access. However venous access is often difficult to achieve in small very ill infants and children. Therefore, when there is failure to achieve direct venous access the intraosseous route should be used. It is only with the failure of both these routes that certain drugs (adrenaline, lidocaine, atropine and naloxone) can be given via the tracheal route [14]. The tracheal route results in low drug concentrations and in the case of adrenaline this could produce transient beta-adrenergic effects (hypotension and lower coronary artery perfusion pressure) that are detrimental.
DEFIBRILLATION

The effectiveness of AEDs and of Biphasic waveform defibrillation has led to the new recommendation of performing a single shock sequence immediately followed by two minutes of chest compressions and ventilations before the cardiac rhythm is re-assessed and a further shock given, if required.

The energy level for defibrillation has also been revised. A few studies have shown that an initial monophasic or biphasic shock of 2J/kg generally terminated VF. However there have been paediatric case series that have shown that higher energy levels (>4J/kg) have also terminated VF with negligible adverse effects [15,16]. In an effort to improve first shock defibrillation efficacy, paediatric defibrillation is now recommended at 4J/kg for variable-dose manual defibrillation.

ADRENALINE

Adrenaline has retained its place as the mainstay drug in resuscitation. Studies where Adrenaline was compared to Vasopressin showed no statistically significant difference between the two drugs for ROSC, death at 24 hours or death before hospital discharge. [17,18,19]

The dose of adrenaline should be 10mcg/kg for the first and all subsequent doses (every 3 to 5 minutes). High-dose intravenous adrenaline (100mcg/kg) may be considered harmful and is no longer recommended except in exceptional circumstances (beta-blocker overdose).

SODIUM BICARBONATE

The routine use of sodium bicarbonate during resuscitation is not recommended. Sodium bicarbonate exacerbates intracellular acidosis, produces a negative inotropic effect on the myocardium, presents a large osmotic sodium load and produces a left shift to the oxygen dissociation curve (decreasing oxygen release to the tissues).

HYPOVOLAEMIA

Hypovolaemia is a reversible cause of cardiac arrest that if recognised in time is preventable. In the initial stages of fluid resuscitation there are no advantages to using colloid solutions and isotonic saline solutions are recommended. Dextrose solutions should be avoided as these may cause hyponatraemia and hyperglycaemia, worsening the neurological outcome after cardiac arrest.

THERAPEUTIC HYPOTHERMIA

A child who regains a spontaneous circulation but remains comatose following cardiac arrest may benefit from being cooled to a core temperature of 32-34°C for 12-24 hours. After this period of mild hypothermia, the child should be rewarmed slowly at 0.25-0.5 °C/hr.

PARENTAL PRESENCE

Reports have shown that it is comforting for families to be at the side of the arrested child as it helps them gain a realistic view of the attempted resuscitation and death. These families show less anxiety and depression in the several months after death. A dedicated experienced member of staff should accompany the parents during the resuscitation event to explain the actions of the team and to answer questions. The parents should not interfere with the procedure or distract members of the resuscitation team. The team leader of the resuscitation event, not the parents, will, together with the rest of the team, decide when to terminate the resuscitation procedure.

SUMMARY

- The management of the seriously ill child is a difficult process that needs skill, experience and practice.
- All efforts must be made to prevent progression of the illness by the recognition and treatment of respiratory and circulatory failure and shock.
- Paediatric resuscitation procedures have been revised and now emphasise:
  - good effective chest compressions with minimal interruption.
  - the compression: ventilation ratio is 30:2, except for healthcare professionals where it is 15:2.
  - for VF attempt early defibrillation using either a biphasic AED or 4J/kg.
  - adrenaline is given at 10mcg/kg, preferably via the intravenous or intraosseous routes.
  - therapeutic hypothermia may be of benefit in the post resuscitation phase.
REFERENCES

BIBLIOGRAPHY