CASE ONE

SHORT CASE NUMBER: 3_9_1
CATEGORY: CHILDREN & YOUNG PEOPLE
DISCIPLINE: PAEDIATRICS_MEDICINE
SETTING: EMERGENCY DEPARTMENT
TOPIC: PAEDIATRIC EMERGENCIES

Case

Michael Wang, aged 5 years, presents with his anxious mother. Michael has a known history of asthma and has previously required hospitalisation. Tonight Michael is severely short of breath and has deteriorated despite 30mg of prednisolone given 5 hours earlier and Ventolin nebulisers. On arrival at the emergency centre, Michael becomes unconscious and apparently stops breathing.

Questions

1. Describe your management of Michael in terms of the primary assessment.
2. In a table, outline the 5 main categories of causation in relation to paediatric emergencies and provide 3 examples of an illness in each category.
3. In a table, summarise the changes in vital signs (respiratory rate, heart rate, systolic blood pressure) in the following age ranges: < 1yr, 1-2 yrs, 2-5 yrs, 5-12 yrs and > 12 yrs.
4. In a table, list the 3 main categories of causation of collapse in children and provide 3 examples in each category.
5. Outline the principles of resuscitation in children.
6. Using a flowchart, summarise the steps involved in treating an ECG rhythm of VF, VT, non VT and non VF rhythms.
7. Summarise paediatric arrest management in point form or a flow chart.

Suggested reading:

Raftos J. (2012). Emergencies: causes and assessment. In: M. South., & D. Isaacs (Eds). *Practical Paediatrics (*7th Ed) (pp 194-207). Edinburgh: Churchill Livingston/Elsevier.

ANSWERS

1. Describe your management of Michael in terms of the primary assessment.

In approaching the critically ill child, the diagnosis is of secondary importance to:

- *primary assessment*, which is a structured activity, and
- *timely resuscitation procedures*.

The *primary assessment*, sometimes also known as the primary survey, follows progression through the following A, B, C, D, E steps:

- **A**irway
- **B**reathing
- **C**irculation
- **D**isability (deficiency of cerebral function), with attention to
- **E**xposure.

This structured approach is based on the knowledge that the brain requires a continual supply of its two main metabolites: oxygen and glucose. An airway problem, by depriving the brain of its oxygen supply, will rapidly lead to death and therefore must be corrected first. A breathing problem preventing oxygen moving into the lung and carbon dioxide out of the lung is the next priority. A circulatory problem preventing the oxygen being carried to the brain is next, and so on.

The primary assessment

Airway

The child and infant airways, compared with those of the adult, present particular anatomical and physiological differences that increase their susceptibility to compromise. Infants are obligate nose-breathers. Infants and small children have smaller airways and a smaller mandible, a proportionately larger tongue and more floppy epiglottis and soft palate. The narrowest portion of their airway is below the cords at the level of the cricoid ring, in contrast to adults, where the narrowest portion is at the level of the vocal cords. The trachea is short and soft and hyperextension or flexion of the neck may cause obstruction.

Ensuring that the patient has a patent airway is of the highest priority. In evaluating the airway a look, listen and feel approach is used.

Movement of the chest wall and the abdomen should be carefully looked for. The degree to which intercostal and other accessory muscles are being used to overcome obstruction should be noted. Paradoxical movement of the abdomen may be noted if there is upper airway obstruction.

Listening over the mouth and nose for air movement should follow. Particular note should be made of inspiratory stridor, which is a sign of tracheal, laryngeal or other upper airway obstruction. In severe obstruction, expiratory sounds may also be heard but inspiratory noises will still predominate. A stethoscope should be used to listen over the trachea and in the axillae for air movement.

Finally the examiner, by placing his or her face close to the child's mouth, may feel evidence of air movement.

Breathing

In childhood, conditions that result in respiratory compromise are the most common reason for emergency intervention and are the major cause of a poor outcome.

As with the airway, there are important differences between the child and the adult. Children have a higher metabolic requirement. They have more immature musculature, with easy fatigability of the diaphragm, which is the major muscle of respiration. The chest wall is more compliant and the ribs are more horizontal, decreasing the efficiency of the bellows effect.

The airways in the child are proportionately smaller and therefore produce an increased resistance to air flow, especially when traumatized or inflamed. Resistance across an airway is inversely proportional to the fourth power of the radius. Thus, halving the radius increases the resistance very significantly.

Having established patency of the airway, evaluation for the presence and adequacy of breathing should follow. It is helpful to divide this into three aspects:

- effort of breathing
- efficacy of breathing
- effects of respiratory inadequacy on other organs.

Effort of breathing
Respiratory rate is age-dependent. Tachypnoea is an early response to respiratory failure. Increased depth of respiration may occur later as respiratory failure progresses. However, it should be noted that tachypnoea does not always have a respiratory cause and may occur in response, for example, to metabolic acidosis. As the intercostal muscles and diaphragm increase their contraction, intercostal and subcostal recession develops. In the infant, sternal retraction may also occur.

The ribs are horizontal in young children. This reduces the 'bellows' effect that the intercostal muscles give to the adult. In the child the sternomastoid muscles must be recruited to further raise the ribs to increase ventilation.

In infants and small children, flaring of the alae nasi may be seen. It must be remembered that, in this age group, 50% of airway resistance occurs in the upper airway and flaring is an attempt to reduce this resistance. This is a late sign and is indicative of severe respiratory distress.

The effort of breathing is diminished in three clinical circumstances. These must be recognized, as urgent intervention may be required. Firstly, exhaustion may develop as a result of the increased respiratory demands. The younger child is even more prone to this due to more immature musculature. Secondly, respiration requires an intact central respiratory drive centre. Conditions such as trauma, meningitis and poisoning may depress this centre. Thirdly, neuromuscular conditions that cause paralysis, such as muscular dystrophy and Guillain-Barré syndrome, may result in respiratory failure without increased effort.

Symmetrical movement of the chest should be confirmed. In the younger child the diaphragm is the main muscle of respiration; therefore, one should also look for movement of the upper abdomen.

Inspiratory and expiratory noises should be noted. Wheezing is heard with lower airway narrowing, as in asthma, often with a prolonged expiratory phase. Crepitations may be heard with pneumonia and heart failure.

Efficacy of breathing
Auscultation of both sides of the chest will confirm air movement. Beware the silent chest! Oximetry is useful for providing a measure of arterial oxygen saturation (S_aO_2), which reflects the efficacy of breathing; however, oximetry may be difficult to obtain in the cold or shocked child because of poor perfusion, and is less accurate when the S_aO_2 is less than 70%.

Effects of respiratory inadequacy on other organs
The impact of hypoxia on the cardiovascular system is to cause tachycardia, but preterminally it may cause bradycardia.

Cyanosis is also a preterminal sign. Hypoxia may also cause peripheral shutdown and pallor secondary to sympathetic stimulation. The effect of hypoxia on the brain is to cause initial agitation and irritability in infants, followed by increasing loss of consciousness.

Circulation

Cardiac output is the product of stroke volume and heart rate. The normal heart rate decreases with age. Infants have a small, relatively fixed cardiac stroke volume; thus they must increase their heart rate to respond to increased demand.

Infants have a relatively larger intravascular volume (85 ml/kg) that decreases with age to 60 ml/kg in the teenager. The normal ranges for blood pressure increase with age. This is due to the fact that systemic vascular resistance increases as the child gets older.

Assessment of circulation

An increase in heart rate is the earliest response to any reduction in intravascular volume. As shock progresses, bradycardia may develop as a preterminal sign. It is important to assess pulse volume both peripherally and centrally. Weak central pulses indicate severe shock. Capillary refill can be a sensitive indicator of vascular status. To assess this, light pressure should be applied to the skin over the sternum for 5 seconds. In the normal individual, capillary return of blood, seen as a slight flush of the pallid area where pressure was applied, will occur in less than 3 seconds. Caution should be used in interpreting this sign in the child who has been exposed to a cold environment.

In the shocked child, hypotension is a late preterminal sign.

Effects of circulatory inadequacy on other organs

Circulatory inadequacy leads to poor tissue perfusion, which in turn leads to metabolic acidosis. Tachypnoea occurs to compensate for this. Initial sympathetic stimulation may cause agitation, but later poor cerebral perfusion causes increasing drowsiness and coma in the preterminal phase. Prerenal failure develops with hypovolaemia and hypotension, with reduction of urine output. Normal urine output is greater than 1 ml/kg/h in the child and greater than 2 ml/kg/h in the infant.

Signs of cardiac failure

The signs of cardiac failure should be sought. Raised jugular venous pulse height is important in the older child but may be difficult to determine in the younger child because of the relatively short, often chubby neck. Listen for a gallop rhythm and for lung crepitations. Palpation of the abdomen may reveal an enlarged liver.

Disability

The assessment of neurological function as part of the primary assessment has three main aims:

- to rapidly determine the level of consciousness
- to find localising intracranial lesions
- to determine whether there is raised intracranial pressure.

It must be remembered that respiratory and cardiovascular failure can cause decreased consciousness and must be dealt with first.

Conscious level

Conscious level can be rapidly assessed using the AVPU method:

- *A* Alert
- *V* responds to Voice
- *P* responds to Pain
- *U* Unresponsive.

The child who is unresponsive or who only responds to pain has a Glasgow Coma Scale (GCS) score of 8 or less. The GCS has no place in the primary survey but it is a useful tool for monitoring changes in neurological status after initial stabilisation.

Posture and tone

Hypotonia may be seen in the seriously ill child no matter what the underlying diagnosis. Hypertonia and posturing should be observed, if present, and any asymmetry noted. Decorticate posturing is evidenced by flexed upper limbs and extended lower limbs, whereas in decerebrate posturing both the upper and lower limbs are extended. These are both preterminal signs and must be acted on immediately.

Pupil size and reactivity

Examination of the pupils can give valuable information. It is important to determine whether there is dilatation, non-reactivity or inequality. Most importantly, unequal pupils may indicate tentorial herniation or a rapidly expanding lesion on one side of the brain. Small, reactive pupils may indicate a metabolic disorder or medullary lesion.

Practical points

- In the collapsed child, a careful and orderly primary assessment and timely resuscitation measures are of more importance than the diagnosis
- Children differ from adults physiologically and anatomically
- Conditions affecting respiration are a common pathway to collapse in the child
- Cyanosis and hypotension are preterminal signs
- Decerebrate and decorticate posturing are preterminal signs

Respiratory patterns in neurological failure

Raised intracranial pressure can lead to a number of abnormal breathing patterns, ranging from hyperventilation to apnoea.

Circulatory changes in neurological failure

Hypertension, bradycardia and hypoventilation form the Cushing triad. These are late signs of raised intracranial pressure and must be acted on immediately. Hypotension is a preterminal event.

Exposure

Infants and small children have a proportionately greater surface area and therefore lose heat more rapidly than older children and adults. Infants are also less able to respond to hypothermia. Early measurement of core temperature is therefore important, and appropriate warming during resuscitation should be maintained. Fever may indicate infection. It is important to fully expose the child for the primary assessment, as valuable clues such as rashes in meningococcal disease or bruises in inflicted injury may be missed. The child may respond with fear or embarrassment to exposure and therefore it must be undertaken sensitively.

Reassessment

Frequent reassessment should be undertaken, especially if there is any deterioration during the resuscitation. A search for a definitive diagnosis should now be completed.

2. In a table, outline the 5 main categories of causation in relation to paediatric emergencies and provide 3 examples of an illness in each category.

Causes of paediatric emergencies

Airway	Breathing	Circulation	Disability	Exposure
Croup	Asthma	Congenital heart disease	Seizure	Hypothermia
Epiglottitis	Bronchiolitis	Duct dependent lesions:	Meningitis	Hyperthermia
Laryngeal foreign body	Pneumonia	Critical aortic stenosis	Encephalitis	Inflicted injury
Bacterial tracheitis	Foreign body	Hypoplastic left heart	Head injury	
Trauma	Congestive heart failure	Coarctation	Raised intracranial pressure	
Angioneurotic oedema	Neuromuscular diseases	Dysrhythmias:		
Retropharyngeal abscess	Trauma:	Bradycardia	Hypoglycaemia	
	Pneumothorax	Tachycardia	Metabolic disorder	
	Haemothorax	Supraventricular	Poisoning	
	Lung contusion	Ventricular	Envenomation	
	Flail chest	Torsade de pointes		
	Near drowning	Fibrillation		
	Smoke inhalation	Pulseless electrical activity		
	Metabolic acidosis:	Shock:		
	Diabetic ketoacidosis	Cardiogenic		
	Poisoning	Cardiomyopathy		
	Salicylates	Heart failure		
	Methanol	Myocardial contusion		
		Hypovolaemic		
		Haemorrhage		
		Vomiting/diarrhoea		
		Burns		
		Distributive		
		Septicaemia		
		Anaphylaxis		
		Spinal cord injury		
		Obstructive		
		Cardiac tamponade		
		Hypertension		
		Dissociative		

3. In a table, summarise the changes in vital signs (respiratory rate, heart rate, systolic blood pressure) in the following age ranges: < 1yr, 1-2 yrs, 2-5 yrs, 5-12 yrs and > 12 yrs.

Vital signs by age

Age (years)	Respiratory rate (breaths/min)	Heart rate (beats/min)	Systolic blood pressure (mmHg)
<1	30-40	110-160	70-90
1-2	25-35	100-150	80-95
2-5	25-30	95-140	80-100
5-12	20-25	80-120	90-110
>12	15-20	60-100	100-120

4. In a table, list the 3 main categories of causation of collapse in children and provide 3 examples in each category.

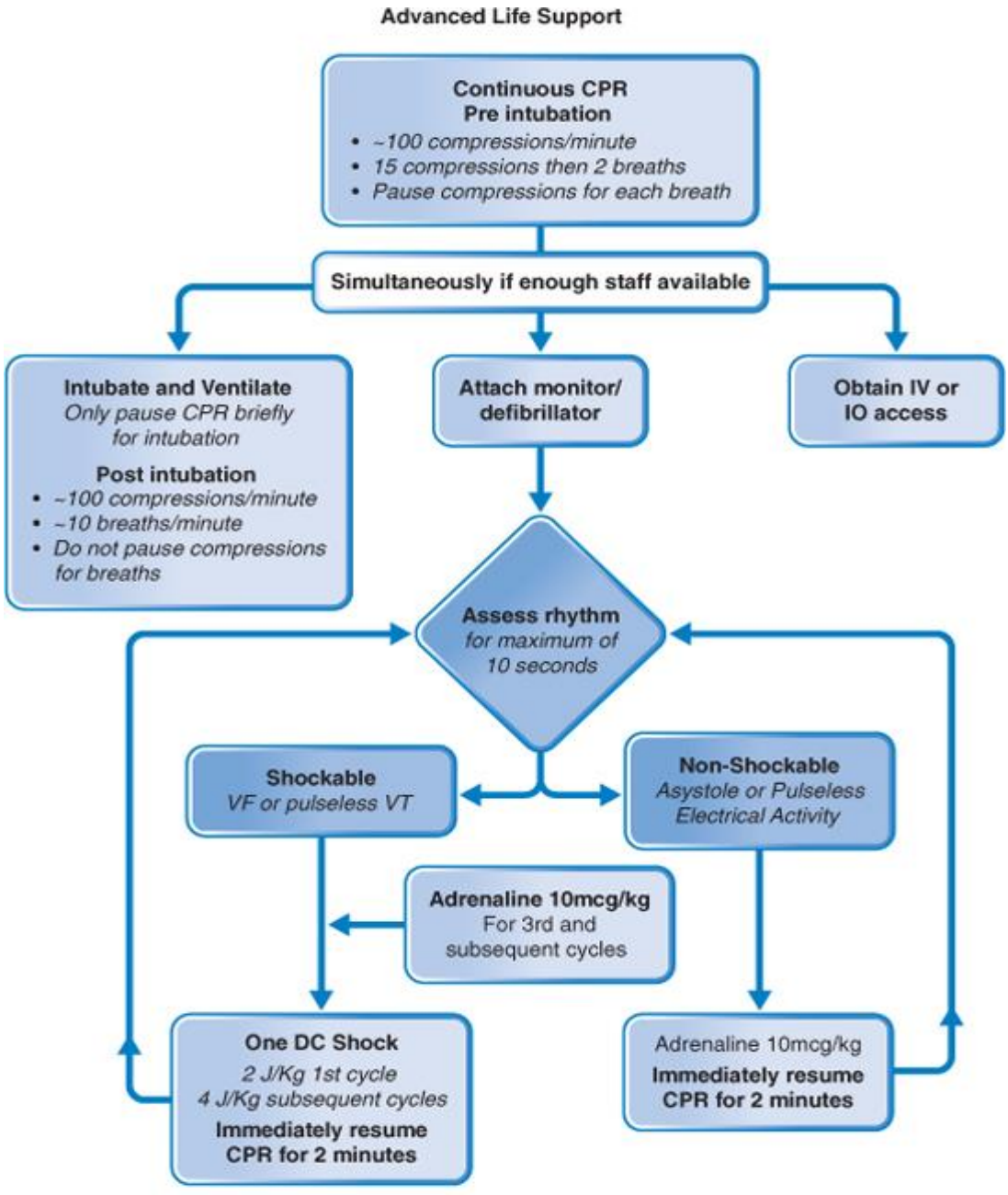
Causes of collapse in children

Category	Diagnosis
Primary neurological process	Meningitis
	Head injury
	Encephalitis
	Seizures
Failure of oxygen supply to brain	Acute asphyxia (e.g. drowning, birth asphyxia)
	Respiratory causes (e.g. severe asthma, croup)
	Cardiac causes (e.g. arrhythmias, myocarditis)
	Hypovolaemia (e.g. dehydration, haemorrhage)
	Sepsis
	Anaphylaxis
Metabolic disturbance or toxins	Hypoglycaemia
	Hyponatraemia
	Drug or other toxic ingestion
	Envenomation
	Bacterial toxins

5. Outline the principles of resuscitation in children.

The general principles of resuscitation might be the same as used in the resuscitation of adults but specific techniques are required in children. The primary aim is to restore an adequate supply of oxygenated blood to the brain - to prevent secondary brain damage. The resuscitation procedures required will vary, depending on the degree of physiological impairment, from simple ones, such as application of an oxygen facemask or administration of a bolus of intravenous fluid, through basic cardiopulmonary resuscitation to advanced life support measures including endotracheal intubation, mechanical ventilation and the use of vasoactive drugs.

6. Using a flowchart, summarise the steps involved in treating an ECG rhythm of VF, VT, non VT and non VF rhythms.



7. Summarise paediatric arrest management in point form or a flow chart.

Practical points

- Do not waste time assessing the adequacy of breathing and circulation in a collapsed child. Assessment can be misleading and time-consuming
- If the circulation or breathing are inadequate or you are uncertain, administer cardiac compressions and artificial respiration
- Never hesitate to give a trial of an intravenous fluid bolus to a collapsed child
- Learn the technique of intraosseous needle placement - this simple technique can be life-saving
- Call for extra assistance early