SECTION 12: Management of Paediatric Emergencies (IMEESC 3.2)

Recognition of the seriously ill child

The outcome following cardiac arrest is poor for children. Early recognition and treatment of children presenting with problems affecting respiratory, cardiovascular and CNS function will reduce mortality and morbidity.

This section will focus on recognition and management of the child developing a potentially life threatening condition. It will link with the next section on management of some important conditions. The child with trauma will be covered in a separate section.

The primary assessment ensures that problems with the greatest threat to well being are treated first. The priority is assessment and management of

A – airway
B – breathing
C – circulation
D – disability – which covers conditions affecting the CNS

To be able to evaluate the child, you must be aware of the normal respiratory and heart rates of children at different ages

Age (years)	Heart Rate (bpm)	Systolic BP (mmHg)	Resp rate (/ min)
≤ 1	**110 - 160**	**70 – 90**	**30 - 40**
1 - 2	**100 - 150**	**80 – 95**	**25 - 35**
2 - 5	**95 - 145**	**80 – 100**	**25 - 30**
5 - 12	**80 - 120**	**90 – 110**	**20 - 25**
≥ 12	**60 - 100**	**100 – 120**	**15 - 20**

WHO definitions for tachycardia are: > 160 bpm aged under 1 year and >120 bpm aged 1 to 5 years.

WHO definitions for raised respiratory rates in the child are:

< 2 months fast breathing is > or = 60/minute

2months to 11 months fast breathing is > or = 50/minute

1 to 5 years fast breathing is > or = 40/minute.

Primary Assessment of the Airway (IMEESC 14.3**)**

If the child is crying or able to talk, then they have a patent airway. The degree of patency can be assessed by

Look

- obvious obstruction to upper airway
- chest and abdominal movements
- drooling of saliva
- posture adopted – e.g. is the neck extended to maximise the airway opening.

Listen

- Noises
  - coughing or choking sounds
  - Stridor which suggests an upper airway obstruction
  - Air entry

Feel – air movement

If any concerns regarding patency of the airway, use the opening airway techniques and re-assess. Proceed along the lines of basic life support and airway maintenance.

Primary Assessment of Breathing

It is important to check

- Effort of breathing – how hard is the child having to work to breathe; and is the child becoming exhausted
- Efficacy of breathing – is the effort being put in resulting in good air entry and oxygenation
- Effects of inadequate breathing – looking for signs that in spite of the effort being put in, the child is not being adequately oxygenated

Effort of breathing

Be aware of the exhausted child who may show signs of little respiratory effort, but be seriously unwell. Apparent reduction in effort should be accompanied by improvement in the child's condition. If it is not, the child is getting worse, and getting tired. Children with CNS depression and those with neuromuscular problems may not have increased effort of breathing – this does not mean they are recovering.

Respiratory rate

- Too fast suggests either lung / airway disease, or a metabolic acidosis
- Too slow suggests fatigue or respiratory depression usually from a sedative drug like diazepam
- Irregular breathing in an unconscious child suggests raised intracranial pressure

Recession

- More common in younger children, and suggests a serious problem if noted in a child over the age of 6-7 years
- Look for intercostal, subcostal and sternal recession
- The degree of recession is a useful indicator of the severity of the problem

Inspiratory / expiratory noises

- Stridor is usually inspiratory and suggests upper airway narrowing

- Severe obstruction might cause expiratory stridor as well
- Wheeze is usually expiratory and associated with lower airway disease
- In neither stridor nor wheeze is the volume of noise an indicator of the severity of the condition

Grunting

- This means the child is trying to breathe out against a partially closed larynx, to prevent collapse of small airways at the end of expiration
- It is usually heard in infants with stiff lungs and is a sign of severe respiratory distress

Use of accessory muscles

- Head bobbing in infants is an attempt to use the sternomastoid muscles to increase air entry. It is generally ineffective although might be useful in older children when the head bobbing does not occur
- flaring of the nostrils increases the calibre of the nasal airway in infants
- neck extension helps keep the airway straight as to allow ease of air entry
- splinting of the pectoral girdle assists when there is increased stiffness of the lungs

Efficacy of breathing

look chest movements
listen bilateral air entry
a silent chest is a very serious sign
pulse oximetry
useful in almost all cases
unreliable in severe anaemia, shock or carboxyhaemoglobinaemia

Effects of inadequate respiration on other organ systems

Heart rate

- hypoxia leads to tachycardia, as the heart works to increase cardiac output and the amount of oxygen being carried to the organs
- fever, pain and anxiety also cause tachycardia, so this is a non-specific sign. Measuring trends in heart rate is useful
- severe hypoxia leads to an ischaemic heart and brain stem resulting in slowing of the heart rate – this is a very serious sign and can rapidly progress to cardio-respiratory arrest if the hypoxaemia is not effectively treated.

Skin colour

- Hypoxia causes vasoconstriction as the body diverts blood from non-essential areas of the body. This causes pallor.
- Cyanosis is a late sign of hypoxia, and may not be detectable in an anaemic child. Unless chronic and associated with congenital heart disease, it represents a serious life threatening problem that needs urgent treatment.

Central nervous system

- Hypoxia and/or hypercapnia cause agitation and drowsiness
- The change in mental status is difficult to detect in infants
- Failure to interact or recognise parents is a serious sign
- Check AVPU

If there are problems with breathing, provide a high flow of oxygen. It may be necessary to help with ventilation.

Primary Assessment of Circulation

It is important to check

- Cardiovascular status
- Effects of circulatory inadequacy on other organs

Cardiovascular status

Heart rate

- Initially increases in shock as the body tries to maintain cardiac output with a falling stroke volume
- Be sure to be familiar with normal heart rates (above)

Pulse volume

- The quality of the pulse may be helpful; the absence of peripheral pulses and weak central pulses is a sign of serious cardiovascular problems

Capillary refill

- This is measured by pressing over the sternum, or non-dependant periphery (the nail bed is useful in pigmented skin: press on a finger nail), for 5 seconds and then releasing. Normal capillary refill is $\leq$ 3 seconds
- It is less reliable when the child is cold
- Although not a sensitive or specific sign of shock, it is a useful measure which, taken with other signs, may help in evaluating the response to resuscitation

Blood pressure

- **Systolic BP = 80 + (age in years x 2)**
- Always use the correct sized cuff – the length should be 2/3 the length of the upper arm, and the bladder should go round at least 40% of the arm – but not overlap.
- BP may be maintained despite a loss of up to 50% of the circulating blood volume so is a **late sign which if not treated urgently may progress to cardio-respiratory arrest.**
- Monitoring trends in BP and changes in pulse pressure are useful aides

Effects of circulatory inadequacy on other organ systems

Respiratory system

Tachypnoea and hyperventilation occur in response to metabolic acidosis when the child tries to increase the rate of oxygenation of the blood being circulated.

Skin

Pale, mottled skin indicates under perfusion

Central nervous system

Altered mental status indicate an under-perfused brain

Urine output

< 2ml/kg/hr in infants and <1ml/kg/hr in the older child indicates under perfusion of the kidneys.

If there are signs of circulatory failure, consider giving a fluid bolus of 20ml/kg of 0.9% saline

Primary assessment of disability

Once a respiratory or cardiac cause of altered level of consciousness has been ruled out, it is important to consider the CNS causes. In order to function properly the brain needs adequate perfusion with adequately oxygenated blood:

- this may be compromised by respiratory or cardiovascular inadequacy (as above) or by raised intracranial pressure, causing reduced cerebral perfusion pressure

- intracranial pressure may be raised by
    - increased brain volume e.g. infection, oedema, trauma or tumour
    - increased CSF e.g. outflow obstruction
    - increased volume of blood e.g. trauma, hypercapnia

- glucose- hypoglycaemia **(less than 2.5 mmol/litre (45mg/dl)** is an important cause of impaired consciousness in children.

CNS function may be compromised by convulsions, drugs, and CNS infections

CNS compromise presents with neurological deficit, and effects the respiratory and cardiovascular systems

Neurological assessment

Conscious level

- A rapid assessment of conscious level can be made by using the AVPU scoring system

A	**ALERT**
V	**responds to VOICE**
P	**responds to PAIN**
U	**UNRESPONSIVE**

- Pain should be elicited by sternal pressure or by pulling the frontal hair. A child who **only** responds to pain has a Glasgow Coma score of ≤ 8

Posture

- Many children who are seriously unwell have a degree of hypotonia – particularly infants
- Decerebrate or decorticate postures are ominous signs and may need to be elicited by use of a painful stimulus

Pupils

- Note pupil size, equality and reactivity
- The most important signs are inequality, dilation and unreactivity to light which indicate serious brain disorder
- Many drugs have an impact on the pupils and their effects are symmetrical

Respiratory effects of CNS failure

Raised intracranial pressure or drugs may cause

- Hyperventilation
- Irregular respiratory patterns (Cheynes Stokes) – suggestive of a mid or hind brain problem
- Slow, sighing respiration
- Apnoea

Cardiovascular effects

- Hypertension and bradycardia (Cushing's response) are indicative of a life-threatening rise in intracranial pressure and represent the brains efforts to increase cerebral perfusion pressure
- The same signs appear with pressure on the medulla oblongata caused by herniation of the brain through the foramen magnum. This is associated with altered pupillary signs and is **a late sign which if not treated will lead to cardio-respiratory arrest.**

If there is a problem with the CNS, make sure the airway, breathing and circulation problems have been corrected. Always check blood glucose and correct if it is low.

Summary : The Rapid Clinical Assessment of an infant or child

AIRWAY

Look, listen and feel

BREATHING

Effort of breathing
Respiratory rate and pattern
Added noises – stridor / wheeze
Listen to the chest – bilateral air entry
Saturation monitoring
Skin colour

CIRCULATION

Heart rate
Pulse volume
Capillary refill
Skin temperature
BP

DISABILITY

Mental status –
A – ALERT
V – responds to **VOICE**
P – responds to **PAIN**
U – UNRESPONSIVE

Posture
Pupils

On completion of this primary survey, and stabilisation of A, B and C, the next step is to identify the most likely underlying cause of the problem (if you have not already done so) and initiate definitive treatment

The next sections look at some common conditions affecting airway, breathing, circulation and central nervous system

Section 12 Quiz 1

With regard to the interpretation of clinical signs, which of the following statements are true?

a) a heart rate of 90 bpm in a 7 year old would be considered normal
b) a breathing rate of 60 per minute in a 6 month old would be considered normal
c) a breathing rate of 45 per minute in a 3 year old would be considered normal
d) a heart rate of 100 per minute in a 2 year old would be considered normal
e) a breathing rate of 16 per minute in a 14 year old would be considered normal

Section 12 Quiz 2

During the primary assessment of airway and/or breathing which of the following statements are correct?

a) a slow respiratory rate is always reassuring
b) intercostal recession is a particularly serious sign if seen in a 7 year old child
c) the severity of stridor is directly related to the volume of the noise produced
d) pulse oximetry is of little use because of its limitations
e) cyanosis may not be detected in an anaemic child
f) a high flow of oxygen should be provided as soon as a problem with breathing is recognised

Section 12 Quiz 3

During the primary assessment of circulation, which of the following statements are correct?

a) capillary refill can be measured by pressing on the sternum for 2 seconds and then releasing
b) the quality of the peripheral pulse may be a helpful sign
c) blood pressure may be maintained at normal levels when 40% of blood volume has been lost
d) a fast breathing rate may be noticed when the main problem is with circulation
e) a more reliable assessment of circulation can be obtained when all the parameters are considered together rather than in isolation
f) a fluid bolus of 20 ml/kg of 0.9% saline should be given if there are signs of shock

Section 12 Quiz 4

During the primary assessment of disability, which of the following statements are correct?

a) the Glasgow coma score is the fastest way of assessing conscious level
b) it is important to check blood glucose level
c) if the pupils are unequal and unreactive, drugs are likely to be the cause

ANSWERS

1. a,d,e 2. b,e,f 3. b,c,d,e,f 4. b

The Infant or Child with Serious Breathing Difficulties

Once the initial assessment has been completed, attention must be focused on managing the most likely cause of the breathing difficulty.

When dealing with a child with respiratory problems, always perform the primary assessment and manage problems as they arise.

A – always support and protect the airway

B --provide high flow oxygen; assist ventilation if needed

C – give IV fluids if signs of circulatory failure

Whatever the cause of the breathing difficulty, it is important to act when there are signs that the child is getting worse. Some important signs to look for are below

- Increasing recession
- Increasing respiratory rate
- Decreasing respiratory rate in a child who is not improving
- Apnoeic episodes
- Increasing pulse rate or bradycardia
- Fatigue or exhaustion
- Altered mental state
- Cyanosis

There are many causes of breathing difficulties – not all of them are due to a respiratory condition – see table below

Not all of these conditions are discussed in this section of the manual. More detail is in the Basic Life Support section. Only those subjects in **bold type** are discussed here.

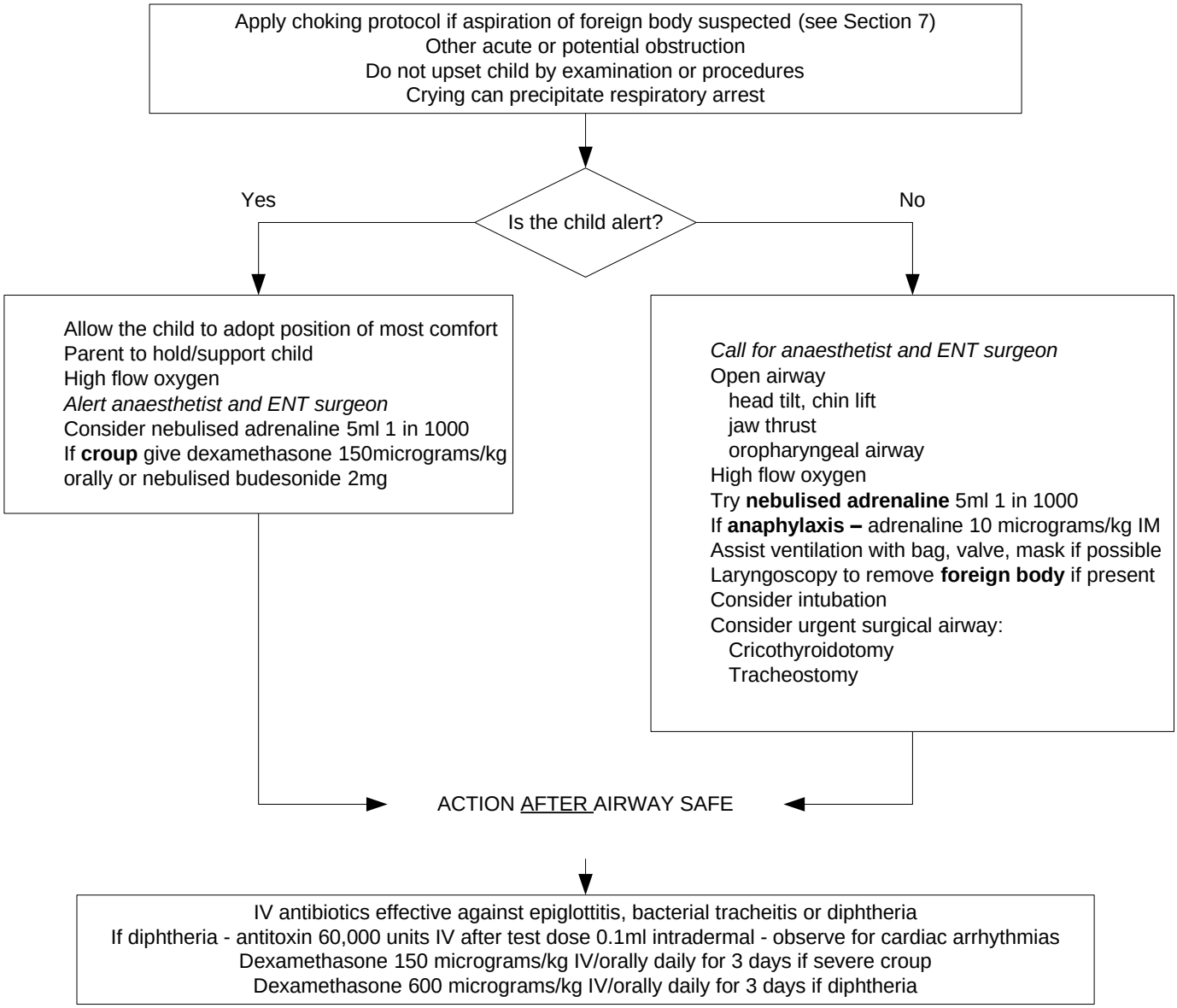
Table – Range of problems that cause breathing difficulties

Breathing difficulties	Causes
Upper airway obstruction	❑ Diphtheria ❑ **Anaphylaxis** ❑ **Croup** ❑ Foreign body (see BLS section) ❑ **Epiglottitis** ❑ Retro-pharyngeal abscess ❑ Anatomical causes
Lower airway obstruction	❑ Tracheitis ❑ **Asthma** ❑ **Bronchiolitis**
Disorders affecting lungs	❑ **Pneumonia** ❑ Pulmonary oedema
Disorders around the lungs	❑ Pneumothorax ❑ Empyema ❑ Rib fractures
Disorders of the respiratory muscles	❑ Neuromuscular
Disorders below the diaphragm	❑ Peritonitis ❑ Abdominal distension
Increased respiratory drive	❑ Diabetic ketoacidosis ❑ Shock ❑ Poisoning (eg salicylates) ❑ Anxiety attack ❑ Hyperventilation
Increased respiratory drive	❑ Diabetic ketoacidosis ❑ Shock ❑ Poisoning (eg salicylates) ❑ Anxiety attack ❑ Hyperventilation
Decreased respiratory drive	❑ Coma ❑ Convulsions ❑ Raised intracranial pressure ❑ Poisoning

Upper airway obstruction

This is potentially life threatening and may be caused by swelling, secretions or foreign material. The smaller the child the more at risk they are because of the small cross sectional area of the airways.

Pathway of Care: Acute Upper Airway Obstruction in Children



Specific topics

Croup

Croup is usually caused by a virus. As with any condition which affects the airway, the patient and family will be frightened. Do not do anything to make this worse. Do not put anything in the child's mouth, or cause pain by repeated attempts at cannulation.

Clinical Features

- Child age 6months – 5 years
- 1 – 3 days coryza
- mild fever < 38.5
- barking cough or hoarseness, worse at night
- inspiratory stridor
- variable respiratory distress
- usually resolve without need for admission

Treatment

- Oxygen if SaO2 < 95%
- In severe cases nebulised adrenaline 5ml 1:1000
- Dexamethasone 0.6 mg/kg PO or IM or equivalent dose of other steroid**

Or

- Budesonide 2mg nebulised
- If concerned re bacterial tracheitis treat with antibiotics (e.g. cefuroxime)
- Intubation may be needed in severe cases

**** 1mg prednisilone = 5mg hydrocortisone = 0.15mg dexamethasone**

Epiglotittis This is almost always caused by *Haemophilius Influenzae type B* and is very rare in children who have been immunized. Some of the features are similar to croup, but the child is more unwell; the onset is more rapid and cough is not a feature

Comparison of Croup and Epiglotittis		
Feature	**Croup**	**Epiglotittis**
Onset	Over a few days	Over a few hours
Preceding coryza	Yes	No
Cough	Severe, barking	Absent or slight
Able to drink	Yes	No
Drooling saliva	No	Yes
Appearance	Unwell	Toxic, very unwell
Fever	< 38.5	> 38.5
Stridor	Harsh, rasping	Soft
Voice	Hoarse	Muffled, soft voice
Need for intubation	≈ 1%	> 80%

Treatment of Epiglotittis

Calm, reassurance. Do not distress the child
Elective intubation is the best treatment but may be very difficult – consider the need for surgical airway
IV antibiotics only when airway is safe– ceftriaxone or cefotaxime 30mg/kg

Measles

Measles is a highly contagious viral disease with serious complications (such as blindness in children with pre-existing vitamin A deficiency) and high mortality. It is rare in infants under 3 months of age.

Diagnosis

Fever plus a generalized maculopapular rash and one of the following—cough, runny nose, or red eyes. In children with HIV infection, these signs may not be present and the diagnosis of measles may be difficult.

Severe complicated measles

The above plus:
- inability to drink or breastfeed
- vomits everything
- convulsions

On examination, look for signs of late complications after the rash has disappeared, such as:
- lethargy or unconsciousness
- corneal clouding
- deep or extensive mouth ulcers.
- pneumonia
- dehydration from diarrhea
- stridor due to measles croup
- severe malnutrition.

Treatment of severe measles

Children with severe complicated measles require treatment in hospital

Vitamin A therapy. Give oral vitamin A **to all** children with measles unless the child has already had adequate vitamin A treatment for this illness as an outpatient. Give oral vitamin A 50 000 IU (for a child aged <6 months), 100 000 IU (6–11 months) or 200 000 IU (12 months up to 5 years). If the child shows any eye signs of vitamin A deficiency or is severely malnourished, a third dose must be given 2–4 weeks after the second dose.

If the temperature is ≥39 °C (≥102.2 °F) and this is causing the child distress, give paracetamol.

Nutritional support
Give zinc supplement of 10mg per day (elemental formula) up to 6 months of age and 20mg per day (elemental formula) for children > 1 year

Life threatening complications

- Pneumonia
- Diarrhea: treat dehydration, bloody diarrhea or persistent diarrhea
- Measles croup: WHO say do not give steroids: EMCH as with other causes of croup give one dose of steroids
- Eye problems. Conjunctivitis and corneal and retinal damage may occur due to infection, vitamin A deficiency, or harmful local remedies. In addition to giving vitamin A (as above), treat any infection that is present. If there is a clear watery discharge, no treatment is needed. If there is pus discharge, clean the eyes using cotton wool boiled in water, or a clean cloth dipped in clean water.

Apply tetracycline eye ointment, 3 times a day for 7 days. Never use steroid ointment. Use a protective eye pad to prevent other infections. If there is no improvement, refer to an eye specialist.

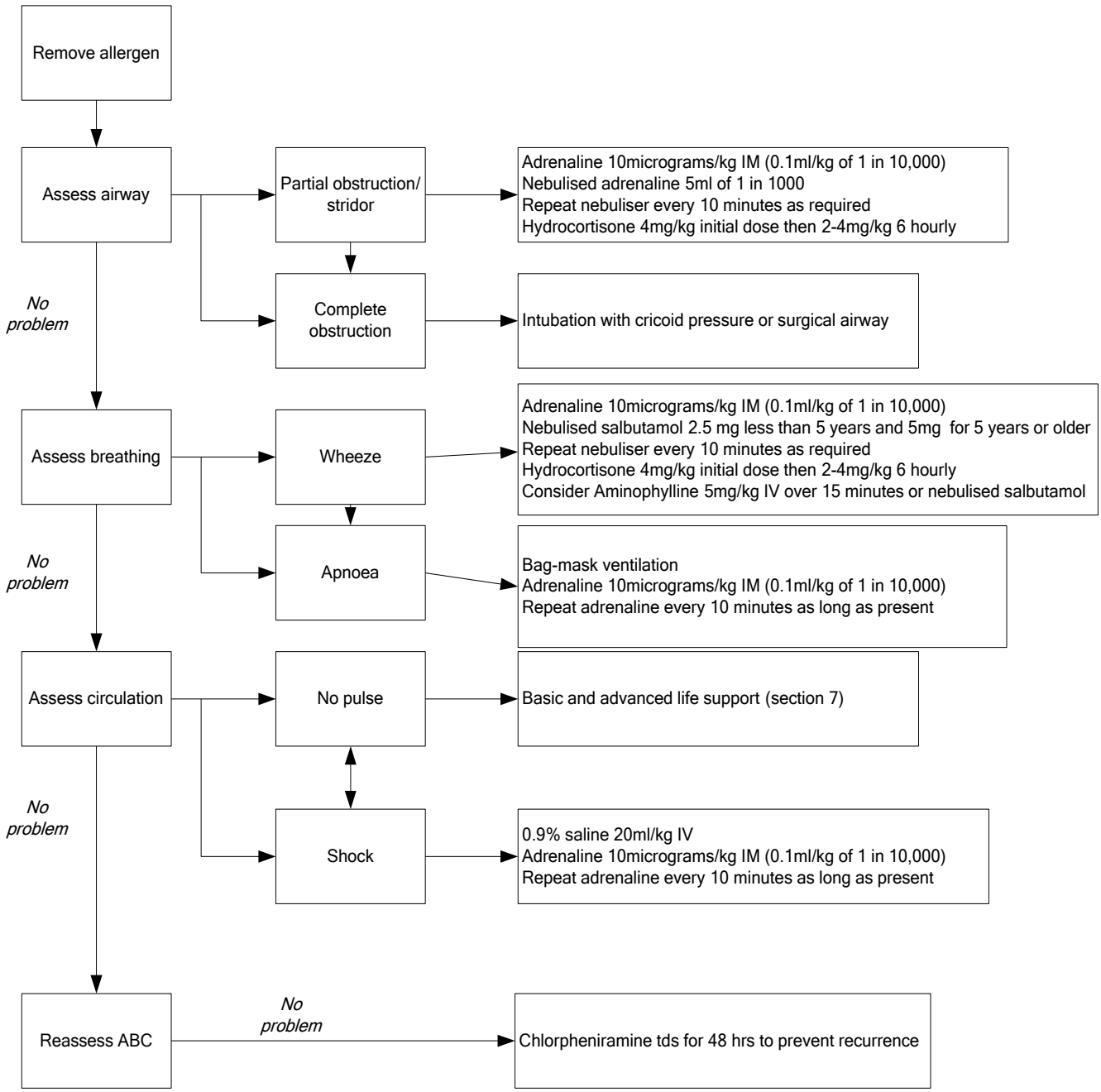
- Mouth ulcers. If the child is able to drink and eat, clean the mouth with clean, salted water (a pinch of salt in a cup of water) at least 4 times a day.
  - — Apply 0.25% gentian violet to the sores in the mouth after cleaning.
  - — If the mouth ulcers are severe and/or smelly, give IM/IV benzylpenicillin (50,000 units/kg every 6 hours (50mg/kg) and oral metronidazole (7.5 mg/kg 3 times a day) for 5 days.
  - — If the mouth sores result in decreased intake of food or fluids, the child may require feeding via a nasogastric tube.
- Neurological complications. Convulsions, excessive sleepiness, drowsiness or coma may be a symptom of encephalitis or severe dehydration.

Anaphylaxis

This is a severe allergic reaction, which may cause respiratory or circulatory problems – or both. The main treatments are IM adrenaline 10micrograms/kg (only given IV / IO if severe shock or cardiac arrest) steroids and IV fluids

Diagnosis
Allergic reaction with respiratory difficulty and / or shock

Pathway of care for Anaphylaxis in a child



The child with wheezing (bronchiolitis and asthma)

Wheezing is a whistling noise heard during expiration. The child who has cough or difficulty breathing *and* wheezing will have one of the following:

- Bronchiolitis *(mainly <1 year old)*
- Asthma *(over 1 year old)*
- Pneumonia with wheezing **(ensure no lung hilar compression or inhaled foreign body)**

In pneumonia with wheezing and in asthma a bronchodilator provides important symptomatic relief. An aerosol and large volume spacer (which may be improvised) is the best way of administering a bronchodilator (see below).

Bronchiolitis

A lower respiratory viral infection, typically most severe in young infants, occurs in annual epidemics, and is characterized by airways obstruction and wheezing. Respiratory syncytial virus is the most important cause. Secondary bacterial infection may occur and is common in some settings. Episodes of wheeze may occur for months after an attack of bronchiolitis, but eventually will stop.

Clinical features

- Infants are coryzal, have a troublesome cough and may feed poorly or even be unable to suck and feed. There may be vomiting.
- The nose is often obstructed by secretions
- On examining the chest, there may be hyperinflation, chest wall indrawing, nasal flaring, grunting, wheeze and fine crackles at the lung bases.
- Young infants may present with apnoeic/hypoxaemic episodes which may be recurrent and life threatening
- There may be hypoxaemia: SaO2 less than 94% with / without cyanosis
- Some infants will have such severe respiratory distress that there is gasping

Treatment

Only supportive treatment, for examples oxygen, gentle suction of the nose, and fluids, help; antibiotics and bronchodilators have no role. However, in the most severe cases and unless **certain** that pneumonia is not present, it is safer to give antibiotics and a trial of a bronchodilator (stop it if it is not helping).

Non-invasive respiratory support to help overcome small airway obstruction (nasal CPAP and continuous negative extrathoracic pressure (CNEP)) may be valuable (if available). CNEP may be more effective because of the nasal blockage that accompanies bronchiolitis.

- Give oxygen by nasal cannulae to keep SaO2 94-98%. Check nasal cannulae are in the correct place and not blocked by secretions on a regular basis
- Nasal clearance. Gentle nasal suction should be used to clear secretions in those where nasal blockage is thought to be causing respiratory distress. This may be aided by saline nasal drops or spray.
- Ensure that daily maintenance fluids are achieved. If not possible by mouth, use nasogastric feeding. This should be considered in any patient who is unable to maintain oral intake or hydration (expressed breast milk)
- If vomiting despite nasogastric feeding or severe respiratory distress is present, give fluids IV
- If signs of pneumonia give antibiotics
- If fever (≥ 39 ° C or ≥ 102.2 ° F) causing distress, give paracetamol.

Failure to respond

If condition worsens suddenly, consider pneumothorax. Tension pneumothorax associated with major respiratory distress and shift of the heart requires immediate relief by needle thoracocentesis: see procedures section. If needle thoracocentesis is helpful, insert a chest tube with an underwater seal until the air leak closes spontaneously and the lung expands- see procedures section for details of how to do this. **The signs of pneumothorax in severe bronchiolitis may be difficult to detect clinically; however, needle thoracocentesis in the absence of a pneumothorax may cause pneumothorax, so if unsure, undertake a chest x-ray.**

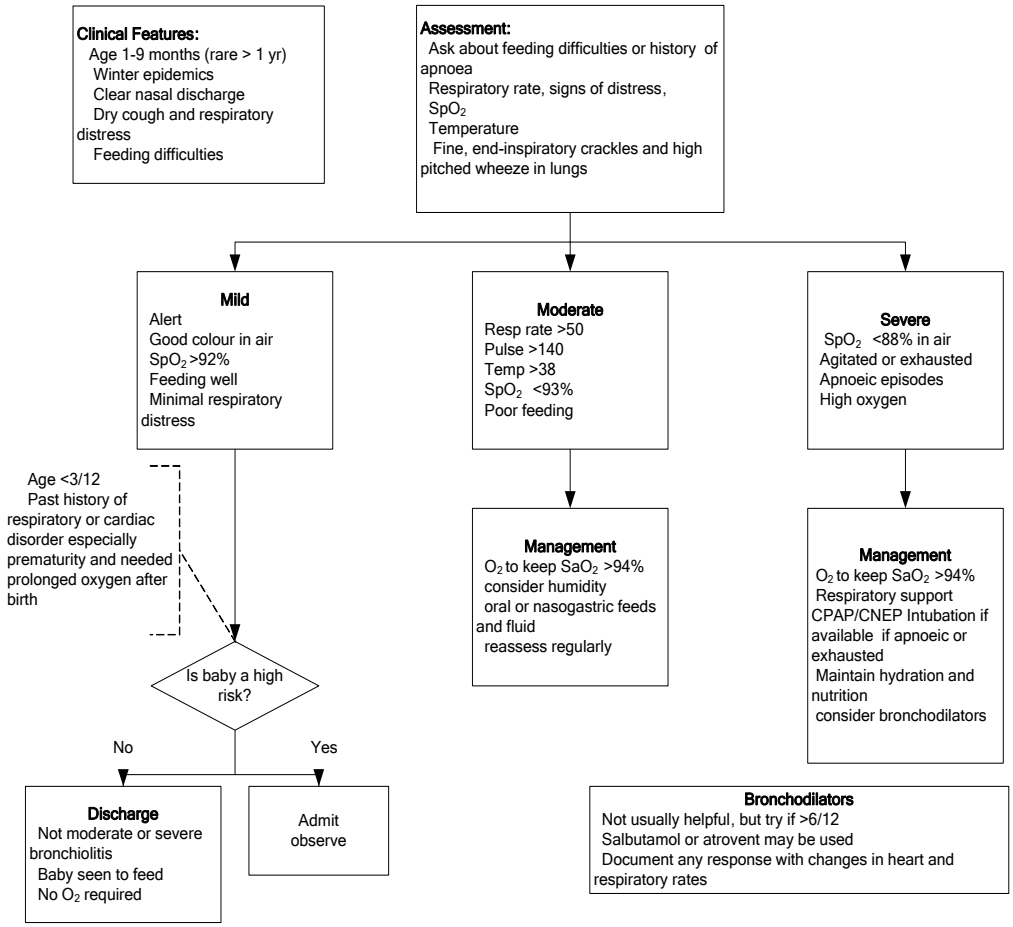
If apnoeic episodes develop (most likely in premature infants) after bag valve mask resuscitation, nasal CPAP or CNEP and sometimes intubation and ventilation may be needed in a high dependency ward (if available): contact an anaesthetist urgently.

Infection control

Bronchiolitis is infective and easily transmitted to other infants and young children in hospital. The following strategies may reduce cross infection:

- Hand washing between patients
- Gloves and aprons
- Ideally isolate but need close observations
- Restrict visiting by anyone with symptoms of upper respiratory tract infection

Pathway of care for Bronchiolitis



Asthma

Asthma is a condition characterized by episodic or recurrent symptoms of cough, prolonged expiration with wheeze, chest tightness and shortness of breath and no fever. It is due to variable and reversible airway obstruction associated with chronic airway inflammation.

Young children (< 5 years) often have "asthma-like" symptoms (cough, wheeze and shortness of breath) in response to respiratory infections, but with no demonstrable problem between infections. This tendency often stops in early school years. In these children, treatment of episodic symptoms with acute asthma therapies may still provide relief of symptoms, but preventers (that is inhaled steroids) will usually be unhelpful unless the child has continuous symptoms or is likely to be atopic (eg personal or family history of asthma, eczema or allergic rhinitis). In the youngest children (< 2 years old) with severe episodes or symptoms continuing between infections (interval symptoms), it is necessary to consider other diagnoses, such as bronchiectasis, tuberculosis, foreign body and cystic fibrosis.

Diagnosis between episodes of asthma

The diagnosis is clinical, and based on a **history** of:

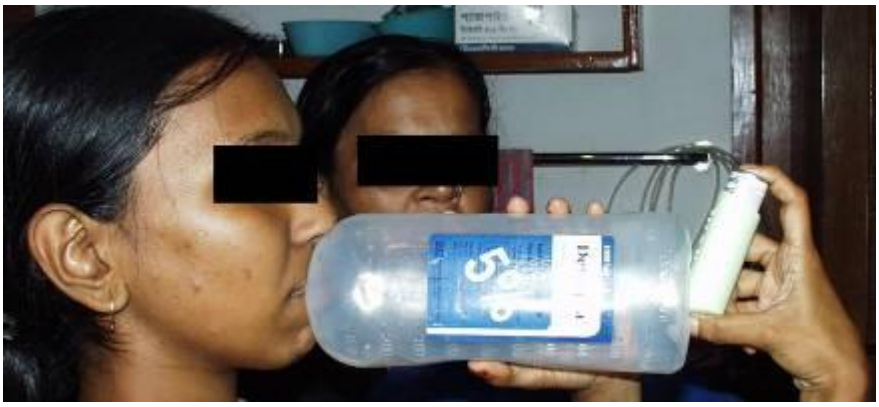
- recurrent cough (mostly dry, becoming productive with exacerbations), wheeze, shortness of breath, or chest tightness
- symptoms worse at night, and on exertion
- symptoms worsened by respiratory infections, inhaled irritants (for example cigarette smoke), cold air, animal furs, excitement or upset
- personal or close family history of eczema, rhinitis or asthma.

Examination may identify:

- no abnormalities
- slow growth
- overinflation of chest, Harrison's sulci
- wheeze, particularly on forced expiration
- rhinitis or eczema.

Investigations are not usually needed, but may help support the diagnosis or exclude other conditions:

- Chest *X* ray - is normal or shows overinflation (flat diaphragms and hyperlucency, particularly when severe or acute), or increased peri-hilar linear markings



Management

- Avoid allergic/irritant factors, for example smoke, chemical fumes, house dust mites, animal fur.
- Discourage cigarette smoking and new pets at home.
- Do not stop child from exercising, but pre-dose 5-10 minutes beforehand with a dose of inhaled beta-2 agonist bronchodilators (for example salbutamol or terbutaline).
- Occasional symptoms (for example on 2-4 days per week) may be relieved with a bronchodilator (a reliever).
- Use inhaled where possible, apart from in acute severe or life-threatening attacks when the intravenous route may be used.
- Use an aerosol spray (metered dose inhaler) with a spacer (first choice):
  (i) A commercial medium to large volume spacer, for example Volumatic, Aerochamber, or a large (2 litre) plastic bottle with the aerosol sealed into one end, and the open end held closely over the nose and mouth. (see Figure)
  (ii) Use 200-1000 micrograms of salbutamol (2-10 sprays) or : more may be needed in younger children, or if acutely breathless (and repeated)
  (iii) Each spray/puff should be inhaled individually in turn with 4-5 breaths, rather than filling the spacer device with multiple sprays
  (iv) For children < 5 years old, attach a facemask (for example inverted adult mask) to the mouthpiece of a spacer

  Clean spacer with soapy water and leave to dry naturally to reduce static electrical charges on inside.

- Alternatively use a nebuliser to deliver salbutamol (less portable).

Children with asthma should always have immediate availability to their usual reliever inhaler device: over 7-8 year olds may keep their device with them.

More frequent symptoms, regular nocturnal symptoms or daily use of a bronchodilator should be treated with regular medication aimed to control airway inflammation (preventer), such as inhaled steroids. Use inhaled, preferably through a spacer (first choice)

- eg beclometasone proprionate or budesonide: 200-400 micrograms twice daily
- rinse mouth after each dose of inhaled steroid
- aim for rapid control of symptoms, and then tail down dose over months
- gaining control may be helped by a short course (7-10 days) of systemic steroid (for example prednisolone 500 micrograms/kg once daily after food or milk, maximum daily dose 40 mg)
- continue with bronchodilator use for symptom relief (avoid regular use)

For regular or severe symptoms, consider:

- if diagnosis is correct
- aggravating factors, for example rhinitis, stress, gastro-oesophageal reflux
- medication is being taken and taken correctly
- increasing inhaled steroid dose (beclomethasone to 400-800 micrograms twice daily) or
- ***adding leukotriene antagonists (for example montelukast) – good in pre-school children or long-acting inhaled (for example salmeterol)***or
- oral methylxanthines (for example theophylline 5 mg/kg 3-4 times a day)
- **as a last resort,** use of alternate-day oral prednosilone (start at 500 micrograms/kg on alternate days and reduce rapidly to 100 micrograms/kg on alternate days [to nearest 1mg or 5mg tablets]). Stop as soon as possible.

Children on inhaled or oral steroids should have regular checks of their growth and be watched for steroid side effects (for example oral thrush)

The control of asthma should be regularly reviewed (for example three-monthly) and medication stepped up or down dependent on symptoms and in those over 7 years: peak flow measurements ***or spirometry.*** Families should have written instructions and may learn to change treatment themselves, with support.

Management of an episode of acute asthma

Initial treatment of a **mild to moderate acute attack** of asthma includes:

- Reassure child and parents and avoid upset which may exacerbate respiratory distress
- Give regular inhaled beta-2 agonist bronchodilator, for example salbutamol aerosol 200-1000 micrograms (2 to 10 sprays each of 100 mcg with each spray given after every 4-5 breaths) via spacer maximum every 30 minutes to 2hourly until the child is better.
- OR if not responding to spacer 2.5 mg for <5 years and 5 mg for >5 years via nebuliser 2-4 hourly (use oxygen to drive the nebuliser if possible)
- Give systemic steroids: oral prednisolone 1mg/kg (maximum of 40 mg) for 3-5 days depending on duration of symptoms with food or milk to avoid gastric irritation
- Treat or remove any exacerbating factors (see "Diagnosis" above).
- Give antibiotics only if signs of pneumonia, especially a persistent fever

Very severe or life-threatening asthma

Features of severe or life-threatening asthma include:

- too breathless to feed, drink or talk
- marked recession/use of accessory muscles
- respiratory rate > 50 breaths/min
- pulse rate > 140 beats/min
- poor chest movement/silent chest
- exhaustion/agitation/reduced conscious level (due to hypoxia or hypercapnia)
- hypoxaemia SpO2 less than 90% in air or cyanosis (very late sign)

Treat immediately (use 'ABC' approach):

- **100% oxygen** via facemask held by parent or nurse close to child's face with reservoir bag at 10-15 litres/min or if appropriate nasal cannulae to keep SaO2 94-98%.

- Inhaled beta-2 agonist **bronchodilator** via spacer as above in acute asthma, that is salbutamol aerosol 1000 micrograms (10 sprays each of 100 mcg with each spray given after every 4-5 breaths) via spacer maximum every 10 minutes and if no better use nebuliser as below. If nebuliser not available, continue to give 10 sprays over 40-50 breaths every 10 to 30 minutes until better.

- Children aged <3 years are likely to require a face mask connected to the mouthpiece of a spacer for successful drug delivery.

- Inhalers should be sprayed into the spacer in individual sprays and inhaled immediately by tidal breathing.

- Or inhaled from a nebuliser 2.5 mg nebules for <5 years and 5 mg for >5 years, and repeated as required (ideally drive the nebuliser with oxygen at 6-8 litres/minute rather than compressed air). Sometimes nebulisers made be needed continuously (described as back-to-back that is as each nebule finishes repeat)

- If nebulised or inhaled B agonist bronchodilators are not available, give a subcutaneous injection of adrenaline—10 micrograms/Kg (0.01 ml/kg of 1:1000 solution) (up to a maximum of 300 micrograms), measured accurately with a 1 ml syringe (**ensure the needle is not in a vein before injecting**). If there is no improvement after 15 minutes, repeat the dose once.

- **Systemic steroids oral** prednisolone (see above) or IV/IM hydrocortisone 4 mg/kg 4-6 hourly until no longer has symptoms of an acute episode. Start the steroids as soon as possible. A soluble preparation dissolved in a spoonful of water is preferable in those unable to swallow tablets. Use a dose of 20 mg for children 2-5 years old. Repeat the dose of prednisolone in children who vomit and give intravenous (or IM if a venous cannula cannot be inserted) hydrocortisone (4 mg/ kg repeated four-hourly) in those who are unable to retain orally ingested medication. Treatment for three to five days is usually sufficient, but the length of course should be tailored to the number of days necessary to bring about recovery. Weaning is unnecessary unless the course of steroids exceeds 14 days.

IF 2-3 DOSES OF INHALED BRONCHODILATOR AND SYSTEMIC STEROIDS DO NOT RESULT IN IMPROVEMENT OR IF LIFE-THREATENING FEATURES ARE PRESENT, USE:

  - **intravenous beta-2 agonist salbutamol** (loading dose 5-15 micrograms/kg over 10-15 min, followed by 100-500 nanograms/kg/min (that is 0.1-0.5 micrograms/kg/min) by IV infusion OR
  - **Intravenous magnesium sulphate** 40 milligrams / kg (maximum 2 grams) over 20 minutes OR
  - **both**
- an alternative to the above treatments include aminophylline (loading dose 5 mg/kg over 20 minutes, followed by 1 mg/kg/hour by IV infusion if 1-12 years and 500 micrograms/kg/hour if > 12 years or < 1 year of age. Do not give the loading dose if already received any form of aminophylline or caffeine in the previous 24 hours. Side effects include nausea, vomiting, tachycardia or tachyarrhythmia and seizures and have made this a less preferred treatment.

Severe and life-threatening hypokalaemia may occur with IV salbutamol, potentiated by steroids. If possible monitor the ECG continuously and check K^+ 12 hourly. ECG signs of hypokalaemia are: ST depression, T wave reduction and prominent U waves. Ensure maintenance potassium intake is given.

If there is poor response to the above treatment, or the child's condition worsens suddenly, obtain a chest X-ray to look for evidence of pneumothorax. In the presence of hyperinflation from asthma, detection of a pneumothorax on the chest x ray may be difficult.

Monitor above clinical features regularly and also monitor oxygen saturation, by pulse oximeter if available. Keep SpO2 94-98% by the administration of oxygen, either by face mask or by nasal cannulae. Use oxygen to drive nebulisers.
In cases not responding to above measures, obtain chest Xray and consider mechanical ventilation (slow rate, long expiration). A blood gas measurement showing respiratory acidosis can be valuable at this time, but remember that invasive procedures can worsen respiratory distress.

If intubation and ventilation becomes essential, ketamine induction followed by inhalational anaesthetic gases (for example halothane) may assist broncho-dilatation.

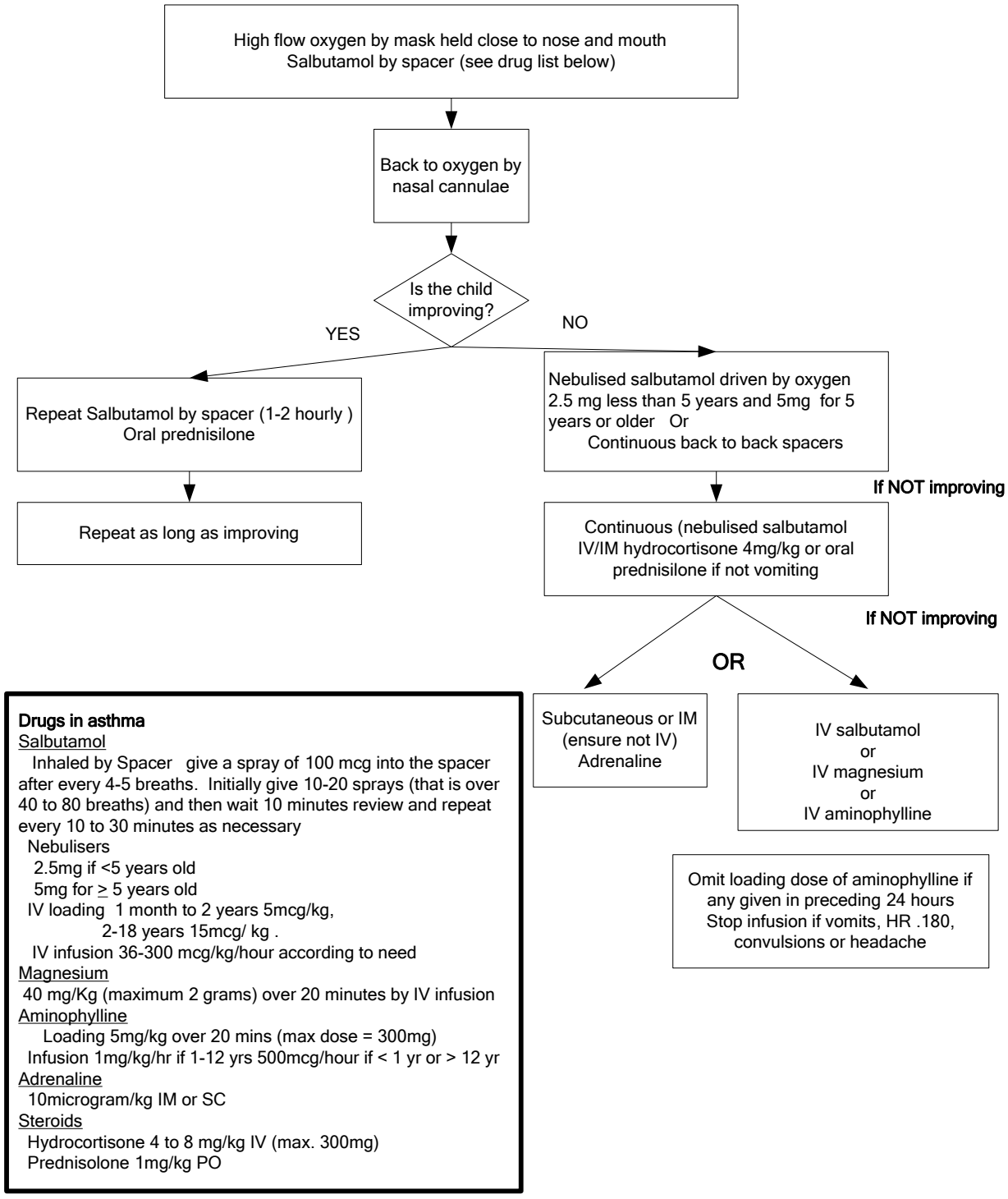
Severe Asthma - Indications for intubation and ventilation (if available):

- Increasing exhaustion
- Progressive deterioration in
  - clinical condition
  - oxygenation decreasing and/or oxygen requirement increasing
  - **pCO2** increasing (if measurable from arterial/capillary gas)
- Sudden deterioration – and always think about a pneumothorax

Follow-up care

Once improved sufficiently to be discharged home, inhaled salbutamol through a metered dose inhaler should be prescribed with a suitable (not necessarily commercially available) spacer and the parents instructed in how to use this.

Pathway of care very severe or life-threatening asthma



Drugs in asthma

Salbutamol

Inhaled by Spacer give a spray of 100 mcg into the spacer after every 4-5 breaths. Initially give 10-20 sprays (that is over 40 to 80 breaths) and then wait 10 minutes review and repeat every 10 to 30 minutes as necessary

Nebulisers

2.5mg if <5 years old

5mg for ≥ 5 years old

IV loading 1 month to 2 years 5mcg/kg,

2-18 years 15mcg/ kg .

IV infusion 36-300 mcg/kg/hour according to need

Magnesium

40 mg/Kg (maximum 2 grams) over 20 minutes by IV infusion

Aminophylline

Loading 5mg/kg over 20 mins (max dose = 300mg)

Infusion 1mg/kg/hr if 1-12 yrs 500mcg/hour if < 1 yr or > 12 yr

Adrenaline

10microgram/kg IM or SC

Steroids

Hydrocortisone 4 to 8 mg/kg IV (max. 300mg)

Prednisolone 1mg/kg PO

Acute lower respiratory tract infection

Always consider that the child might be suffering from TB or HIV infection.
A high fever in a child with breathing difficulties is likely to be due to epiglotittis, bacterial tracheitis or pneumonia. If the airway is clear, the most likely diagnosis is pneumonia. Although high fever and respiratory signs are the usual way for pneumonia to present, it should always be considered in the list of causes of abdominal pain and neck stiffness

Clinical examination (and CXR) cannot reliably tell the difference between a viral and a bacterial pneumonia, so all cases are treated with antibiotics

Features of Pneumonia

- Fever, cough, breathlessness and lethargy following an upper respiratory infection
- Pleuritic chest pain, abdominal pain and neck stiffness indicate pleural involvement
- Signs of consolidation
  - Dull percussion
  - Reduced breath sounds
  - Bronchial breathing

  May be absent in an infant
- CXR may show pleural effusion or empyema as well as consolidation

Treatment

- Oxygen to maintain SaO_2 > 94%
- IV antibiotics
  - Cefotaxime plus either
    - Flucloxacillin

      OR
    - Erythromycin
  - WHO benzyl penicillin and amoxicillin (see below)
- Maintain hydration and replace losses due to high fever
- Do not overload
- CXR is helpful, but not essential

The following section is modified from the WHO Pocket Book of Hospital Care for Children.

CLASSIFICATION OF THE SEVERITY OF PNEUMONIA (WHO)

Sign or symptom	Classification	Treatment
• Central cyanosis • Severe respiratory distress e.g. head nodding, • Not able to drink	Very severe pneumonia	Admit to hospital Give recommended antibiotic Give oxygen Manage the airway Treat high fever if present
Chest in-drawing	Severe pneumonia	Admit to hospital Give recommended antibiotic Manage the airway Treat high fever if present

Sign or symptom	Classification	Treatment
Fast breathing ≥60 breaths/minute in a child aged <2 months ≥50 breaths/minute in a child aged 2 – 11 months ≥40 breaths/minute in a child aged 1 – 5 years Definite crackles on auscultation	Pneumonia	Home care Give appropriate antibiotic for 5 days Soothe the throat and relieve cough with a safe remedy Advise the mother when to return immediately Follow up in 2 days
No signs of pneumonia or severe or very severe pneumonia	No pneumonia Cough or cold	Home care Soothe the throat and relieve cough with safe remedy Advise the mother to return Follow up in 5 days if not improving If coughing for more than 30 days follow chronic cough instructions

Very severe pneumonia: Diagnosis

Cough or difficult breathing plus at least one of the following:

- central cyanosis
- inability to breastfeed or drink, or vomiting everything
- convulsions, lethargy or unconsciousness
- severe respiratory distress.

In addition, some or all of the other signs of pneumonia or severe pneumonia may be present, such as:

— fast breathing: age <2 months: ≥60/minute
age 2–11 months: ≥50/minute
age 1–5 years: ≥40/minute
— nasal flaring
— grunting (in young infants)
— lower chest wall indrawing
— chest auscultation signs of pneumonia:
— decreased breath sounds
— bronchial breath sounds
— crackles
— abnormal vocal resonance (decreased over a pleural effusion, increased over lobar consolidation)
— pleural rub

If possible, obtain a chest X-ray and SaO2.

Emergency Treatment

Admit the child to hospital

Antibiotic therapy

- Give ampicillin (50 mg/kg IM every 6 hours) and gentamicin (7.5 mg/kg IM once a day) for 5 days; then, if child responds well, complete treatment at home or in hospital with oral amoxicillin (15 mg/kg three times a day (max 500mg, 1g in severe)) plus IM gentamicin once daily for a further 5 days.
- Alternatively, give chloramphenicol (25 mg/kg IM or IV every 8 hours) until the child has improved. Then continue orally 4 times a day for a total course of 10 days. Or use ceftriaxone (80 mg/kg IM or IV once daily).
- If the child does not improve within 48 hours, switch to gentamicin (7.5 mg/kg IM once a day) and cloxacillin (50 mg/kg IM or IV every 6 hours), as described below for staphylococcal pneumonia. When the child improves, continue cloxacillin (or flucloxacillin) orally 4 times a day for a total course of 3 weeks.

Oxygen therapy

- Give oxygen to all children with very severe pneumonia
- Oxygen if SaO2 < 90% (WHO) or < 94% ESSEMCH until the signs of hypoxia (such as severe lower chest wall in-drawing or breathing rate of ≥70/minute) are no longer present.
- Nurses should check every 3 hours that the catheter or prongs are not blocked with mucus and are in the correct place and that all connections are secure.

Supportive care

- If the child has fever (≥39 °C or ≥102.2 °F) which appears to be causing distress, give paracetamol.
- If wheeze is present, give a rapid-acting bronchodilator
- Remove by gentle suction any thick secretions in the throat, which the child cannot clear.
- Ensure daily maintenance fluids appropriate for age but avoid over-hydration.
    — Encourage breastfeeding and oral fluids.
    — If the child cannot drink, insert a nasogastric tube and give maintenance fluids in frequent small amounts. If the child is taking fluids adequately by mouth, do not use a nasogastric tube as it increases the risk of aspiration pneumonia. If oxygen is given at the same time as nasogastric fluids, pass both tubes through the same nostril.
- Encourage eating as soon as food can be taken.
- Give zinc supplement of 10mg per day (elemental formula) up to 6 months of age and 20mg per day (elemental formula) for children > 1 year

Complications

If not improved after two days, or if condition has worsened, if possible, obtain a chest X-ray.

Staphylococcal pneumonia. This is suggested if there is rapid clinical deterioration despite treatment, by a pneumatocoele or pneumothorax with effusion on chest X-ray, numerous Gram-positive cocci in a smear of sputum, or heavy growth of S. aureus in cultured sputum or empyema fluid. The presence of septic skin pustules supports the diagnosis.

- Treat with cloxacillin (50 mg/kg IM or IV every 6 hours) and gentamicin (7.5 mg/kg IM or IV once a day). When the child improves, continue cloxacillin orally 4 times a day for a total course of 3 weeks. Note that cloxacillin can be substituted by another anti-staphylococcal antibiotic such as oxacillin, flucloxacillin, or dicloxacillin.

Pleural effusion and empyema

Diagnosis

On examination, the chest is dull to percussion and breath sounds are reduced or absent over the affected area.

A pleural rub may be heard at an early stage before the effusion is fully developed.

A chest X-ray shows fluid on one or both sides of the chest.

(An ultrasound examination may be helpful in identifying the size of the effusion and helping to guide drainage ESS-EMCH)

When empyema is present, fever persists despite antibiotic therapy and the pleural fluid is cloudy or frankly purulent.

Treatment

Drainage
Pleural effusions should be drained, unless they are small. If effusions are present on both sides of the chest, drain both. It may be necessary to repeat drainage 2–3 times if fluid returns.

Subsequent management depends on the character of the fluid obtained. Where possible, pleural fluid should be analysed for protein and glucose content, cell count and differential count, and examined after Gram and Ziehl- Neelsen staining, and bacterial and Mycobacterium tuberculosis culture.

Failure to improve
If fever and other signs of illness continue, despite adequate chest drainage and antimicrobial therapy, assess for possible tuberculosis. A trial of antituberculosis therapy may be required

Heart failure

Heart failure causes fast breathing and respiratory distress.

Underlying causes include congenital heart disease (usually in the first months of life), acute rheumatic fever, myocarditis, suppurative pericarditis with constriction, infective endocarditis, acute glomerulonephritis, severe anaemia, very severe pneumonia and severe malnutrition.

Heart failure can be precipitated or worsened by fluid overload, especially when giving salt-containing IV fluids.

Diagnosis

The most common signs of heart failure, on examination, are:

- Tachycardia (heart rate >160/minute in a child under 12 months old; >120/minute in a child aged 12 months to 5 years).
- Gallop rhythm

- Basal crackles on auscultation.
- Enlarged, tender liver.

In infants—fast breathing (or sweating), especially when feeding
In older children oedema of the feet, hands or face, or distended neck veins (raised JVP).

Severe palmar pallor may be present if severe anaemia is the cause of the heart failure.
If the diagnosis is in doubt, a chest X-ray can be taken and will show an enlarged heart.
Measure blood pressure if possible. If raised consider acute glomerulonephritis: microscope urine

Treatment

The main measures for treatment of heart failure in none-severely malnourished children are:

Diuretics. Give frusemide a dose of 1 mg/kg should cause increased urine flow within 2 hours. For faster action, give the drug IV. If the initial dose is not effective, give 2 mg/kg and repeat in 12 hours, if necessary. Thereafter, a single daily dose of 1–2 mg/kg orally is usually

sufficient. Maximum is around 40mg per dose, but can give more.

Digoxin.

Supplemental potassium. Supplemental potassium is not required when frusemide is given alone for treatment lasting only a few days. When digoxin and frusemide are given, or if frusemide is given for more than 5 days, give oral potassium (3–5 mmol/kg/day).

Oxygen. Give oxygen if the child has a respiratory rate of ≥70/min, shows signs of respiratory distress, or has central cyanosis or an oxygen saturation of < 94% (EMCH).

Supportive care

• Avoid the use of IV fluids, where possible.

• Support the child in a semi-seated position with head and shoulders elevated and lower limbs dependent.

• Relieve any fever with paracetamol to reduce the cardiac workload.

Section 12 Quiz 5

Which of the following statements are true when considering acute upper airway obstruction in children?

a) upsetting the child can make obstruction much worse
b) expert advice from ENT surgeon and/or anaesthetist should be sought only after diagnosis has been made and specific treatment started
c) nebulised adrenaline may improve symptoms
d) oral or nebulised steroids are indicated for treatment of epiglottis
e) if anaphylaxis is the cause, breathing and circulation problems should be anticipated

Section 12 Quiz 6

When assessing breathing problems in children in their 1st year of life, which of the following statements are true?

a) bronchiolitis is the commonest cause of wheeze
b) management of bronchiolitis includes oxygen to keep SaO_2 > 94%
c) bronchodilators are usually helpful in babies less then 3 months old
d) if the baby has difficulty feeding, naso or orogastric tube nutrition may be needed

ANSWERS

5. a,c,e **6.** a, b, d

Section 12 Quiz 7

Features of severe asthma include which of the following?

a) agitation and/or decreased conscious level
b) decreased chest movement and decreased breath sounds
c) cyanosis
d) respiratory rate greater than 50/minute

Section 12 Quiz 8

Which of the following statements about the management of severe asthma are true?

a) salbutamol by spacer or nebuliser
b) oral prednisolone 0.5 mg/kg
c) 5 mg nebulised salbutamol for children aged 1 – 4 years old
d) consideration of pneumothorax if there is a sudden deterioration during treatment

ANSWERS

7. a,b,c,d **8.** a, d

Management of the Infant or Child in Shock

Shock is defined as failure of the circulatory system to deliver adequate amounts of oxygen and nutrients to the tissues.

Mechanisms that can cause shock

1. loss of fluid or blood (hypovolaemic)
2. failure of the heart pump (cardiogenic)
3. abnormal function of vessels supplying nutrients and oxygen to tissues (distributive)
4. inadequate capacity of blood to release oxygen(dissociative eg severe anaemia or carbon monoxide poisoning)
5. restriction of circulation to the tissues (obstructive)

In many causes of shock, mechanisms may coexist, therefore the clinician must consider which emergency treatments will be effective OR HARMFUL for any individual patient. **Management of shock is focused in four areas:**

- Oxygen is safe and must be given in all causes of shock
- Resuscitation and support for the circulation, after airway and breathing are stable and/or supported
- Cannot take IV fluids back but can give more if necessary
- Treatment of the underlying cause

Shock results from a number of different causes each with different treatments. A treatment for one cause of shock may be harmful if given to a child with a different cause of shock.

- Loss of fluid e.g. gastroenteritis; trauma
- Redistribution of fluid e.g. septicaemia; anaphylaxis
- Failure of circulation e.g. cardiac disease; tension pneumothorax

The clinical diagnosis of the cause of shock is not easy or definitive: shock is a spectrum of conditions and mechanisms.

Diagnosis depends on history, clinical examination, and response to treatment given. It is often possible to identify the cause of shock with a good history and a careful examination.

Diagnostic pointers to the cause of shock (those in **bold** will be discussed in detail	
Diarrhoea and / or vomiting with signs of severe dehydration	**Gastroenteritis;** volvulus; intussusception
Fever; non-blanching (purpuric) rash	**Meningococcal septicaemia, Dengue Haemorrhagic Fever**
Urticaria; wheeze; oedema; exposure to allergen	Anaphylaxis
Trauma	Blood loss; tension pneumothorax; internal bleeding
Burns	Fluid loss; blood loss
Pallor, tachycardia, severe malaria, severe acute malnutrition	Severe anaemia
Fever, signs of shock and a very sick child	Septicaemia
Baby <4 weeks old; cyanosis, with no response to oxygen	Congenital heart disease
Very fast pulse; heart failure	**Arrhythmia;** cardiomyopathy
Dehydration, polyuria, polydipsia, high glucose	**Diabetic keto-acidosis**
History of sickle cell disease or diarrhoeal illness and low haemoglobin	Haemolysis with severe anaemia

The diagnosis and management of shock is complicated if there is malnutrition, and this will be discussed in a separate section.

Clinical diagnosis of shock

Tachycardia*
Weak pulse* (ideally central - brachial, femoral or carotid but difficult to gauge)
Low BP (LATE SIGN and very difficult to measure in young children)
Extreme central pallor (severe anaemia)
Raised respiratory rate (due to acidosis)
Poor skin circulation with raised capillary refill time (CRT) > 3 seconds*
Increased skin sweating – not sure you would get this, usually shut down
Reduced conscious level
Reduced urine output

*The WHO diagnosis of shock includes all of the * above*

Investigations that might be helpful but difficult in some circumstances

Hb is essential
Plasma electrolytes helpful, especially sodium and bicarbonate
Lactate helpful (if available)
Blood glucose
(CVP measurement if skilled staff to undertake procedure and measurement)

Initial Management of Shock

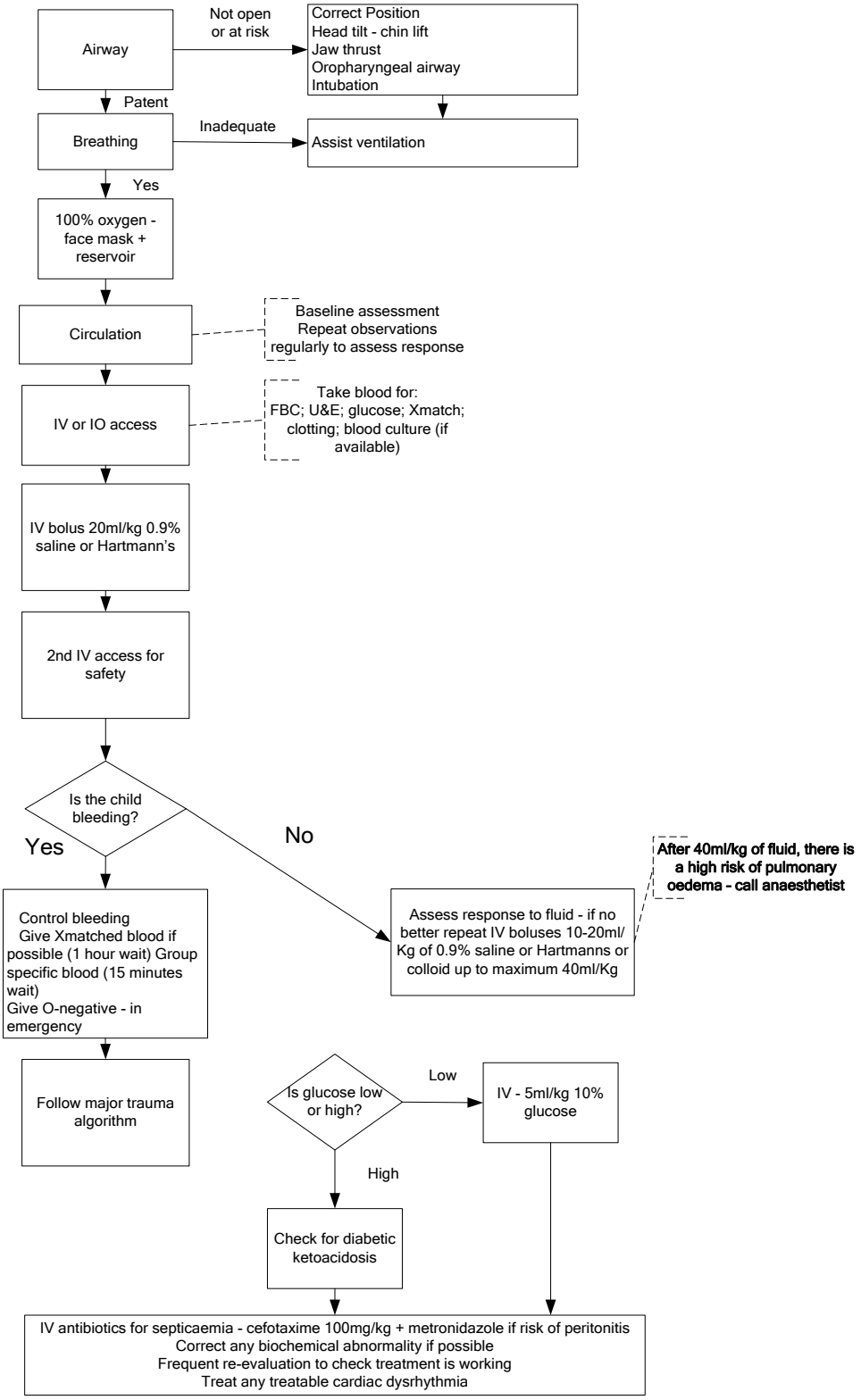
Even though it may be clear on initial inspection that the child is in shock, the first priority will still be to call for help, manage the airway, followed by breathing and then management of the circulation.

ALL CHILDREN WITH SUSPECTED SHOCK MUST RECEIVE HIGH FLOW OXYGEN.

Intravenous access with short, wide bore venous cannula, or placement of an intraosseous line (see procedures) is important. More than one line is preferable - rapid fluid resuscitation may be needed. Take blood for investigations (if available)

FBC; glucose; renal and liver function; blood culture and cross matching

Pathway of Care for the Child in Hypovolaemic Shock (due to severe dehydration/gastroenteritis, blood loss from trauma, septicaemia with purpura (meningococcal or Dengue) but see separate sections for anaphylactic shock and septic shock without purpura



Specific causes of shock

Immediate resuscitation is needed to maintain oxygenation and perfusion of vital organs. Once this is underway, the cause of shock needs to be found and treated.

Severe anaemia causing shock

Although blood is urgently needed, there is a significant risk of circulatory overload and pulmonary oedema.

We suggest an initial 10ml/Kg bolus of packed cells (ideally using a centrifuge but otherwise by hanging the blood so that the bottom of the bag has more red cells in it.

Frequent reassessment is needed looking for any heart and respiratory rate changes (warning signs would be an increase in heart rate of 10/min or more and of respiratory rate of 5/min or more). Also examine the liver and listen to the lung fields with a stethoscope before the bolus and during the post bolus reassessment. If the liver is enlarging or there are fine crepitations in the lung fields then there is developing pulmonary oedema. In an older child the JVP can be a helpful indicator of circulatory filling.

If there are signs of circulatory overload an exchange transfusion may be helpful. From a large vein remove 20ml of the patient's anaemic blood and immediately replace with 20ml of packed cells. A 3 way tap for this can be helpful. Continue until the patient's Hb is > 7g/dl or there is resolution of the shock.

Septic shock due to meningococcal septicaemia or Dengue Haemorrhagic fever

In these conditions there is severe circulatory hypovolaemia and IV boluses of 0.9% saline, Hartmann's solution, colloids or blood are urgently needed.

Suspected septic shock without purpura

The management of this situation is currently being reviewed. However, in this condition there may be coexisting circulatory hypovolaemia, severe anaemia and myocardial suppression (particularly when there is severe acidosis).

IV fluid boluses of 10ml/Kg of isotonic crystalloids (0.9% saline or Hartmann's solution) can be helpful in some cases but careful reassessment involving examination for circulatory overload is needed after each bolus is given.

Correction of severe acidosis with sodium bicarbonate 8.4% (0.5mmol/Kg) may be helpful.

Careful correction of severe anaemia (see above) can also be helpful.

High dose IV antibiotics, including those active against gram negative and/or anaerobic organisms (depending on the possible cause of the septicaemia) should be given urgently.

Shock due to major trauma

Please see Section 13. The main causes of shock are acute blood loss (which may be concealed), obstruction to the circulation resulting from tension pneumothorax and myocardial contusion.

Anaphylaxis

See earlier in this Section

The child with acute diarrhoea

Most important issues

- Rehydration therapy
- Continued feeding
- Antibiotics **not** given routinely. Indicated in bloody diarrhoea (probable *Shigella)* and suspected cholera
- Antidiarrhoeal drugs and antiemetics should never be given and can be dangerous

Classification of diarrhoea

Introduction

Diarrhoeal diseases are a leading cause of childhood morbidity and mortality in disadvantaged countries.In 2001, an estimated 1.5 million children below 5 years died from diarrhoea, 80% of them in the first two years of their life. Around half of these deaths are due to watery diarrhoea and occur either because of lack of access to oral rehydration solution (ORS) or because of incorrect case management. About a third of deaths are caused by persistent diarrhoea and the remainder (approximately 15%) by dysentery.

ORS has been a simple and effective solution reducing morbidity and mortality in diarrhoeal illness. The new low osmolarity ORS solution reduces by 33% the need for supplemental IV fluid therapy after initial rehydration when compared to the previous standard WHO ORS solution. The new ORS solution also reduces the incidence of vomiting by 30% and stool volume by 20%.

Also zinc supplementation has shown to significantly reduce the severity and duration of diarrhoea.

Definition

Diarrhoea is the passage of loose or watery stools, usually at least three times in a 24-hour period. However, it is the consistency of the stools rather than the number that is most important. Mothers usually know when their children have diarrhoea and may provide useful working definitions in local situations. The volume of fluid lost through the stools in 24 hours can vary from 5 ml/kg (near normal) to 200 ml/kg, or more. Dehydration occurs when these losses are not replaced adequately and a deficit of water and electrolytes develops. The concentrations and amounts of electrolytes lost also vary. The total body sodium deficit in young children with severe dehydration due to diarrhoea is usually about 70-110 millimoles per litre of water deficit. Potassium and chloride losses are in a similar range.

The most common causes of diarrhoea are rotavirus, enterotoxigenic *Escherichia coli* (ETEC) and, during epidemics, *Vibrio cholerae* O1 or O139.

- **Acute watery diarrhoea** (including cholera), which lasts several hours or days: the main danger is dehydration; malnutrition also occurs if feeding is not continued. If there is a current epidemic, Cholera is likely and causes severe dehydration with a positive stool culture for V. cholerae O1 or O139
- **Acute bloody diarrhoea,** or dysentery: (blood is mixed in with stool) the main dangers are intestinal damage, sepsis and malnutrition; other complications, including dehydration, may also occur.

- **Persistent diarrhoea,** is defined as passage of three or more loose watery stools in a 24 hour period which lasts 14 days or longer: the main danger is malnutrition and serious non-intestinal infection; dehydration may also occur.
- **Diarrhoea with severe malnutrition** (marasmus or kwashiorkor). The main dangers are: severe systemic infection, dehydration, heart failure and vitamin and mineral deficiency.
- **Diarrhoea** associated with a **recent course of broad-spectrum oral antibiotics**

Assessment of the child with diarrhoea

- Fever, vomiting, and loose stools are the common symptoms of acute gastroenteritis.
- If possible rule out other serious illness e.g. meningitis, malaria and bacterial sepsis.
- Assess for degree of dehydration, bloody diarrhoea, persistent diarrhoea, malnutrition and serious non-intestinal infections.

History

Specific points to enquire about in the history include:

- Duration of diarrhoea
- Presence of blood in the stool
- Local knowledge or reports of cholera epidemic
- Recent use of antibiotics
- Presence of fever, cough, or other important problems (e.g. convulsions, measles)
- Usual feeding practices
- Type and amount of fluids (including breast milk) and food taken during the illness
- Drugs or other remedies taken
- Immunisation history

Physical examination

First assess for shock and treat first and urgently if it is present. Children with shock will have a high and increasing heart rate, weak pulse, poor skin circulation time with prolonged capillary refill time (> 3 seconds) and low or even immeasurable blood pressure. These children require an immediate resuscitation (ABC) including high concentrations of oxygen and an IV bolus of 10-20ml/Kg of either 0.9% saline or Hartmann's solution given as rapidly as possible. If IV access is not possible (often veins are collapsed) consider intraosseous needle. If shock is not relieved by 20ml/Kg, give another bolus of 10-20ml/Kg but watch very carefully for fluid overload and in particular pulmonary oedema (most likely if also severely anaemic).

The examination includes measurement of vital signs together with clinical correlation. . The degree of dehydration is graded according to signs and symptoms that reflect the amount of fluid lost Infants with acute diarrhoea are more apt to dehydrate than are older children because they have a higher body surface-to-weight ratio, have a higher metabolic rate, and are dependent on others for fluid. Although the most accurate assessment of fluid status is acute weight change, the patient's weight before illness often is not known.

In severe dehydration, prolonged skin retraction time, and decreased perfusion are more reliably predictive of dehydration than sunken fontanelle or absence of tears. A good correlation has been reported between time of capillary refill and fluid deficit. However, fever, ambient temperature and age can affect capillary refill time as well. **In severe dehydration, shock and death follows soon if rehydration is not started quickly.**

Children with some dehydration or severe dehydration should be weighed without clothing, when estimating their fluid requirements. If weighing is not possible, a child's age may be used to estimate the weight. *(Age in years + 4) x 2 for children less than 10 years old. For an infant up to 1 year: birth weight doubles by 5 months and triples by 1 year.*

Treatment should never be delayed because weighing is not rapidly available. Also:

- Look for abdominal mass or abdominal distension.
- In an infant < 1 week, diarrhoea is sometimes a sign of neonatal sepsis (see Section 11). In an infant blood in the stool may be an intussusception or in the first week of life haemorrhagic disease of the newborn.

Remember: Typhoid, surgical conditions such as intussusception, antibiotic-associated colitis, and rarely imflammatory bowel disease.

Investigations

Laboratory investigations are rarely needed. Serum electrolytes, especially sodium or potassium concentrations may be useful in severe dehydration. Stool cultures should be undertaken if at all possible in dysentery (bloody diarrhoea) but are not needed to initiate treatment in the usual case of acute watery diarrhoea. Stool microscopy can be useful for diagnosing *Giardia lamblia, Cryptosporidium* and amoebic dysentery.

Principles of case management

The 5 essential elements in the management of all children with diarrhoea are 1) resuscitation from shock if present by rapid IV boluses of Hartmann's solution or 0.9% saline 2) rehydration therapy, 3) maintenance therapy, 4) zinc supplementation, and 5) continued feeding.

Calculating Fluid Requirements

WHO Plans A-C for gastroenteritis in children (see Appendix) include estimates of total fluid requirements and assume that most children will be drinking by 4 hours into treatment and thus able to "self-regulate". For patients where this is not the case, Fluid Management can be conducted using the following guidelines.

Estimating Fluid requirements

The amount of fluid that the child needs over a 24 hour period needs to be calculated. It is the sum of:

Estimated fluid deficit + maintenance requirements + on-going losses

Deficit

<u>If an accurate recent pre-illness weight is available</u>, subtract current weight to estimate lost fluid (1 kg = 1 litre of fluid)

eg a child who weighed 9.2 kg is seen with diarrhea and weight 8.3kg:

estimated fluid loss is [9.2 - 8.3]kg = 0.9kg = 900ml deficit, that is 10% dehydrated

<u>If no recent weight or considered to be unreliable:</u>

decide degree of dehydration

weigh child (or estimate from age as follows: wt(kg) = 2x[age(yrs)+4])

use formula: % dehydration x weight (kg) x 10 = deficit (in mls)

eg a child whose weight is estimated as 10 kg is 10% dehydrated:

estimated fluid loss is 10 x 10 x 10 = 1000 mls (40 ml/hour if replaced over 24 hours)

Maintenance

Estimated maintenance fluid requirements based on body weight for a child are:

Body weight	**Fluid needed per day**	**Fluid needed per hour**
First 10kg body weight	100 ml/kg	4 ml/kg
Second 10kg	50 ml/kg	2 ml/kg
Subsequent kg	20 ml/kg	1 ml/kg

Ongoing losses

For each diarrheal stool: <2 yrs old, give 50-100 ml or 10ml/Kg

> 2 yrs old give 100-200 ml or a cup or small glass

For each vomit: 2ml / kg ORS: give small frequent volumes (eg 5ml every minute in a child) via spoon or syringe or cup. Gradually increase amount given and closely supervise.

For naso-gastric tube aspirates Replace volume for volume with either ORS or Normal saline with 5 or 10% glucose and 5mmol/litre of potassium chloride OR Hartmanns with 5 or 10% glucose.

Over-hydration

Signs of over hydration, cardiac failure (as in severe malnutrition) chronic malnutrition or protein losing enteropathy are:

- Tachycardia, increased respiratory rate, oedematous (puffy) eyelids, crepitations at lung bases, enlarged liver, raised JVP
- pulmonary oedema on CXR

Management

- stop giving ORS solution, but give breast milk or plain water and food
- do not give a diuretic unless pulmonary oedema, then give frusemide 1 mg/kg/IV

Reassess

- ABC
- state of intravascular rehydration
- plasma electrolytes if possible
- urine output and urine electrolytes
- give fluid according to plan or change fluid regime if appropriate, don't forget ongoing losses
- reassess regularly (including biochemistry if possible)
- don't forget glucose measurements

Zinc is an important micronutrient for a child's overall health and development. Zinc is lost in greater quantity during diarrhoea. Replacing the lost zinc is important to help the child recover and to keep the child healthy in the coming months. It has been shown that zinc supplements given during an episode of diarrhoea reduce the duration and severity of the episode, and lower the incidence of

diarrhoea in the following 2–3 months. For these reasons, all patients with diarrhoea should be given zinc supplements as soon as possible after the diarrhoea has started. **Zinc supplementation is 10mg/kg for infants less than 6 months and 20mg/kg for older children for 14 days.**

Type of dehydration with diarrhoea	**Symptoms/signs present**	**Treatment**
No dehydration	None Increased thirst	• Treat at home with extra fluids. WHO plan A see below • Breast feeding or standard diet must continue • Warn mother re: danger signs of some or severe dehydration and when to return • Zinc supplements
Some dehydration (5-9% fluid deficit)	Two or more of the following signs: • Restless and irritable • Sunken eyes • Drinks eagerly/Thirsty • Loss of skin turgor-tents when pinched and goes back slowly Any one additional sign of severe dehydration below	• Treat with WHO plan B in hospital for at least 24 hours (if feasible) • ORS / Resomal if malnutrition • Breast or standard feeding to continue • Zinc supplements
Severe dehydration (10% or greater)	Two or more of the following signs • Prostration/ Reduced conscious level • Sunken eyes • Loss of skin turgor-tents when pinched and goes back very slowly (>/= 2 seconds) • Not able to drink or drinks poorly In addition may show: Rapid deep breathing from acidosis Lack of urine output	• WHO plan C • Rapid IV rehydration giving ORS whilst IV cannula put into place • Test for and treat any hypoglycaemia • Breast or standard feeding as soon as able to • Zinc supplements
Shock	High and increasing heart rate Weak pulse volume Poor skin circulation time (cool and poorly perfused extremities) with prolonged capillary refill time (> 3 seconds) Low or even unmeasurable blood pressure Reduced conscious level or coma	• Urgent IV or intraosseous access • Urgent IV/IO fluid bolus of 10ml/Kg N Saline or Hartmann's • Repeat 10ml/Kg boluses if remains shocked up to total of 40ml/Kg then beware of fluid overload • Then revert to WHO plan C

In the rehydration phase, the fluid deficit should be replaced and clinical hydration attained.

In the maintenance phase, adequate dietary and fluid intake should be maintained.

In both phases, excess fluid losses must be replaced continuously.

A child's fluid deficit can be estimated as follows:

- Mild or no signs of dehydration <5% fluid deficit: <50 ml/kg
- Some dehydration 5-10% fluid deficit: 50-100ml/kg
- Severe dehydration > 10% fluid deficit: > 100 ml/kg Rehydration therapy is based on degree of dehydration.

Treatment with low osmolarity ORS

The formula for standard and the latest recommended low osmolarity oral rehydration salts (ORS) recommended by WHO and UNICEF is given in Table below. The quantities shown are for preparation of one litre of ORS solution involving 1 sachet added to 1 litre of clean water.

When prepared and given correctly, ORS solution provides sufficient water and electrolytes to correct the deficits associated with acute diarrhoea. Potassium is provided to replace the large potassium losses associated with acute diarrhoea, especially in infants, thus preventing serious hypokalaemia. Citrate (or bicarbonate) is provided to prevent or correct base deficit acidosis. Glucose is essential because, when it is absorbed, it promotes the absorption of sodium and water in the small intestine. This is true irrespective of the cause of the diarrhoea. Without glucose, ORS solution would be ineffective.

Table Composition by weight of WHO/UNICEF oral rehydration salts (ORS) to be dissolved in boiled water to produce 1 litre

Ingredient	**Original standard ORS (grams/litre clean water)**	**New and recommended low osmolarity ORS (grams/litre clean water)**
Sodium chloride	3.5	2.6
Tri-sodium citrate dihydrate	2.9	2.9
Potassium chloride	1.5	1,5
Glucose anhydrous	20	13.5

When glucose is not available use sucrose (ordinary sugar) 27grams/litre of clean water

When trisodium citrate dehydrate not available use sodium bircarbonate 2.5grams/litre of clean water

Table Resulting molar concentration of components of WHO solutions

Composition of standard versus reduced osmolarity ORS (Bicarbonate ORS - 30 mmols/l of bicarbonate instead of citrate)

ORS	**Standard mEq/litre**	**Reduced Osmolarity mEq/litre**
Glucose	111	75
Sodium	90	75
Chloride	80	65
Potassium	20	20
Citrate	10	10
Osmolarity	**311** milliosmoles/litre**	**245 milliosmoles/litre**

** hyperosmolar with respect to plasma osmolality (normal = 276 to 295 milliosmoles/litre

Health workers and mothers criticised standard ORS because it did not reduce stool output or duration of diarrhoea. Reduced osmolarity ORS is as effective as standard ORS for preventing/treating diarrhoea but it also reduces stool output/volume by 25%, reduces vomiting by almost 30% and reduces need for supplemental IV rehydration by 33%. This means less need for hospital care, less disruption of breast feeding, less use of needles and, where IV treatment is not available, less risk of dying from acute diarrhoea.

It is as effective as standard ORS in cholera in adults but may produce transient hyponatraemia. In children it appears as effective as standard ORS in cholera but careful observations for a hyponatraemia should be undertaken if possible.

Note: use ReSoMal instead of low osmolarity ORS in children with severe malnutrition.

Practicalities of case management by WHO

Examine the child and select the appropriate WHO Treatment Plan.
- No signs of dehydration: WHO Treatment Plan A at home to prevent dehydration and malnutrition (see Appendix).
- Mild to moderate dehydration: WHO Treatment Plan B to treat dehydration (see Appendix).
- Severe dehydration: WHO Treatment Plan C to treat severe dehydration urgently (see Appendix).

Treatments for different degrees of dehydration

1. Shock

These children require immediate resuscitation (ABC) and emergency treatment

Airway (if reduced conscious level)

- Use an opening manoeuvre, if not open or partially obstructed. Keep the airway open. If there is improvement but the airway closes without active opening support, consider airway adjuncts to support the airway.
- Suction
- The airway may need to be secured by intubation using experienced senior help (if available)

Breathing

Give 100% oxygen (mask with reservoir and flow rate of at least 61/min) regardless of SpO_2 (increases O_2 delivery as well as improving tissue oxygenation).

For inadequate ventilation or depressed conscious level (AVPU) with hypoventilation, respiration should be supported with oxygen via a **bag and mask** and experienced senior help summoned (if available)

Circulation

- Try to obtain vascular access to give boluses quickly. Insert IV cannula and send blood for full blood count, urea and electrolytes, cross-match (if anaemic) and clotting. If peripheral veins are difficult to access, external jugular or long saphenous vein cut-down are good alternatives. If a skilled person is available an internal jugular vein central line is ideal since it can also allow CVP measurements (if available).
- Give initial **rapid** bolus 10ml/Kg of 0.9% saline **or** Hartmanns. It is essential that the bolus is given as rapidly as possible. **Do not use 5% glucose or 0.18% saline/4% glucose solutions for resuscitation which can be dangerous (hyponatraemia and cerebral oedema).** In the absence of syringe pumps, boluses should be manually pushed in using 20-50ml syringe (using a 3 way tap and link to an IV giving set)
- Further 10ml/Kg boluses will usually be required if shock continues. Once a **total** of 40ml/Kg of boluses have been given IV, complications such as pulmonary oedema may occur. If available, expert help, including CVP monitoring are essential.
- Keep patient warm but do not overheat as will cause peripheral vasodilatation and reduce blood to vital centers. Hypothermia will exacerbate poor peripheral perfusion, acidosis and coagulation abnormalities.
- Elevate legs (raise foot of bed)
- Give a 10ml/Kg bolus of fresh blood as soon as possible if severe anaemia is present but watch for circulatory overload
- Consider broad spectrum IV antibiotics
- A central venous pressure (CVP) line is ideal for avoiding under-transfusion or fluid overload. Insertion should not delay initial resuscitation but if peripheral access is inadequate this route may be used for volume replacement. If DIC established, CVP insertion is hazardous (especially subclavian vein).

If IV access is not possible (often veins are collapsed) consider intraosseous needle (see procedures chapter page ...).

If the child has a reduced level of consciousness or has a convulsion, particularly an infant or young child, hypoglycaemia may be present. Always measure the blood glucose in this situation. However, if blood glucose measurement is not possible, always treat as for presumed hypoglycaemia and, in addition to the IV fluids given above, give 5ml/Kg of 10% glucose IV or, if no IV access, by intra-osseous needle.

If shock has been treated, reassess the child every 15–30 minutes until signs of shock have resolved.

2. Severe dehydration but without shock (10% or more fluid deficit) (WHO plan C)

The deficit is >/= 100ml/Kg

Children with severe dehydration but who are not shocked require rapid IV rehydration with close monitoring, which is followed by oral rehydration once the child starts to improve sufficiently.

When the child's level of consciousness returns to normal, he or she can take the remaining estimated deficit by mouth.

Assess hydration status frequently.

In areas where there is a cholera outbreak, give an antibiotic effective against cholera.

While the intravenous cannula is being sited, give ORS solution if the child can drink.

Note: The best IV fluid solution is Ringer's lactate Solution (also called Hartmann's Solution for Injection). If Ringer's lactate is not available, Normal Saline solution (0.9% NaCl) can be used. **Do not use 5% glucose or 0.18% saline/4% glucose solutions which can be dangerous causing hyponatraemia and cerebral oedema.**

Step 1 give 100 ml/kg of the chosen solution divided as shown below:

Give 30 ml/kg IV over 1 hour IV for infants < 1 year and IV over 30 minutes for children older than 1 year
Then, give 70 ml/kg IV over 5 hours for infants < 1 year and IV over 2.5 hours for children older than 1 year

For more information, see WHO Treatment Plan C (Appendix). This includes guidelines for giving ORS solution by nasogastric tube or by mouth when IV therapy is not possible.

If the child develops signs of fluid overload, stop the infusion.

If the child has a reduced level of consciousness or has a convulsion, particularly an infant, hypoglycaemia may be present. Always measure the blood glucose in this situation.

However, if blood glucose measurement is not possible, always treat as for presumed hypoglycaemia and in addition to the IV fluids given above, give 5ml/Kg of 10% glucose IV or if no IV access give intraosseously.

Sublingual sugar (sucrose) for treatment of hypoglycaemia

Sublingual sugar may be used as immediate 'first aid' measure in managing hypoglycaemia in a conscious child in situations where IV administration of glucose may be impossible or delayed.

Give 1 teaspoonful of sugar moistened with 1-2 drops of water under the tongue. More frequent

repeated doses are needed to prevent relapse. Children should be monitored for early swallowing which leads to delayed absorption, and in this case another dose of sugar should be given. If sublingual sugar is given, repeat doses at 20 minute intervals.

Recheck the blood glucose in 20 minutes and if the level is low (<2.5 mmol/litre or <45mg/dl), repeat the IV glucose (5 ml of 10% glucose/kg) or repeat sublingual sugar.

Prevent further hypoglycaemia by feeding; where possible (see above). If IV fluids are being given prevent hypoglycaemia by adding 10 or 20 ml of 50% glucose to 90 ml or 80ml of Ringer's lactate or 0.9% saline to give respectively a 5% or 10% glucose solution (see).

Ongoing care

If severe hydration is not improving, give the IV solution more rapidly. Thereafter, reassess the child by checking skin pinch, level of consciousness, and ability to drink, at least every hour, in order to confirm that hydration is improving. Sunken eyes recover more slowly than other signs and are less useful for monitoring.

When the full amount of IV fluid has been given, reassess the child's hydration status fully.

If signs of severe dehydration are still present, repeat the IV fluid infusion as outlined above.

Persistent severe dehydration after IV rehydration is unusual; it usually occurs only in children who pass large watery stools frequently during the rehydration period, for example during cholera.

If the child is improving but still shows signs of some dehydration, discontinue IV treatment and give low osmolarity ORS solution for 4 hours (see below and Treatment Plan B). If the child is normally breastfed, encourage the mother to continue breastfeeding frequently.

If there are no signs of dehydration, follow the guidelines below and WHO Treatment Plan A,. Where appropriate, encourage the mother to continue breastfeeding frequently. Observe the child for at least 6 hours before discharge home, to confirm that the mother is able to maintain the child's hydration by giving ORS solution.

All children should start to receive some ORS solution (about 5ml/kg/hour) by cup when they can drink without difficulty (usually within 3–4 hours for infants, or 1–2 hours for older children). This provides additional base and potassium, which may not be adequately supplied by the IV fluid.

3. Moderate (some) dehydration (5-9% fluid deficit) WHO treatment plan B see Appendix

- Low osmolarity ORS should be administered
- The initial amount of fluid administered for rehydration is shown
- The deficit is 50-90ml/Kg

4. Mild or no dehydration (< 5% dehydration) WHO treatment plan A

In acute diarrhoea without dehydration, omit the rehydration phase of therapy and start maintenance therapy immediately.

- Commence oral rehydration with 50 ml/kg over 2-4 hours.
- The parent gives small amounts of fluid (for example one teaspoon) containing 50-90 mEq/litre of sodium (for example ORS) frequently.
- Gradually increase the amount, as tolerated using teaspoon, syringe, medicine dropper, cup or glass.
- Reassess hydration after 2-4 hours, then progress to the maintenance phase or continue rehydration

Electrolyte disturbances

Knowing the levels of serum electrolytes rarely changes the management of children with diarrhoea. Indeed, these values are often misinterpreted, leading to inappropriate treatment. It is usually not helpful to measure serum electrolytes. The disorders described below are usually adequately treated by oral rehydration therapy (ORT) with low osmolarity ORS solution.

Hypernatraemia

Some children with diarrhoea develop hypernatraemic dehydration, especially when given drinks that are hypertonic owing to their content of sugar (e.g. soft drinks, commercial fruit drinks) or salt. These draw water from the child's tissues and blood into the bowel, causing the concentration of sodium in extracellular fluid to rise. If the solute in the drink is not fully absorbed, the water remains in the bowel, causing osmotic diarrhoea.

Children with hypernatraemic dehydration (serum Na+ > 150 mmol/litre) have thirst that is out of proportion to other signs of dehydration. Their most serious problem is convulsions, which usually occur when the serum sodium concentration exceeds 165 mmol/litre, and especially when intravenous therapy is given. Seizures are much less likely when hypernatraemia is treated with ORS solution, which usually causes the serum Na^+ concentration to become normal within 24 hours.

It is absolutely essential that intravenous rehydration does not lower the serum Na^+ too rapidly. Intravenous glucose solutions (5% glucose or 0.18% saline/4% glucose) are particularly dangerous and can result in cerebral oedema, usually fatal or permanently disabling.

Hyponatraemia

Children with diarrhoea who drink mostly water, or watery drinks that contain little salt, may develop hyponatraemia (serum Na+< 130 mmol/litre). Hyponatraemia is especially common in children with shigellosis and in severely mal-nourished children with oedema. Hyponatraemia is occasionally associated with lethargy and, less often, seizures. ORS solution is safe and effective therapy for nearly all children with hyponatraemia. An exception is children with oedema, for whom ORS solution may provide too much sodium. ReSoMal may be helpful here.

Hypokalaemia

Inadequate replacement of potassium losses during diarrhoea can lead to potassium depletion and hypokalaemia (serum K+< 3 mmol/litre), especially in children with malnutrition. This can cause muscle weakness, paralytic ileus, impaired kidney function and cardiac arrhythmias. Hypokalaemia is worsened when base (bicarbonate or lactate) is given to treat acidosis without simultaneously providing potassium. Hypokalaemia can be prevented, and the potassium deficit corrected, by using ORS solution for rehydration therapy and by giving foods rich in potassium during diarrhoea and after it has stopped (bananas, coconut water, dark green leafy vegetables).

It is also essential to check blood potassium, especially if the child has not passed urine, prior to replacing potassium to avoid complications of hyperkalemia secondary to pre-renal failure.

If it is necessary to give potassium intravenously (for instance serum K^+ < 2.0mmol/litre or ECG signs of hypokalaemia: ST depression, T wave reduction and prominent U waves) then great care must be taken. In acute depletion, an infusion at the rate of 0.2 mmol/kg/hour can be used and the serum K^+ checked after 3 hours. The potassium for injection MUST be diluted before use and thoroughly mixed before being given. **The maximum concentration of potassium that can be given through a peripheral vein is 40 mmol/litre. The maximum infusion rate of potassium is 0.5 mmol/kg/hour.**

Note: The injectable form of KCl usually contains 1.5 g that is 20 mmol of potassium in 10 ml and can be given orally. The daily requirement of K+ is 2.5-3.5 mmol/kg.

Dietary therapy

During diarrhoea, a decrease in food intake, lack of nutrient absorption and increased nutrient requirements combine to cause weight loss and failure to grow. In turn, malnutrition can make the diarrhoea more severe, more prolonged and more frequent, compared with diarrhoea in non-malnourished children. Therefore give nutrient-rich foods during the diarrhoea and when the child is recovering.

- **Breastfed infants:** Continue feeding on demand.
- **Bottle-fed infants:** Administer full-strength formulas immediately after rehydration (no longer than 4 hours). Lactose intolerance may develop and cause an exacerbation of diarrhoea with a lactose-containing formula. If this happens, temporarily reduce or remove lactose from the diet.
- **Older children:** Continue their usual diet during diarrhoea. Recommended foods include starches, cereals, yoghurt, fruits and vegetables. Foods high in simple sugars and fats should be avoided. Excess fluid losses via vomiting or diarrhoea must be replaced with ORS (see above).

Drug therapy: use of antimicrobials and "anti-diarrhoeal" drugs

Antimicrobials should not be used routinely. This is because, except as noted below, it is not possible to distinguish clinically episodes that might respond, such as diarrhoea caused by enterotoxigenic E. coli, from those caused by agents unresponsive to antimicrobials, such as rotavirus or *Cryptosporidium.* Moreover, even for potentially responsive infections, selecting an effective antimicrobial requires knowledge of the likely sensitivity of the causative agent, information that is usually unavailable. In addition, use of antimicrobials adds to the cost of treatment, risks adverse reactions and enhances the development of resistant bacteria. **Antimicrobials are reliably particularly helpful only for children with bloody diarrhoea (probable shigellosis), suspected cholera with severe dehydration, and serious non-intestinal bacterial infections such as pneumonia. Antiprotozoal drugs are rarely indicated except as indicated below when a definite diagnosis is available.**

Antimicrobials for acute diarrhoea

Neonates

Diarrhoea and vomiting may be a symptom of septicaemia. If septicaemia is suspected parenteral antibotics are required (see Section 11).

Bloody diarrhoea

- **Bacterial causes:** *Campylobacter jejuni, Shigella sonnei, Sh. flexneri* and *Sh. dysenteriae,* and less commonly *salmonella, E. coli*0157:117 and *Aeromonas.*
- May be accompanied by abdominal pain and rectal prolapse.
- As culture facilities may not be available, sick, toxic children with bloody diarrhoea should be treated for shigella dysentery. Mild infections due to *Sh. sonnei* are usually self-limiting. *Shigella* in disadvantaged countries are commonly resistant to co-trimoxazole and ampicillin. Nalidixic acid, ciprofloxacin, ceftriaxone **or antibiotic of choice for the area,** should be used for a 5-day course. In infants with bloody diarrhoea due to systemic infection, give ceftriaxone 75 mg/kg IV/IM once daily for 5 days.
- In infants and young children, exclude surgical causes (e.g. intussusception).

Salmonella

If non-typhoidal *Salmonella* is suspected in infants under 1 year of age or in immunocompromised children, blood cultures should be undertaken. If positive or the infant is toxic, an appropriate parenteral antibiotic should be given for example chloramphenicol or ceftriaxone or ciprofloxacin for 7-10 days. Look out for pneumonia or metastatic abscesses in bone, brain or elsewhere. Otherwise *Salmonella* gastroenteritis is not treated with antibiotics.

Note: Systemic *Salmonella* infection is common in malnutrition, HIV infection, sickle cell disease and schistosomiasis.

Campylobacter jejuni *(also* Shigella *and* Salmonella) may cause severe abdominal pain, mimicking a surgical emergency. Otherwise the disease is self-limiting and does not require antibiotics. If treatment is considered appropriate, erythromycin (12.5 mg/kg 4 times daily) for 5 days is the antibiotic of choice.

Other causes of diarrhoea warranting antimicrobial treatment

- **Amoebic dysentery:** diagnosed by microscopy of fresh, warm stool. Treatment is metronidazole 50 mg/ kg once daily (maximum dose = 2 g) for 5-7 days.
- **Cholera:** is usually only diagnosed during epidemics. If child has severe watery diarrhoea, suspect cholera or enterotoxigenic *E. coli* (only diagnosed by specialist laboratories). Treatment for cholera: tetracycline 50 mg/kg for 3 days in children >8 years. Alternative in young children is chloramphenicol 25 mg/kg 8 hourly for 3 days. In addition to rehydration, give antibiotic to which local strains of *Vibrio cholerae* are sensitive. These include tetracycline, doxycycline, co-trimoxazole, erythromycin and chloramphenicol.
- **Giardiasis:** diagnosed by microscopy of stool is usually self-limiting or asymptomatic. If symptomatic in a malnourished child or the disease is prolonged, it is justified to treat with metronidazole for 5 days (as for amoebic dysentery). Tinidazole is an alternative (50 mg/kg for 5 days).
- **Clostridium difficile** usually occurs after a course of antibiotics for some other illness and is associated with antibiotic-associated pseudomembranous colitis (danger of bowel perforation). Antibiotics, especially clindamycin, may alter the flora of the gastrointestinal tract and allow overgrowth of *C. difficile. C. difficile* produces a toxin which causes damage to gut mucosa resulting in pseudomembranous colitis. Confirmation is by culture of *C. difficile* in the faeces. Treatment is with oral vancomycin for 7-10 days which clears *C. difficile* from the gut. Dose: 10 mg/kg four times daily for older children (maximum dose in a day = 2 g).

Antidiarrhoeal" drugs and antiemetics have no practical benefits for children with acute or persistent diarrhoea. They do not prevent dehydration or improve nutritional status, which should be the main objectives of treatment. *Some, like loperamide, have dangerous, and sometimes fatal, side effects. These drugs should never be given to children below 5 years.*

Treatment of rectal prolapse

Gently push back using a surgical glove or wet cloth or if oedematous and cannot be reduced, warm compresses of magnesium sulphate may reduce the oedema.

Haemolytic uraemic syndrome

If lab tests are not available, suspect when purpura, pallor, altered consciousness and low or absent urine output are present. If lab tests are available, blood smear shows fragmented red cells and decreased or absent platelets. There will be an increase in blood urea and creatinine.

Adapted WHO Treatment Plan C: intravenous rehydration therapy for patients with severe dehydration

The preferred treatment for children with severe dehydration is rapid intravenous rehydration in hospital. Guidelines for IV rehydration are given in the Table below.

Children who can drink, even poorly, should be given ORS solution by mouth until the intravenous drip is running. In addition, all children should start to receive some ORS solution (about 5 ml/kg/hour) when they can drink without difficulty, which is usually within 3-4 hours (for infants) or 1-2 hours (for older patients). This provides additional base and potassium, which may not be adequately supplied by the intravenous fluid.

The most widely commercially available solution for use in intravenous rehydration is Ringer's lactate solution (Na+ = 131mmol/litre; K+ = 5mmol/litre; HCO_3 = 29 mmol/litre; Ca^2+ = 2 mmol/litre) (also

called Hartmann's Solution for Injection). It supplies an adequate concentration of sodium and sufficient lactate (which is metabolised to bicarbonate) for the correction of acidosis. The concentration of potassium is low and there is no glucose to prevent hypoglycaemia. This can be corrected by adding 100 ml of 50% glucose to 500 ml of Ringer's lactate solution giving approximately a 10% glucose solution (50 ml gives a 5% solution). It can be used in all age groups for the initial treatment of severe dehydration caused by acute diarrhoea of any aetiology.

If Ringer's lactate solution is not available, 0.9% saline may be used (again with 5 or 10% glucose as for Ringer's above) but it does not contain a base to correct acidosis and does not replace potassium losses.

	Ringer's lactate or N Saline	
AGE	First give: 30ml/Kg	Then give:70ml/Kg
Infants under 12 months	Over 1 hour (repeat once if shock is still present)	Over 5 hours
Older child	Over 30 minutes (repeat once if shock is still present)	Over 2.5 hours

Ringer's Lactate Solution or 0.9% saline already prepared with 5% glucose have the added advantage of providing glucose to help prevent hypoglycaemia without needing the addition of 50% glucose.

Plain glucose (5% dextrose) solutions or 0.18% saline in 5% dextrose MUST NOT be used since they do not contain enough electrolytes and thus does not correct the electrolyte losses or the acidosis. It does not effectively correct hypovolaemia and can produce dangerous hyponatraemia.

When the planned amount of intravenous fluid has been given (after 3 hours for older patients, or 6 hours for infants), the child's hydration status should be reassessed fully.

Look and feel for all the signs of dehydration:

- If signs of severe dehydration are still present, **repeat** the intravenous fluid infusion as outlined in Treatment Plan C. This is very unusual, however, occurring only in children who pass large watery stools frequently during the rehydration period
- If the child is improving but still shows signs of some dehydration, **discontinue** the intravenous infusion and give ORS solution for 4 hours, as specified in Treatment Plan B (see above)
- If there are no signs of dehydration, follow Treatment Plan A (see above). If possible, observe the child for at least 6 hours before discharge while the mother gives the child ORS solution, to confirm that she is able to maintain the child's hydration. Remember that the child will require therapy with ORS solution until the diarrhoea stops.

If the child cannot remain at the treatment centre, teach the mother how to give treatment at home following Treatment Plan A, give her enough ORS packets for 2 days and teach her the signs that indicate she should bring her child back.

Table Guidelines for intravenous treatment of children with severe dehydration

- Start IV fluids immediately. If the patient can drink, give ORS by mouth until the drip is set up. Give 100mI/kg Ringer's lactate solution divided as indicated above
- Reassess the patient every 1-2 hours. If hydration is not improving, give the intravenous drip more rapidly.

- After 6 hours (infants) or 3 hours (older patients), re-evaluate the patient. Then choose the appropriate Treatment Plan A (see above), B (above) or continue Treatment Plan C.

Monitoring the progress of intravenous rehydration

Patients should be reassessed every 15-30 minutes to exclude the development of shock. Thereafter, they should be reassessed at least every hour to confirm that hydration is improving. If it is not, the intravenous drip should be given more rapidly.

What to do if intravenous therapy is not available

If intravenous therapy is not available at the facility, but can be given nearby (i.e. within 30 minutes), send the child immediately for intravenous treatment. If the child can drink, give the mother some ORS solution and show her how to give it to her child during the journey.

If intravenous therapy is not available nearby, health workers who have been trained can give ORS solution by nasogastric tube, at a rate of 20 ml/kg body weight per hour for 6 hours (total of 120 ml/kg body weight). If the abdomen becomes swollen, ORS solution should be given more slowly until the abdomen becomes less distended.

If nasogastric treatment is not possible but the child can drink, ORS solution should be given by mouth at a rate of 20 ml/kg body weight per hour for 6 hours (total of 120 ml/kg body weight). If this rate is too fast, the child may vomit repeatedly. In that case, give ORS solution more slowly until vomiting subsides.

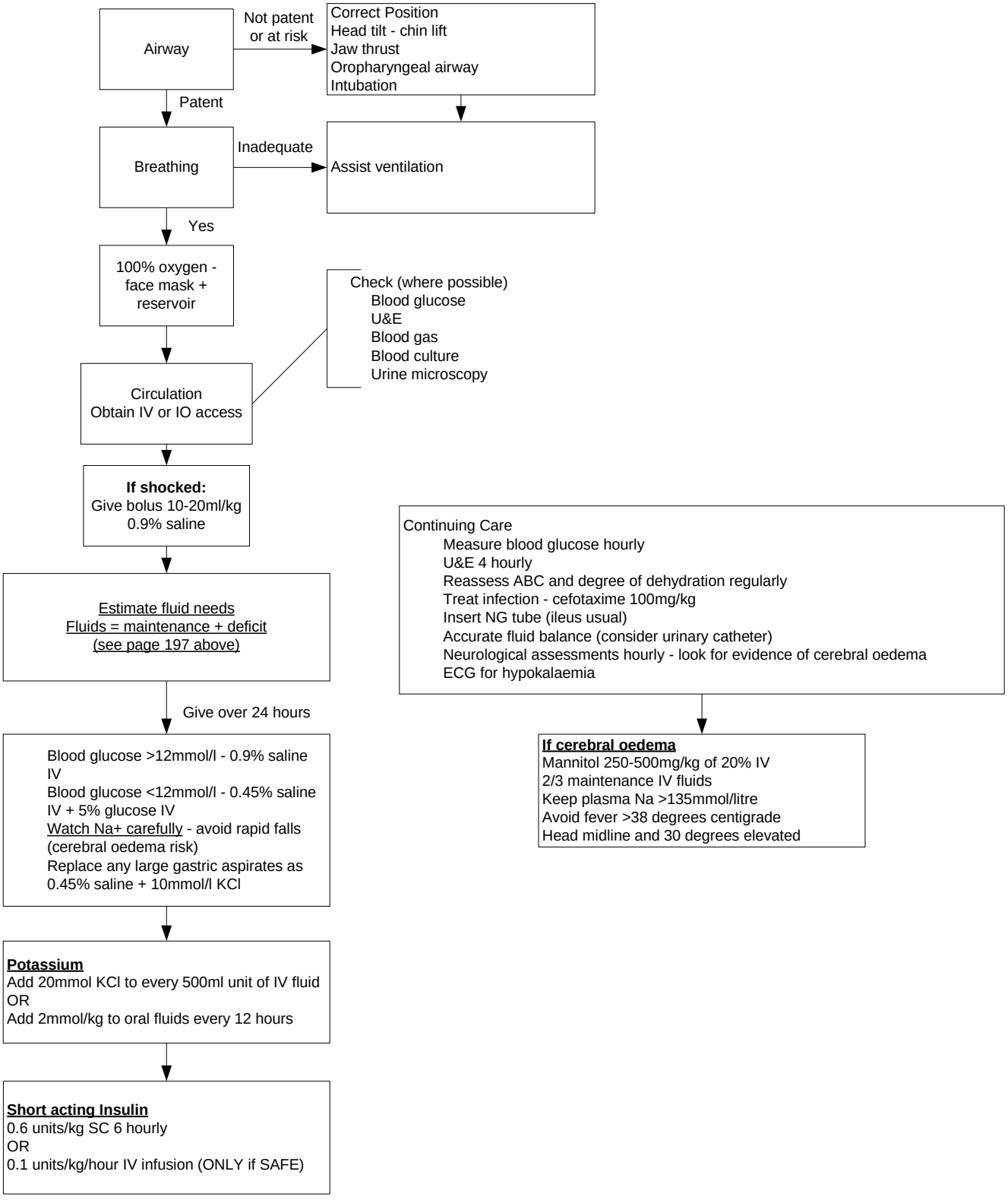
Children receiving nasogastric or oral therapy should be reassessed at least every hour. If the signs of dehydration do not improve after 3 hours, the child must be taken immediately to the nearest facility where intravenous therapy is available. Otherwise, if rehydration is progressing satisfactorily, the child should be reassessed after 6 hours and a decision on further treatment made as described above for those given intravenous therapy.

If neither nasogastric nor oral therapy is possible, the child should be taken immediately to the nearest facility where intravenous or nasogastric therapy is available.

Diabetic Ketoacidosis (IMEESC 13.8)

DKA is the commonest endocrine emergency and should be suspected in any patient presenting with dehydration, abdominal pain, ketotic breath, altered level of consciousness. The mainstay of treatment is to correct dehydration; reduced blood glucose levels and treat any intercurrent infection. The most serious acute complication of DKA is cerebral oedema (mortality rate 80%) which is thought to be due to over vigorous resuscitation

Pathway of care for DKA



Septicaemia

In septic shock, the cardiac output may be normal or raised, but fail to deliver as much oxygen as the body needs. This is partly due to the changes in small blood vessels which become dilated and leaky, so blood is not distributed normally. In addition, in septic shock, cells do not take up oxygen as effectively.

Features of septic shock
- Fever
- Hyperventilation
- Tachycardia
- Prolonged capillary refill
- Altered mental state

Late signs
- Hypotension
- Irregular or slow pulse or breathing pattern

Meningococcal septicaemia
- Purpuric non-blanching rash
- 7% no rash; 15% blanch
- not always associated with meningitis

Toxic shock syndrome
- high fever, headache, confusion
- red conjunctivae and oral mucosa
- scarletiniform rash+ desquamation
- subcutaneous oedema
- vomiting and watery diarrhoea

Non-typhoidal salmonella
Common in malarial areas

It can be difficult to tell the difference between severe dehydration and septic shock in the malnourished child. Always treat for septic shock.

Resuscitation in septic shock
- Oxygen – consider assisting ventilation if respiratory effort is great, or oxygenation poor
- Fluids – start with 20ml/kg and repeat
- After 40ml/kg, the child will need ventilatory support
- Check glucose and correct hypoglycaemia with 5ml/kg 10% glucose
- Give ceftriaxone 100mg/kg/IV as soon as possible (add ampicillin in neonates) (WHO Benzyl penicillin + chloramphenicol)
- Check and treat any clotting abnormality with vit K, FFP, platelets if available
- Inotropes e.g. dobutamine 5 – 20 mcg/kg/min, or adrenaline 0.05 – 2 mcg/kg/min may be needed and expert advice should be sought
- Correct any fall in potassium or calcium-if possible monitor acid base.

Dengue Haemorrhagic Fever
Dengue Haemorrhagic Fever-DHF with shock DSS- Dengue Shock Syndrome

Plasma leakage, sometimes sufficient to cause shock, is the most important complication of DHF in children. The patient is considered to have shock if he/she has a rapid pulse rate and signs of poor capillary perfusion (, weak pulse volume, cold extremities, delayed capillary refill-greater than 3 seconds). Hypotension is usually a late sign. The pulse pressure (i.e. the difference between the systolic and diastolic pressures) is usually ≤ 20 mm Hg in DSS. Shock often occurs on day 4–5 of illness. Early presentation with shock (day 2 or 3 of illness), very narrow pulse pressure (≤ 10 mm Hg), or undetectable pulse and blood pressure suggest very severe disease (-DSS.
Other complications of dengue include skin and/or mucosal bleeding and, occasionally, hepatitis and encephalopathy. However, most deaths occur in children with profound shock, particularly if the situation is complicated by fluid overload (see below).

Diagnosis

Suspect severe dengue in an area of dengue risk if a child has fever lasting more than 2 days plus any of the following features:

- evidence of plasma leakage
    - high or progressively rising haematocrit
    - pleural effusions or ascites
- circulatory compromise or shock
    - cold, clammy extremities
    - prolonged capillary refill time (greater than 3 seconds)
    - weak pulse (fast pulse may be absent even with significant volume depletion)
    - narrow pulse pressure (see above)
- spontaneous bleeding
    - from the nose or gums
    - black stools or coffee-ground vomit
    - skin bruising or extensive petechiae
- altered conscious level
    - lethargy or restlessness
    - coma
    - convulsions
- severe gastrointestinal involvement
    - persistent vomiting
    - increasing abdominal pain with tenderness in the right upper quadrant
    - jaundice

Treatment

Admit all patients with severe dengue to a hospital with facilities for urgent IV fluid treatment and blood pressure and haematocrit monitoring.

Fluid management – patients without shock (usually with a Pulse pressure >20 mm Hg)

- Give IV fluids for repeated vomiting or a high or rapidly rising haematocrit.
- Give only isotonic solutions such as Ringer's lactate, Hartmanns solution or N Saline
- Start with 6 ml/kg/hour for two hours, then reduce to 2–3 ml/kg/hour as soon as possible depending on the clinical response.
- Give the minimum volume required to maintain good perfusion and urine output. IV fluids are usually only needed for 24–48 hours since the capillary leak resolves spontaneously after this time.
- Monitor closely for hypoglycaemia and provide bolus injections of 5ml/Kg 10% glucose IV as required

Fluid management – patients with shock DSS (Pulse pressure ≤ 20 mm Hg)

- Treat as an emergency.
- Give high concentration oxygen by face mask with a reservoir.
- Give 20 ml/kg of an isotonic crystalloid solution such as Ringer's lactate or Hartmanns solution or 0.9% saline as rapidly as possible. If IV access is not possible because of shock, give fluids intraosseously.
- If there is no detectable pulse or BP then IV colloid 20ml/Kg should be given (3% gelatin, dextran 70, hetastarch) as rapidly as possible as a bolus

  - If the child responds (capillary refill and peripheral perfusion start to improve, pulse pressure widens), reduce to 10 ml/kg for one hour and then gradually to 2–3 ml/kg/hr over the next 6–8 hours.
  - If the child does not respond (continuing signs of shock), give a further 20 ml/kg of the crystalloid or colloid rapidly Revert to the lower volume crystalloid schedule of 10ml/Kg over 1 hour and then 2-3ml/Kg/hour as soon as possible.
- Further small boluses of extra IV isotonic crystalloid fluid (5–10 ml/kg) may need to be given during the next 24–48 hours.
- Make fluid treatment decisions based on clinical response, i.e. review vital signs hourly and monitor urine output closely. Changes in the haematocrit can be a useful guide to treatment but must be interpreted together with the clinical response. For example, a rising haematocrit together with unstable vital signs (particularly narrowing of the pulse pressure) indicates the need for a further bolus of fluid, but extra fluid is not needed if the vital signs are stable even if the haematocrit is very high (50–55%). In these circumstances continue to monitor frequently and it is likely that the haematocrit will start to fall within the next 24 hours as the reabsorptive phase of the disease begins.

Fluid overload is an important complication of DSS and the treatment given for shock. It can develop due to:

- excess IV fluids
- incorrect use of hypotonic rather than isotonic crystalloid solutions
- continuation of IV fluids for too long (once plasma leakage has resolved)
- necessary use of large volumes of IV fluid in children with catastrophic leak.

If fluid overload is within the circulation then pulmonary oedema can occur. Constantly observe the patient for signs of **circulatory** fluid overload as manifest by the following: gallop rhythm, enlarged liver and, pulmonary oedema (fast breathing, fine basal crackles on auscultation and worsening hypoxaemia with cyanosis).

If present:

- Give oxygen if not already underway to keep oxygen saturations 94-98%
- stop IV fluids
- apply positive pressure ventilation (ideally non-invasive by nasal continuous positive airway pressure OR positive pressure ventilation after intubation (anaesthetist needed)
- If positive pressure is not available then sit the patient up and frusemide may have to be given 2mg/Kg Iv and repeat after 1 hour

Children who remain in shock and show signs of severe fluid overload are extremely difficult to manage and have a high mortality.

Repeated small boluses of a colloid solution may help, together with high doses of inotropic agents to support the circulation (see standard textbooks of paediatrics).

Avoid diuretics since they will lead to further intravascular fluid depletion unless there is pulmonary oedema and positive pressure support is not available or ineffective.

Aspiration of large pleural effusions or ascites may be needed to relieve respiratory symptoms but there is the risk of bleeding from the procedure.

If shock has resolved but the child has fast or difficult breathing and large pleural effusions, give oxygen therapy.

If shock has resolved and the child is stable, stop IV fluids and keep the child on strict bed rest for 24–48 hours. Excess fluid will be reabsorbed and lost through urinary diuresis.

In most cases, IV fluids can be stopped after 36–48 hours.

Treatment of haemorrhagic complications

Mucosal bleeding may occur in any patient with dengue but is usually minor. It is due mainly to the low platelet count, and this usually improves rapidly during the second week of illness.

If major bleeding occurs it is usually from the gastrointestinal tract, particularly in patients with very severe or prolonged shock. Internal bleeding may not become apparent for many hours until the first black stool is passed. Consider this in children with shock who fail to improve clinically with fluid treatment, particularly if the haematocrit is stable or falling and the abdomen is distended and tender.

In children with profound thrombocytopenia (<20,000 platelets/mm3), ensure strict bed rest and protection from trauma to reduce the risk of bleeding. Do not give IM injections.

Monitor clinical condition, haematocrit and, where possible, platelet count.

Transfusion is rarely necessary. When indicated it should be given with extreme care because of the problem of fluid overload. If a major bleed is suspected, give 5–10 ml/kg **fresh** whole blood slowly over 2–4 hours and observe the clinical response. Consider repeating if there is a good clinical response and significant bleeding is confirmed.

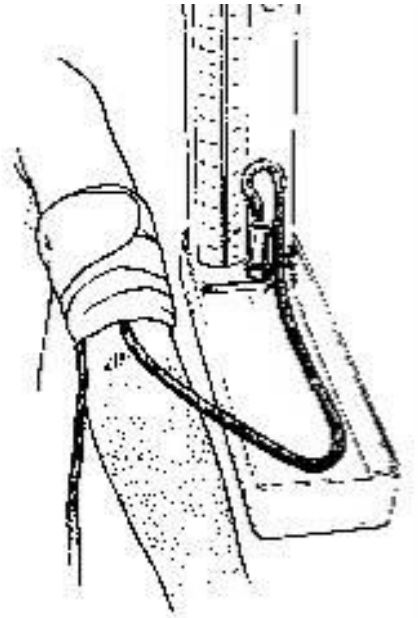
Platelet concentrates (if available) should only be given if there is severe bleeding. They are of no value for the treatment of thrombocytopenia without bleeding and are likely to be harmful.

Supportive care

- Treat high fever with paracetamol if the child is uncomfortable. **Do not give aspirin or non-steroidals such as ibuprofen or diclofenac as this will aggravate the bleeding.**
- Do not give steroids.
- Convulsions are not common in children with severe dengue. But if they occur, manage as outlined below.
- If the child is unconscious see below
- Children with shock or respiratory distress should receive oxygen
- Hypoglycaemia (blood glucose <2.5 mmol/litre or <45 mg/dl) is unusual but if present, give IV glucose

Monitoring

- In children with shock, monitor the vital signs hourly (particularly the pulse pressure, if possible) until the patient is stable, and check the haematocrit 3–4 times per day. The doctor should review the patient at least four times per day and only prescribe intravenous fluids for a maximum of 6 hours at a time.
- For children without shock, nurses should check the child's vital signs (temperature, pulse and blood pressure) at least four times per day and the haematocrit once daily, and a doctor should review the patient at least once daily.
- Check the platelet count daily, where possible, in the acute phase.
- Keep a detailed record of all fluid intake and output.



Tourniquet test in Dengue Haemorrhagic Fever

Apply BP cuff inflated to level of mean arterial pressure (systolic + diastolic, divided by 2). Leave inflated for 5 minutes; a positive test is if there are ≥10 petechiae in 1 sq inch after the cuff is removed

Typhoid

Clinical features

The classic step-ladder rise of fever is relatively rare in childhood.

Although data from South America and other parts of Africa suggest that typhoid may present as a mild illness in young children, this may vary in different parts of the world. There is emerging evidence from South Asia from both community and facility settings that the presentation of typhoid may be more dramatic in children under 5 years of age, with comparatively higher rates of complications and hospitalisation. Diarrhoea, toxicity and complications such as disseminated intravascular complications are also more common in infancy, with higher case fatality rates. However, some of the other features of typhoid fever seen in adults, such as relative bradycardia, are rare and rose spots may only be visible at an early stage of the illness in fair-skinned children.

Multidrug resistant - MDR typhoid appears to be a more severe clinical illness with higher rates of toxicity, complications and case fatality rates. This appears to be a consistent finding and potentially related to the increased virulence of MDR *S. typhi* as well as higher rates of bacteraemia. In endemic areas, therefore, it may be prudent to treat all severely ill, toxic children, especially those requiring hospitalisation, with second-line antibiotics.

Acute perforation of the intestine with haemorrhage and peritonitis can occur. This presents with severe abdominal pain, vomiting, abdominal tenderness, severe pallor and shock. An abscess may form together with enlargement of the liver and spleen.

Diagnosis of typhoid

The sensitivity of blood cultures in diagnosing typhoid fever in many parts of the developing world is limited, as microbiological facilities may be basic and widespread antibiotic prescribing may render bacteriological confirmation difficult. Although bone marrow and duodenal fluid cultures may increase the likelihood of bacteriological confirmation of typhoid, these are difficult to obtain and invasive.

The serological diagnosis of typhoid is also fraught with problems as a single Widal test may be positive in only 50% of cases in endemic areas, and serial tests may be required in cases presenting in the first week of illness. Newer serological tests such as a dot-ELISA, co-agglutination and the Tubex® are promising, but are comparatively expensive, may not be effective in primary care settings and have yet to find widespread acceptability.

The mainstay of diagnosis of typhoid in endemic areas therefore remains clinical. **Thus any high-grade fever of >72 hours' duration associated with any of the aforementioned features, especially with no localizing upper respiratory signs or meningitis or malaria, must be suspected as typhoid and managed accordingly.** While leucopenia (white cell count $<4x10^9$/litre) with a left shift in neutrophils, may be seen in a third of children, young infants may also commonly present with a leucocytosis.

Treatment of typhoid

Making an early diagnosis of typhoid fever and instituting appropriate supportive measures and specific antibiotic therapy is the key to the appropriate management of typhoid fever. The following are the important principles of management:

- Adequate rest, hydration and attention to correction of fluid-electrolyte imbalance
- Antipyretic therapy (paracetamol) as required if fever >39°C
- Soft, easily digestible diet should be continued unless the child has abdominal distension or ileus
- Regular monitoring for clinical recovery and potential complications
- Antibiotic therapy: the right choice, dosage and duration are critical to curing typhoid with minimal

Common clinical features of typhoid fever in childhood (Karachi, Pakistan)

High-grade fever	95%
Coated tongue	76%
Anorexia	70%
Vomiting	39%
Hepatomegaly	37%
Diarrhoea	36%
Toxicity	29%
Abdominal pain	21%
Pallor	20%
Splenomegaly	17%
Constipation	7%
Headache	4%
Jaundice	2%
Obtundation	2%
Ileus	1%
Intestinal perforation	0.5%

- complications. Traditional therapy with either chloramphenicol or amoxycillin is associated with relapse rates of 5-15% and 4-8% respectively.
- **If drug resistance is not locally a problem,** start with oral chloramphenicol and/or oral amoxicillin/ ampicillin (initially intravenous if vomiting).

- **If drug resistance is prevalent,** use cefixime or ceftriaxone or ciprofloxacin (associated with higher cure rates).

First line treatment is Ciprofloxacin 15mg/kg orally up to 500 mg 7-10 days (or 10 mg/kg i.v. up to 400 mg 12hourly until able to take oral)

If there is severe systemic upset or signs suggesting meningitis drug resistance may be present treat with Ceftriaxone 100 mg/kg daily for 7-10 days or Azithromycin 20 mg/kg i.v. or oral for 5-7 days

Where drug resistance to fluoroquinolones/penicillins among Salmonella typhi isolates is known to be significant then follow national guidelines for typhoid fever. A third generation cephalosporin may be the appropriate drug. As multiple drug resistance is now common in some parts of the world (subcontinent and SE Asia) other first line treatment regimens such as Azithromycin may have to be used.

While epidemics are usually associated with a single dominant clone of *S. typhi,* in endemic situations there may be several coexistent strains of *S. typhi* and a clinical judgment may need to be made when instituting antibiotic therapy before culture results become available. This is particularly important as delay in the institution of appropriate second-line antibiotic therapy in resistant cases of typhoid leads to a significant increase in the morbidity and mortality. Despite the availability of newer orally administrable drugs such as quinolones and third-generation cephalosporins, blanket administration of these agents to all cases of suspected typhoid is expensive and will only lead to the rapid development of further resistance.

Corticosteroids

In severely ill and toxic children with typhoid requiring hospitalisation, past studies with **dexamethasone** IV (0.5-1 mg/kg/day 8 hourly for up to six doses) **may be life-saving in some contexts.** However, **steroids can mask abdominal complications and peritonitis.**

Cardiogenic shock

Causes

- **Abnormal pulse rate or rhythm**
- Congenital cardiac abnormality *(see neonatal section)*
- Cardiomyopathy

Abnormal pulse rate or rhythm - Presentation

- History of palpitations
- Poor feeding
- Heart failure or shock
- Episodes of loss of consciousness

When a child presents in shock or imminent cardiac failure due to an abnormal pulse, the treatment priorities are to secure the airway and breathing, and provide oxygen.
Treatment of the rhythm will depend on a few simple criteria

Most serious diseases or injury states are associated with a sinus tachycardia, which might be as fast as 220 in infants and 180 in children. Sinus tachycardia can be caused by fever, dehydration or blood loss and usually responds to basic resuscitation such as oxygen and fluids.

An abnormally slow rate, bradycardia, is defined as ≤ 60 or a rapidly falling heart rate in a child who is deteriorating. Bradycardia is most commonly a finding that will rapidly lead to cardio-respiratory arrest and is associated with respiratory failure and/or shock. Vigorous resuscitation is required.

Assessment
- Is the child stable or in shock?
- Is the rate too fast or too slow?
- Is the pulse regular or irregular?
- If there is an ECG, are the QRS complexes wide or narrow?
- Is there a non-cardiac cause of the problem?

Emergency treatment

- Airway - Secure the airway with simple opening manoeuvres and adjuncts as necessary
- Breathing - High flow oxygen. Assisted ventilation will be needed if the child is shocked
- Circulation
  - Heart rate < 60
    - start chest compressions and vigorous resuscitation
    - ensure adequate oxygenation
    - give a bolus of fluid 20ml/kg IV or IO
    - try atropine 20mcg/kg and adrenaline 10mcg/kg
    - if organophosphate poisoning, give atropine 50-100mcg/kg IV or IM
  - If heart rate 150 - 180 (up to 220 in infant) no ECG and no history of cardiac disease or exposure to drugs causing VT, presume the child has SVT.
  - If ECG shows SVT (or no ECG available)
    - Apply vagal manoeuvres (ice pack on face; valsalva; firm carotid massage
    - If shocked and access to defibrillator give 0.5, 1 and 2 joules
    - If not shocked or no defibrillator, give IV adenosine 50mcg/kg; followed by 100mcg/kg and 250mcg/kg as necessary
    - If no adenosine or defibrillator, try digoxin
  - If ECG shows VT and the child is shocked
    - Cardiovert with 0.5, 1 then 2joules/kg as needed
    - If no defibrillator, give amiodarone 5mg/kg over 30 mins
    - If no other options available
      - treat hyperkalaemia with calcium gluconate and glucose plus insulin
      - give magnesium sulfate (25-50mg/kg) over a few minutes
  - If poisoning with Tricyclic antidepressants
    - treat with sodium bicarbonate 1mmol/kg followed by phenytoin 15mg/kg over 15 minutes if no improvement

After Resuscitation and Emergency Treatment

After emergency treatment of shock a search should be made for organ damage so that appropriate treatment may be given and further morbidity avoided. The problems are similar but of a lesser degree than those expected following resuscitation from cardiac arrest. The most important consideration is renal function.

Section 12 Quiz 9

When considering the cause of shock, which of the following symptoms and/or signs may indicate the likely cause?

a) if the heart rate is very high and heart failure is present, an arrhythmia may be the cause
b) if there is fever with a non-blanching rash, the child should be treated for septicaemia
c) if there is diarrhea, gastroenteritis is likely
d) diabetic ketoacidosis should be suspected if the child is dehydrated with a history of polyuria

Section 12 Quiz 10

Which of the following are signs of severe dehydration?

a) loss of weight of 10% or more when compared with pre-illness weight
b) no urine output
c) decreased capillary refill (> 3 seconds)
d) decreased conscious level
e) sunken eyes

Section 12 Quiz 11

When considering gastroenteritis in children which of the following statements are true?

(a) in infants, circulatory collapse is always preceded by significant vomiting and diarrhea
(b) if there is moderate dehydration, ORS can be given prior to full history and examination
(c) if there is severe dehydration, deficit, can be calculated by % dehydration x wt (kg) x 5 in ml and replaced over 24 hours in addition to maintenance requirements and ongoing losses.
(d) patients should be reassessed regularly after initiating treatment and treatment modified if necessary
(e) reassessment should include biochemistry if available

Section 12 Quiz 12

During treatment of diabetic ketoacidosis which of the following statements are true?

a) 0.9% saline should be given IV until blood glucose is <12 mmol/L
b) rapid fall in plasma Na+ levels may lead to cerebral oedema
c) insertion of NG tube is recommended
d) total body potassium is increased so potassium supplements are not needed
e) if short-acting insulin is given subcutaneously, 0.6 units/kg is an appropriate initial dose

Section 12 Quiz 13

Which of the following statements regarding septic shock are true?

a) there is always a low cardiac output
b) a prolonged capillary refill time may occur
c) hypotension is an early sign
d) confusion may occur
e) there are similar features to those of severe dehydration in the malnourished child

Section 12 Quiz 14

Which of the following statements regarding Dengue haemorrhagic fever are true?

a) the accompanying shock is treated in a similar way to the shock of meningococcal sepsis
b) it most often affects children in the first year of life
c) it can lead to ascites
d) it may cause coagulation disorders

ANSWERS

9. a,b,c,d **10.** a,b,c,d,e **11.** a,b,d,e **12.** a,b,c,e **13.** b,d,e **14.** a,c,d

The infant or child with acute renal failure

Introduction

Minimum urine output: >1ml/Kg/hour in children
>2ml/Kg/hour in infants

Types

- **Pre-renal**:
  - insult to renal tubule cells from poor perfusion, usually due to shock. This is most commonly associated with gastroenteritis, but must also be thought about in trauma, burns, sepsis and heart failure.
- **Renal:**
  - usually due to the same problem causing pre-renal failure, but is more serious. Other causes include poisoning by drugs eg gentamicin, end stage glomerular diseases and haemolytic-uraemic syndrome. Prognosis depends on whether only tubule cells are damaged or if glomeruli are involved. If damage is confined to the proximal tubule (the most vulnerable part of the kidney), this causes acute tubular necrosis (ATN). This will recover fully in 2 to 4 weeks if health can be retained during period of renal failure. More severe insults damage to some or all glomeruli as well, which are in renal cortex. Glomerular damage is irreversible, and acute cortical necrosis usually results in chronic or end-stage renal failure. No reliable imaging can differentiate ATN from cortical necrosis.
- **Post renal:**
  - Acute complete obstruction is rare. Causes include a stone obstructing urethra, and in patient with single kidney include a ureteric stone, or a pelviureteric junction narrowing.

Diagnosis and initial management of ARF

	Pre-renal Failure	**Renal Failure**
Urine Na+ mmol/l	<10	>10
Urine osmolality ÷ plasma osmolality	>1.5	<1.5
FENa	<1%	>2% **
Microscopy of Urine	no casts	granular/red cell casts
(**Fractional excretion of sodium is the diagnostic test for discriminating between pre-renal and renal failure)		

Pre-renal acute renal failure

- **Clinical diagnosis** reflects **features of shock**
  - usually low BP. However, BP may be unexpectedly high because of powerful renin drive in response to hypovolaemia.
  - abdominal pain (induced by splanchnic ischaemia as blood flow diverted from gut to more vital organs).
- **Laboratory diagnosis** by measuring fractional excretion of sodium **(FENa).** Measure the sodium and creatinine in a simultaneously obtained sample of urine (by catheter if necessary) and blood.

FENa (%) = **U/P sodium** x **P/U creatinine** x **100**

- If FENa <1% , renal tubule cells are still alive, and able to respond to shock by reabsorbing sodium which confirms a diagnosis of pre-renal failure. No other tests, including measurements of osmolality, of urinary Na concentration alone, nor urine microscopy can reliably differentiate pre-renal from established renal failure. Ultrasound looks normal or echo-bright.
- **Treatment is by urgent rehydration**. Give 20 ml/kg as rapidly as possible initially, and repeat if necessary. Thereafter give normal (0.9%) saline to fully correct the fluid deficit within 2 to 4 hours. The deficit can be estimated by multiplying the child's weight by the estimated percentage **dehydration**.
- Once rehydration has started give frusemide 2 mg/kg orally or IV.
- If blood pressure remains markedly depressed after rehydration, it may be due to cardiogenic shock; consider inotropes (if available).

Established acute renal failure

- Laboratory diagnosis FENa is typically > 2% because damaged tubules unable to reabsorb sodium avidly.
- Fluid repletion and frusemide will not result in recovery of renal function.
- If FENa not available, give trial of frusemide (2mg/Kg IV) and consider a fluid challenge if evidence of dehydration
- If not dehydrated (or after correction of dehydration) carefully maintain fluid and electrolyte balance and nutrition while waiting/hoping for recovery.
- Dialysis may be needed (if available).
- If recovery not started by 4 weeks, it is unlikely.

Post-renal ARF

- All cause severe acute colicky abdominal pain: unilateral with ureteric obstruction or lower abdominal with bladder neck obstruction.
- Ultrasound, if available, will reveal stones and dilatation proximal to obstruction.
- Remove or bypass the obstruction. For a bladder neck stone obstruction, catheterise. Pain relief with an opiate and a muscle relaxant may allow time for an obstructing stone in the ureter to pass, or for the intermittent blockage from a pelviureteric junction narrowing to clear. If not, stone removed cystoscopically or by ureterolithotomy, or the upper renal tract drained by insertion of a percutaneous nephrostomy under ultrasound guidance. This may require transfer to another centre

Ongoing management of persistent ARF

- Good general care
- Meticulous fluid balance
- Accurately measure all intake and losses. For babies, stool and urine losses estimated by weighing clean and dirty nappies.
- Insensible water losses: (see appendix for table of estimate of body surface area)
  - 300ml/m2/24 hours or
    - 12ml/Kg/24 hours if > 1 year
    - 15ml/Kg/24 hours if an infant
    - 24ml/Kg/24 hours if a preterm infant
  - Increased in hot climate by around 50%.
  - Best guide is to weigh twice daily.

Adequate nutrition is important but difficult to provide. Aim to

- provide normal calorie intake from carbohydrates and fats
- limit protein intake to about 1 g/kg/day to minimise uraemia.
- Young infants who normally take milk, and children too ill to eat solid food, or with gastrointestinal involvement, will need NG feeding or IV nutrition
- nutrition may have to be delivered in a large fluid volume.
- If there is polyuric renal failure or high non-renal water losses such as from diarrhoea or drain fluids this can be achieved.
- if oligoanuric, it is not possible to give sufficient nutrition without fluid overload leading to hypertension and pulmonary oedema.
- Concentrated fat-based oral feeds can be made up from double cream.
- sophisticated IV fluids with high glucose content and individually adjusted sodium (and bicarbonate) concentrations, tailored to balance losses are usually only available in well resourced settings.

Usually necessary to limit salt intake to prevent sodium retention with hypernatraemia, leading to insatiable thirst, and fluid overload.

Provide some bicarbonate to prevent acidosis, typically at a starting dose of 1 mmol/kg/day sodium bicarbonate (note, 1 ml of an 8.4% sodium bicarbonate solution contains 1 mmol, and 1 g of powder contains 12 mmol)

Dietary potassium must be restricted to avoid hyperkalaemia. Hyperkalaemia causes arrhythmias, especially in ARF where other metabolic changes may exacerbate the risk (for example, hypocalcaemia). Aim to keep plasma potassium < 6.5 mmol/L in an older child and < 7.0 mmol/L in neonates who tolerate hyperkalaemia better.

Dietary phosphate restricted to prevent hyper-phosphataemia. Giving calcium carbonate with the food (eg, 0.5 to 2 grams with each meal) will bind the intestinal phosphate and reduce hyper-phosphataemia as well as improving the tendency to hypocalcaemia.

Blood pressure monitoring and anti-hypertensives may be needed

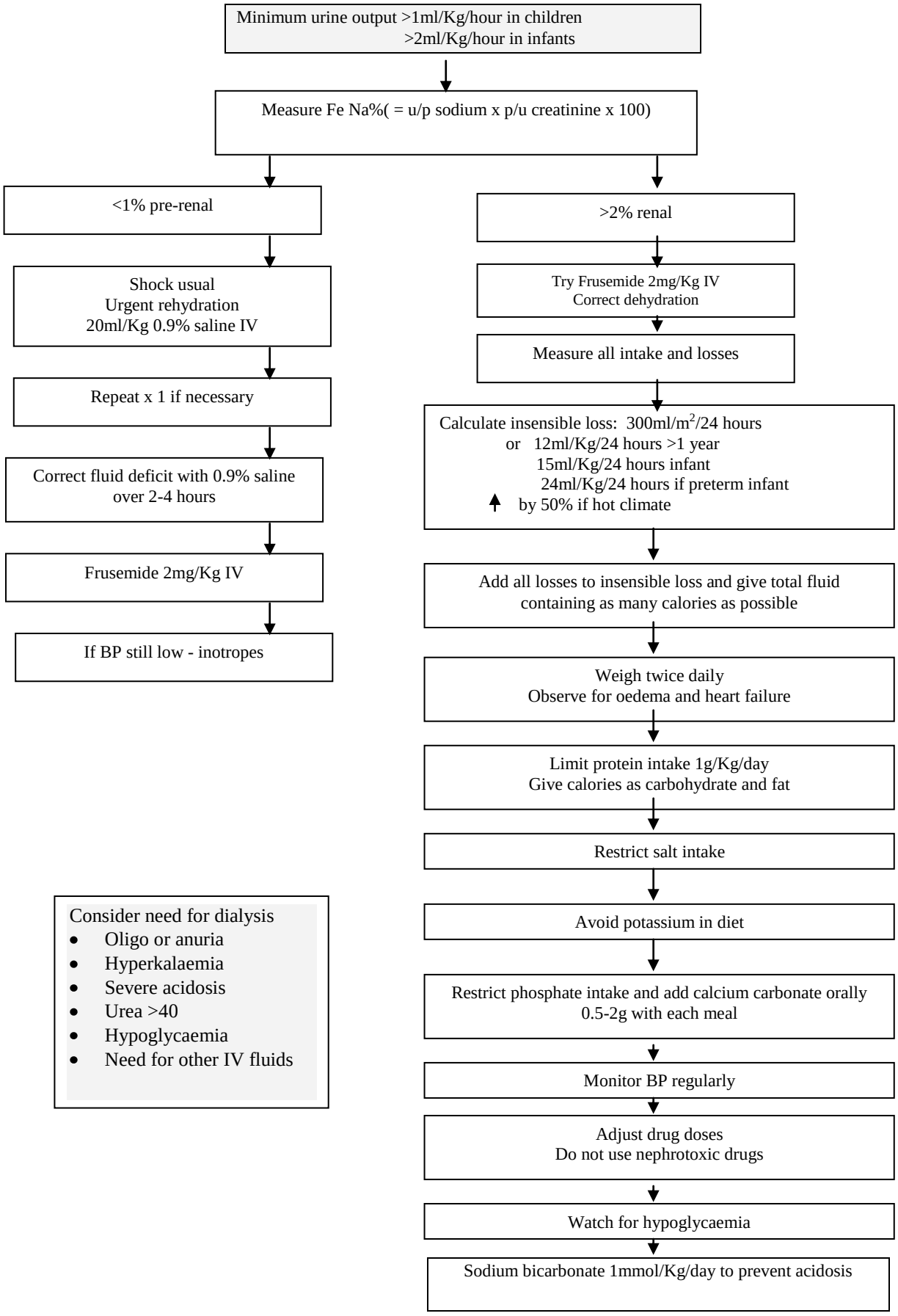
Many drug dosages will need adjustment as they are renally excreted

Peritoneal dialysis

This is indicated if

- oligo-anuria persists
- hyperkalaemia occurs (the commonest indication)
- severe metabolic acidosis. Treatment with sodium bicarbonate is limited because this may lead to massive sodium overload, and hence to dangerous levels of hypernatraemia, and to greater fluid retention.
- hypoglycaemia occurs and needs IV glucose solutions
- other fluids are required such as platelets.
- urea rises > 40 mmol/L causing clinical uraemia

Pathway of care Acute Renal Failure in a child



Nephrotic syndrome

Background and clinical features

The clinical picture is of proteinuria, hypoalbuminaemia and oedema. It must be differentiated from other causes of hypoalbuminaemia such as protein malnutrition and protein-loss from the bowel.

Most children with nephrotic syndrome presenting in childhood, after the age of 1 year and before teenage years, are **steroid responsive**, losing their proteinuria within 1-2 months of treatment. They share clinical characteristics. Children with **steroid resistant** nephrotic syndrome may have a range of diagnoses, including focal segmental glomerulosclerosis, Henoch-Schonlein purpura, lupus and mesangiocapillary glomerulonephritis and a strong association with infections, especially malaria and hepatitis B as well as hepatitis C & HIV.

Acute management

It is reasonable to attempt to induce a remission with steroids, unless the clinical picture virtually excludes the possibility of steroid sensitivity.

- Use prednisolone 60mg/m^2 daily (see table in Appendix) for up to six weeks (about 95% of children who are going to respond do so within one month). Monitor carefully for the development of hypertension on steroids.
- Limit fluid retention by imposing a tight dietary sodium restriction.
- Prevent secondary pneumococcal infection with prophylactic penicillin V (125 mg twice daily up to 5 years of age, 250 mg twice daily thereafter).
- Avoid hypovolaemia (thrombosis). Intravascular hypovolaemia is a high risk and should be monitored clinically by the appearance of cold peripheries and sometimes abdominal pain. There may be initial paradoxical hypertension; hypotension may not occur until late. The best laboratory test is a urinary sodium less than 15 mmol/l, especially if combined with a urine osmolality of over 800 mosmol/kg; blood tests are seldom helpful.
- Treatment of hypovolaemia should be with 1 g/kg intravenous albumin over 4 hours, preferably with 2 mg/kg IV furosemide given half way through.
- Avoid use of furosemide in the acute situation without adequate volume replacement.

Typical features of children with steroid sensitive and steroid resistant nephritic syndrome

Feature	Steroid sensitive	Steroid resistant
Sex	Male > Female	Varies
Age	1-3 years	Usually older
BP	Normal	Usually elevated
Speed of onset	Rapid (days or weeks)	Usually weeks or months
Urine blood	Microscopic	Often macroscopic
Plasma creatinine	Normal or low unless hypovolaemic	May be elevated

Subsequent management IF STEROID SENSITIVE

This is ideally based on daily home monitoring of the morning urine protein level by stick testing. A common definition of a relapse is ++ proteinuria for 7 consecutive days, or + + + for 3 days, and should be responded to by re-introducing salt restriction, penicillin V and prednisolone.

Protocols for doses and duration of using prednisolone and steroid-sparing agents vary. This is a proposed example:

First presentation - give prednisolone 60 mg/m^2 daily (use Appendix), and if respond (by loss of proteinuria), then complete 6 weeks of 60mg/m^2 daily, followed by 40 mg/m^2 on alternate days for a further 6 weeks.

Subsequent relapse - restart 60 mg/m^2 daily until no proteinuria for 3 days, then give 40 mg/m^2 on alternate days for a further 4 weeks.

Frequent relapses - give prophylactic, low-dose (for example 200 micrograms/kg), alternate-day prednisolone. Titrate the dose up until either relapses are prevented, or steroid side effects develop.

If steroid prophylaxis causes unacceptable side effects, add prophylactic levamisole 2.5 mg/kg on alternate days (approximately 50% will benefit) which can be used relatively long term.

If levamisole is ineffective, consider cyclophosphamide 2.5-3 mg/kg daily for 12 weeks, monitoring weekly with white blood cell count, and reducing the dose if the absolute neutrophil count falls below 1 **x** 10^9/litre, or stopping if it falls below 0.5 **x** 10^9/litre. Or 6 x monthly cyclophosphamide infusion (600mg/m2); potentially dangerous in poor circumstances where infections are frequent.

Subsequent management IF STEROID RESISTANT
Persistent haematuria and hypertension at the first presentation may be early warning signs of steroid resistance. Steroids should be used with caution as the hypertension maybe aggravated.

There is a wide range of conditions that may induce steroid resistant nephrotic syndrome. These include infective agents, auto-immune diseases, some drugs and poisons, and unknown causes. The cause may be apparent from the history and examination and other tests but, *in most cases the diagnosis relies on the accurate interpretation of a kidney biopsy.*

The infective causes include hepatitis B, HIV, *schistosoma mansoni,* leprosy, tuberculosis and malaria. These conditions should be sought in those parts of the world where they are likely to be found, and treated appropriately. Hepatitis B typically causes a membranous nephropathy which tends to improve spontaneously. Post-streptococcal glomerulonephritis may cause nephrotic syndrome, but it is seldom the presenting feature. Though it is not the only cause of this clinical picture, **it is sensible to treat any child that develops nephrotic syndrome after an acute nephritic illness with 10 days of oral penicillin V, approximately 10 mg/kg per dose 6 hourly.**

The auto-immune causes of nephrotic syndrome include Henoch-Schonlein and IgA nephritis, lupus, mesangiocapillary glomeru-lonephritis, and some cases of membranous nephropathy. The commonest cause of steroid resistant nephrotic syndrome in many parts of the world is focal segmental glomerulosclerosis (FSGS), whose pathophysiological mechanism is unknown. In some of these conditions (including lupus, mesangiocapillary glomerulonephritis, and FSGS), some children do respond to steroids. However, many children with steroid resistant nephrotic syndrome do not respond to any treatment at all. Most of those that do only respond to more powerful immunosuppressants such as cyclophosphamide or cyclosporine. These treatments are difficult to use because they are expensive, and require close monitoring for side effects. Even under ideal medical conditions with considerable resources, many cases still progress to end-stage renal failure.

Protein in the diet
Children with nephrotic syndrome may lose huge quantities of protein into their urine. If they are on a low protein diet they will quickly lose muscle mass as the body proteins are utilised to synthesise plasma albumin. A relatively high protein diet will be muscle sparing, but will make no significant difference to the plasma albumin concentration.

Post-streptococcal Glomerulonephritis

This is caused by antibodies produced in response to specific strains of streptococci. Because it takes time for antibody production to occur, the signs and symptoms of nephritis do not usually begin until 10 to 20 days after the start of the infection.

The inflamed glomeruli leak blood and protein, so the first symptom is usually the child passing smokey or frankly bloody urine. The glomerular filtration rate usually falls a little, so the plasma creatinine is typically slightly elevated. Also the tubules reabsorb sodium and water excessively which causes water retention out of proportion to the fall in glomerular filtration rate. This leads to swelling which is most easily noticed around the eyes and face, and in the legs, but which does not pit as easily as oedema does in the nephrotic syndrome. The water retention also leads to **hypertension**. Most children with acute post-streptococcal GN do not lose enough protein into the urine to cause nephrotic syndrome as well, though some do, producing a mixed nephrotic-nephritic picture.

A presumptive diagnosis is made by examination of the urine for the presence of protein (using stick tests) and glomerular red cells and casts (by microscopy) in a child with a history of a recent sore throat or skin infection.

Treatment
If post-streptococcal GN is suspected immediately start penicillin V 10 mg/kg four times daily for 10 days to eradicate the organism.

It is essential to measure the child's fluid intake and losses accurately as well as daily weighing, and restrict the amounts of sodium and water allowed. This should be to balance the losses, or to cause net fluid reduction if the child is significantly fluid overloaded. The insensible loss is about 300 ml/m^2 daily, but will be higher in a hot dry climate. Estimate the surface area from the table in Appendix. **Salt restriction is far more important than water restriction,** and is sometimes all that is required for a child to maintain fluid balance. This is because the tubules retain sodium avidly, so any salt eaten will be retained in the body and cause hypernatraemia. This drives an intense thirst, and it then becomes almost impossible to stop the child drinking. By contrast, a tight salt restriction will minimise the thirst, which aids management.

If the plasma albumin concentration is normal or only slightly reduced, it is safe to give an oral dose of furosemide, 1-2 mg/kg. This will increase the urinary excretion of sodium and water and thus improve fluid overload and hypertension. It will also increase potassium loss which is helpful if the fall in glomerular filtration has led to hyperkalemia. It may be repeated as needed. However if the child has a very low plasma albumin from a mixed nephrotic-nephritic picture, giving furosemide may precipitate hypovolaemia. Because of this, either give intra-venous albumin combined with furosemide (see section on management of the nephrotic syndrome), or give furosemide under close observation and be prepared to give albumin if hypovolaemia occurs. Cold peripheries and abdominal pain (from splanchnic vasoconstriction) are important signs of this.

The raised blood pressure is frequently fully controlled by salt and water restriction and furosemide, but in some cases hypotensive agents are also needed. Under such acute conditions it is safe to reduce the blood pressure rapidly.

Section 12 Quiz 15

Which of the following statements are true when considering acute renal failure?

a) minimum urine output for a child is >2ml/kg/hour
b) ultrasound scan, if available, may help diagnose a post renal cause
c) fractional excretion of sodium is the only reliable way of differentiating pre-renal from established renal failure
d) shock may cause pre-renal, renal or post renal failure
e) if recovery from pre-renal or renal failure has not started within 4 weeks, it is unlikely

Section 12 Quiz 16

Which of the following treatments may be helpful in the management of persistent ARF?

a) strict fluid balance management, including insensible losses
b) a protein-limited diet
c) limited sodium and potassium intake
d) phosphate supplement
e) an adjustment to the doses of drugs excreted by the kidneys

ANSWERS

15. b,c,e **16.** a, b,c, e

The Infant or Child in Coma (IMEESC 14.6)

Coma may be the presentation of many illnesses. It is unusual for children to have a structural problem so the cause of coma is most likely to be a diffuse metabolic or infective process, or to be associated with trauma.

In order to function normally, the brain needs an adequate supply of oxygenated blood and glucose. The supply of oxygen might be compromised by problems affecting airway, breathing and circulation. If these are all stable and secure, the problem relates to the brain itself.

For blood to circulate around the brain, the pressure inside the skull – the intracranial pressure (ICP) must be low enough to allow blood to flow.

Causes of coma

- Hypoglycaemia
- **Malaria**
- **Meningitis** (including TB)
- Head injury –see trauma section
- HIV
- **Drugs / poisons**
- **Post convulsion**

Cerebral perfusion pressure (CPP) = mean arterial pressure (MAP) – ICP

Normally for a child < 3 this would be about 60mmHg, and for an older child 70mmHg. By the age of 12, the child has an adult CCP of about 80mmHg.

Primary assessment

The first steps in managing a child with an altered level of consciousness are to assess and, if necessary, support Airway, Breathing and Circulation.

- **Airway** – this is at risk if the child scores 'P' or 'U' on the AVPU scale
- **Breathing** – this may be the cause of coma, by inadequate oxygenation or increasing CO_2; or be compromised by coma with centrally driven hypoventilation. **MUST HAVE BAG VALVE MASK SYSTEM AVAILABLE AT ALL TIMES WHEN MANAGING A CHILD IN COMA OR WITH REDUCED CONSCIOUS LEVEL**

- **Circulation** – hypotension leads to under-perfusion of the brain. In late stages of raised intracranial pressure, the child becomes hypertensive in an attempt to preserve CPP. The body responds by reducing heart rate.

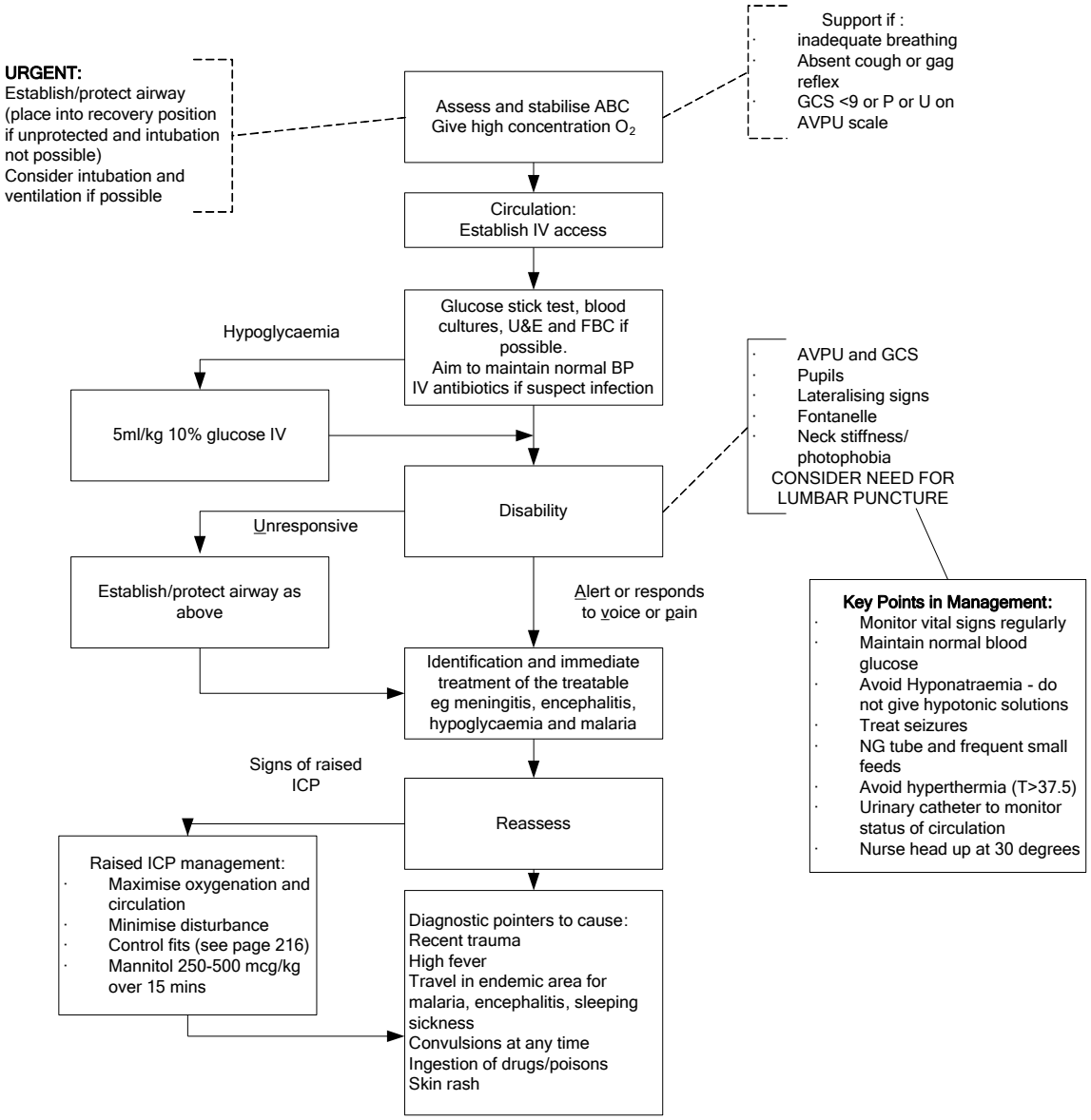
  Hypertension and bradycardia are very serious signs.

- **Disability**
  - Assess using AVPU score
  - Check blood glucose
  - Check pupils for size, equality and reaction to light
  - Palpate fontanel for signs of raised ICP

  A more formal assessment may be made using the Glasgow Coma Scale (GCS)

Pupillary changes	
Pupil size & reactivity	Causes
Small, reactive	Metabolic disorder Medullary lesion
Pin-point	Metabolic disorder Narcotics /orgnophosphates
Fixed, dilated	Hypothermia Hypoxic / ischaemic brain During and post seizure Anticholinergics / barbiturates
One fixed. dilated pupil	Ipsilateral lesion Tentorial; herniation III cranial nerve lesion Epileptic seizure

Pathway of Care for Child in Coma (IMEESC Best Practice Protocol and 13.1 and 13.6)



Specific conditions

Bacterial meningitis

Causes

- Worldwide the commonest causes are *Streptococcus pneumoniae, Haemophilus influenzae* and *Neisseria meningitidis.* Local incidence varies, and in many countries has been altered by vaccine availability.
- Neonatal meningitis is most commonly caused by Group B Streptococcus (Streptococcus agalactiae) and Escherichia coli. Other coliforms and Streptococci as well as Neisseria meningitidis and Listeria monocytogenes may also occur. *Listeria monocytogenes* and Group B *streptococci* cause both early and late neonatal infections and may have a better prognosis than infections caused by coliforms.

Neonatal meningitis has a poorer prognosis than most community acquired meningitis of later childhood.

Diagnosis

- In infants and children: fever, neck stiffness, bulging fontanelle (in infants), vomiting, headache, altered consciousness and possibly convulsions. In meningococcal meningitis there may be a maculopapular or petechial rash.
- Neonates: signs are more subtle and non-specific and include poor feeding, hyper- or hypothermia, convulsions, apnoea, irritability and a bulging fontanelle.
- Contraindications to lumbar puncture include evidence of raised intracranial pressure (especially coma or focal neurological signs), child too sick to tolerate a flexed position, infection at puncture site, bleeding tendency (blood clotting platelet disorder), or a widespread petechial rash suggesting meningococcal disease. In these situations antibiotics should be started and lumbar puncture delayed until it is safe to undertake.
- Gram stain of CSF may identify bacteria in about two-thirds of cases and provides a guide to choice of antibiotic therapy in the absence of culture facilities.
- Other laboratory tests of use include blood culture and latex agglutination and PCR of CSF, and for general management, full blood count, serum electrolytes and glucose, and urine specific gravity. In malarial areas undertake blood smear and treat appropriately.

Other conditions

Consider tuberculous meningitis in children who do not respond to the initial antibiotics and particularly if two or more of the following are present: history >7 days, HIV known or suspected, patient remains unconscious, CSF has moderately high white blood cell count (typically > 300-500/ml) mostly lymphocytes, elevated protein (0.8-4 g/litre) and low glucose (< 1.5 mmol/litre), Chest *X* ray suggesting tuberculosis, optic atrophy, focal neurological deficit or extrapyramidal movements (see Chapter 4.10).

- Children with HIV are more prone to meningitis and septicaemia from *S. pneumoniae* and *Salmonella* species, and relapse is more frequent. Non-typhoidal Salmonella (NTS) meningitis is common in post malarial anaemia and malnutrition and requires lengthy (at least one month of) antibiotic treatment.
- Fungal infections, (eg Cryptococcus neoformans) mostly in children with HIV, often cause severe headache without neck stiffness. Lumbar puncture may improve symptoms.

Condition	**White cell count** (x**10^9/litre)**	**Cell differential**	**Protein (g/litre)**
Normal	0.5 <22 in full term, <30 in premature neonates	PMN </= 2 but <15 neonate	<0.5
Acute bacterial meningitis*	100 to > 300 000	Mostly PMN. Monocytes in *Listeria* infection	>1.0
Tuberculous meningitis	50-500 sometimes higher	Lymphocytes early but also PMN	>>1.0

Table Bacterial meningitis, typical findings in cerebrospinal fluid

Herpes encephalitis	usually <500	Mostly lymphocytes PMN early in the disease	>0.5
Cerebral abscess	10-200	PMN or lymphocytes	>1.0
Traumatic tap	WBC and RBC	RBC/WBC =500/1	Increases by 0.001 g/litre per 1000 RBC

Therapy

Antibiotic choices depend upon activity against the infecting organism, CSF penetration, cost and availability of the antibiotic, route of administration and local patterns of antibiotic resistance (Tables below). If national guidelines are available then they should be used. The degree of diagnostic certainty is also important, especially in the case of meningitis with minimal rash, as treatment should be given for all the common causes of bacterial meningitis according to the child's age group.
It is important to know the antimicrobial sensitivities in the local area. Antimicrobial resistance has emerged among the three major bacterial pathogens causing meningitis outside the neonatal period. In the *Meningococcus* intermediate penicillin resistance may occur and chloramphenicol resistance is emerging. *Haemophilus influenzae* are also frequently beta-lactamase resistant and chloramphenicol resistance is described. Third-generation cephalosporins are therefore the drug of choice for both organisms although, if they are precluded on the basis of cost, chloramphenicol (plus penicillin or ampicillin) is an alternative. Pneumococci resistant to penicillin and to chloramphenicol are widespread in Asia and some parts of Africa, and third-generation cephalosporins are the drugs of choice. However, pneumococcal resistance to third-generation cephalosporins may occur. Treatment of these strains requires the addition of vancomycin or rifampicin to therapy with third-generation cephalosporins.

Third-generation cephalosporins (ceftriaxone or cefotaxime) may be necessary first-choice antibiotics in some areas. In neonates ceftazidime which is active against *Pseudomonas* infections may be the most suitable.

The antibiotic regimen should be rationalised once culture and sensitivity results for the infecting organism become available.

During confirmed epidemics of meningococcal meningitis and where there are other signs such as petechial rash, lumbar punctures are unnecessary. If resources are very limited, oily chloramphenical (100 mg/kg IM) as a single dose up to 3g can be curative. If the oily dose is too large for one buttock, divide into two doses. Alternatively, single dose intramuscular ceftriaxone, 100mg/kg up to 4g, may be recommended.

Duration
Neonates require 14-21 days treatment. In infants and children, a 10-day course is usually adequate for pneumococcal and *Haemophilus,* and 7 days for meningococcal infections. Seven days of ceftriaxone is usually sufficient. Where antibiotic availability is very limited, some authors have used

5-7 day courses of ceftriaxone for uncomplicated meningococcal, pneumococcal or Haemophilus meningitis in infants and children.

Corticosteroids
Dexamethasone may reduce the incidence of neurological sequelae and deafness in bacterial meningitis, although studies in resource-poor countries have been inconclusive. The usually recommended dose of dexamethasone is 0.15mg/kg 4 times daily for 4 days (or if this is not available, prednisolone 2mg/Kg per day for 4 days). The first dose should be given concurrently with, or a maximum of 4 hours after first antibiotic administration.
There is **no** evidence that corticosteroids are helpful in bacterial meningitis where there is delay in presentation and antibiotics have already been given some hours earlier. Steroids are generally not indicated in meningococcal disease.

Do not use steroids in the newborn or children younger than 3 months, nor in suspected cerebral malaria or in viral encephalitis.

Supportive care

- **Fluids:** maintenance fluids should be given once shock or dehydration has been corrected, initially by the intravenous route but later by nasogastric tube or orally. The degree of dehydration may be underestimated, and deep breathing may be a sign of acidosis. Low serum sodium levels often occur in meningitis. **Avoid over-hydration by careful fluid balance and in particular avoid intravenous fluids with low sodium levels such as 5% glucose.** Use 0.45 or 0.9% saline with added glucose (5-10%) or a similar proprietary fluid If electrolytes are being measured, maintain serum Na+ in the high normal range and above 135 mmol/litre.
- A **nasogastric tube** may be helpful in the unconscious child or those who are vomiting, in order to protect the airway. A small amount of milk (1 ml/kg/hour) down this nasogastric tube may prevent gastric erosions. Gastric protection may also be provided using drugs such as ranitidine or omeprazole, where available.
- **Urine output** should be monitored, particularly in the unconscious child. Weighing nappies can be useful in the infant or young child. Catheterisation unless undertaken in an aseptic way can lead to urinary tract infection and is unwise if resources are limited.
- **Seizures:** must be controlled with anticonvulsants, but there is no data to support routine use of prophylactic anticonvulsants.
- If there is a high **fever** (>39°C) apply temperature-reduction methods including paracetamol.
- **Blood glucose** must be monitored every 4 hours particularly in the infant and young child. Hypoglycaemia must be considered in any child with seizures or altered consciousness and corrected as follows: 5 ml/kg of 10% glucose IV and recheck blood glucose 30 minutes later. If it remains low (<2.5 mmol/litre) repeat the intravenous glucose dose (5 ml/kg).
- **Nutritional support:** a nasogastric tube should be inserted if the child is unable to feed orally after 24 hours. Continue expressed breast milk if breastfed or give milk feeds 15 ml/kg every 3 hours.

Monitoring

- Careful observation is essential.
- Raised ICP and shock are the most severe complications. Early recognition and treatment essential.
- Daily weights and urine specific gravity help assess fluid requirement.
- Temperature, pulse, blood pressure, capillary refill time (normal <3 seconds), respiratory rate and effort, conscious level and pupillary responses should be monitored frequently after admission (4-6 hourly), particularly in patients with meningococcal disease. Pulse oximetry is valuable, if available, for monitoring oxygenation and for identifying early evidence of respiratory compromise.
- A critical care pathway is an ideal way of incorporating observations, treatment, laboratory findings on one chart. Doses and treatments can be standardised and incorporated on the chart.
- If available it is ideal to monitor electrolytes (sodium, potassium, calcium and magnesium, urea and/or creatinine) and replacement of deficits (hyponatraemia due to excessive intravenous administration of hypo-osmolar solutions is common and can predispose to seizures). Monitoring of full blood count and coagulation screen should be carried out regularly if initially abnormal.

Nursing care

- Turn an unconscious child 2 hourly, keeping the child dry, and prevent overheating. Insert nasogastric tube if there is persistent vomiting.
- Include the mother or family members in progress reports and make them part of the caring team.

Complications

- Seizures with or without hypoglycaemia.
- If fever does not settle within 48 hours and if the child's condition deteriorates or is not improving, repeat lumbar puncture.
- If fontanelle is patent, monitor the head circumference daily to detect hydrocephalus. Consider a head ultrasound scan to look for ventriculitis, ventricular dilatation, subdural effusion or brain abscess. In older children, computed tomography or magnetic resonance imaging may be desirable if available.
- Aspiration pneumonia may occur in the unconscious child.
- Hydrocephalus, deafness, visual loss, epilepsy and neurological deficits may develop and be evident either early in disease or at follow up. 20% of cases worldwide will develop serious sequelae.

Follow up

- Undertake hearing tests in all children, neurological assessments and head circumference (in infants) on discharge from hospital and at post discharge visits done at 1 month and 6 months after recovery.
- New sequelae are unlikely to develop after discharge but may have been missed.
- Physiotherapy may be required.

Immunisations

Highly effective protein-conjugated polysaccharide vaccines are available against Haemophilus influenzae and several sero-groups of Streptococcus pneumoniae and Neisseria meningitidis. They are effective in young infants as well as older children and adults. Where they are unavailable plain polysaccharide vaccines against Neisseria meningitidis and Streptococcus pneumonia may be provided. Vaccine availability may be limited in low income countries.

Bacterial meningitis: prophylaxis for contacts

Neisseria meningitidis

Rifampicin for two days for all household contacts*: adults 600 mg twice daily 1 month-12 years 10 mg/kg twice daily neonates 5 mg/kg twice daily

In many countries rifampicin is not allowed to be used in any disease other than TB. In this case consider Ciprofloxacin orally as a single dose, adults 500mg, Children 5-12 years 250mg and child 1 month to 5 years 125mg.

Haemophilus influenzae

Rifampicin for four days for all non-vaccinated household contacts at the above doses

Antibiotic treatment in bacterial meningitis when organism is unknown or antibiotic sensitivity not possible			
Age	**Probable pathogens**	**Antibiotic of choice**	**Alternative antibiotics**
Infants> 1 month to children 5 years	N. meningitides Strep. Pneumonia H. Influenzae	Cefotaxime or ceftriaxone Add vancomicin or rifampicin if pneumococcal resistance suspected	Chloramphenicol plus ampicillin (add vancomicin or rifampicin if pneumococcal resistance suspected)
Children > 5 years	N. meningitides Strep. Pneumonia	Cefotaxime or ceftriaxone Add vancomicin or rifampicin if pneumococcal resistance suspected	Chloramphenicol plus ampicillin or benzyl penicillin(add vancomicin or rifampicin if pneumococcal resistance suspected)
Notes ○ Give all antibiotics IV (or IM if not possible) for at least 3 days or until temperature is normal and improving ○ Oral chloramphenicol is not reliably absorbed by malnourished ○ Chloramphenicol is not recommended below 3 months of age			

Table Antibiotic therapy in bacterial meningitis where organism is known

Organism	**Antibiotics of choice**	**Alternative antibiotics**	**Duration**
Haemophilus Influenza	Ceftriaxone/cefotaxime	Ampicillin plus chloramphenicol*	10-14 days
Streptococcus pneumoniae**	Ceftriaxone/cefotaxime	Ampicillin/ Benzylpenicillin plus chloramphenicol*	10-14 days
Neisseria meningitidis	Ceftriaxone/cefotaxime	Benzylpenicillin plus chloramphenicol*	7 days

Gram negative bacilli (including *E. coli*)	Ceftriaxone/cefotaxime +/- gentamicin	Ampicillin plus gentamicin or chloramphenicol*	At least 21 days***
Salmonella enteritidis	Ceftriaxone/cefotaxime plus IV ciprofloxacin (if available)	Meropenem or chloramphenicol* plus ampicillin (may be incomplete cover and excess mortality compared to cephalosporins)	At least 21 days***
Listeria monocytogenes	Ampicillin plus gentamicin		10-14 days
Group B *Streptococcus*	Benzylpenicillin plus gentamicin or Ceftriaxone/cefotaxime		10-14 days
Staphylococcus spp.	Flucloxacillin plus gentamicin	Flucloxacillin plus chloramphenicol*	10-14 days

* Chloramphenicol should be used with caution in children under 3 months of age. Monitoring of serum levels is advisable in this group.
** S. pneumoniae resistant to penicillins and cephalosporins are increasingly prevalent. If resistance is suspected add either rifampicin or vancomycin (see doses below).
*** Gram-negative infections are difficult to treat and have a high rate of sequelae. Repeat lumbar pucture to ensure response to antibiotics may be indicated if the clinical picture is not improving.

Notes
1. Choice depends on local antibiotic resistance patterns, national guidelines and drug availability
2. Give all antibiotics parenterally for at least 3 days
3. Once culture and sensitivity results are available empirical antibiotics should be changed accordingly
4. Do not delay antibiotic therapy if cephalosporins unavailable, use the next most appropriate antibiotic combination

Bacterial meningitis: antibiotic doses

Antibiotic	**Route**	**Dose**
Ampicillin	IV	100mg/kg/6 hourly (max. single dose 3g)
Benzylpenicillin	IV	50 mg/kg/4 hourly
Cefotaxime	IV	50mg/kg/6 hourly (max. single dose 4g)
Ceftriaxone	IV or IM	80mg/kg/24 hours once daily* (max. single dose 4g)
Chloramphenicol	IV	25 mg/kg 6 hourly **(after loading dose of 50 mg/kg)
	Oral	25 mg/kg 6 hourly**
	IM	An oily preparation of chloramphenicol is available and is usually used in a single dose of 50-100 mg/kg with a maximum dose of 3 g. The dose may be repeated after 24 hours. It is recommended only if more suitable alternatives are unavailable
Flucloxacillin or cloxacillin	IV	50 mg/kg 6 hourly (max. dose 8g/day)
Gentamicin	IV or IM	1 month-10 years 7.5mg/Kg once daily > 10 years 6mg/Kg once daily (maximum dose 360mg)
Ciprofloxacin	IV	10 mg/kg 12 hourly (5mg/kg/12 hourly in the neonate)
Meropenem	IV	40 mg/kg 8 hourly (maximum single dose 2g) by slow IV injection over 5 minutes
Vancomycin	IV	15 mg/kg loading dose and then 10 mg/kg 6 hourly*** (total daily dose should not exceed 2g)

* Ideally 80 mg/kg 12 hourly should be given for the first two doses followed by 80 mg/kg per 24 hours.
** Although not recommended in children less than 3 months old or in malnourished children, the evidence for this is slight.

Tuberculous Meningitis

- Commonest in children under 5 years and often occurs within 6 months of infection.
- Onset is usually insidious and diagnosis is often delayed. Late diagnosis is invariably complicated by neurological dysfunction or death.
- Prolonged fever, irritability, headache, vomiting, mental status changes, visual symptoms, focal neurologic deficits or cranial nerve palsies, seizure are some of the common presentations in a child with tuberculous meningitis.

CSF: cell count is usually less than 500 per mm^3 and mainly lymphocytic but polymorpho-neutrophils may be prominent early on which may cause confusion with partially treated bacterial meningitis. Protein is usually raised (0.8-4 g/litre) and glucose is low. However, on admission CSF values may be within normal limits and lumbar puncture must be repeated if there is any doubt.
Brain imaging, for example CT or MRI should be undertaken at diagnosis and 3-4 months, and at any time there is neurological deterioration to detect complications such as hydrocephalus and tuberculomata.

Management:

A 4 drug regimen is recommended for 2 months followed by 2 drugs for 10 months for a total of 12 months in uncomplicated susceptible tuberculosis meningitis. It consists of the following 4 drugs given for first 2 months:

- Isoniazid (15-20 mg/kg once daily orally, or IM or slow IV injection maximum 300 mg daily) PLUS
- Rifampicin (20 mg/kg once daily orally or IV infusion over 2-3 hours maximum 600 mg daily) PLUS
- Pyrazinamide (40 mg/kg once daily orally maximum 2 gm daily) PLUS
- Ethambutol 20 mg/kg/day (maximum 1.5 g daily) orally

Thereafter isoniazid PLUS rifampicin alone are subsequently continued for 10 months.
WHO also now advises 12 months therapy although shorter regimens have been shown to be adequate in some studies.

Corticosteroids must be given in all cases with initiation of therapy. Dexamethasone 0.6 mg/kg/day in two divided doses or prednisolone 1.5 to 2 mg/kg/day is given for 4 weeks and tapered over 2 weeks for a total of 6 weeks duration.

2. Malaria

Management of severe malaria

Severe malaria is a complex, multi-system disease, which constitutes a medical emergency.

Mortality approaches 100% without treatment, and death often occurs within the first few hours. Prompt initiation of antimalarial treatment in peripheral health facilities and comprehensive management in hospital are necessary to prevent deaths.

Neurological sequelae of cerebral malaria affect about 10% of African children who survive cerebral malaria. These sequelae are severe and permanent in up to 19,000 children annually, including spastic paresis and epilepsy.

Care should be provided within 15 minutes of arrival at a health facility. Triage systems should be in place in health centres and hospitals to pick up severely ill patients, referral should be rapid, and emergency facilities be instituted in hospitals with a high standard of medical and nursing care available 24 hours a day.

Any seriously ill or unconscious patient in a malaria endemic area must be tested for malaria by RDT (remember that parasites may not be present in the peripheral blood of a patient with cerebral malaria). Malaria should be assumed in any child with severe anaemia, convulsions, hyperpyrexia and/or hypoglycaemia either in hospital or in a peripheral health facility.

Even if a diagnostic test is not available **the patient should be given an antimalarial before transfer to the hospital (IV, IM, or rectally depending on the skill of the staff in the facility.)** This can be repeated if transfer is impossible or is delayed for more than 12 hours. A note of what has been given should be sent with the patient as soon as transfer can be arranged.

If any doubt exists it is safer to treat than not to treat before transfer.

Immediate measures (in hospital):

- Vital signs: temperature, pulse, blood pressure, respiration (rate and depth)
- State of hydration
- Estimate or ideally measure body weight.
  For an infant up to 1 year: birth weight doubles by 5 months and triples by 1 year
  After 1 year use the following formula: weight (Kg) = 2 (age in years + 4)

Be careful in HIV endemic areas where body weights are often very different from those derived by this formula. Weigh the child if at all possible.

- Level of consciousness (AVPU).

  The depth of coma may be assessed rapidly in children using the coma scale for children or by observing the response to standard vocal or painful stimuli (rub knuckles on child's sternum; if there is no response, apply firm pressure on thumbnail bed with horizontal pencil).
- RDT and malaria smear (thick and thin film) for diagnosis and for continued monitoring of the progress of the disease. **Do not wait for a malaria smear result before initiating treatment as it can take up to an hour. If the RDT is positive, commence treatment immediately.**
- Lumbar puncture if patient is unconscious to eliminate meningitis if there are no contraindications. **Contraindications include: papilloedema or suspicion of raised intracranial pressure (irregular breathing and pupillary responses, posturing), or respiratory difficulty such that flexing the back would compromise respiration**. **In such a situation, give intravenous antibiotics to treat meningitis.**
- Measurement of glucose (finger prick), haemoglobin and haematocrit (Packed cell volume (PCV)).
- Group and cross match blood and **search for a suitable donor**.

Parenteral IV or IM treatment:

In Africa and many other regions sodium artenusate or quinine are the drugs of choice for severe malaria.

Initially give treatment intravenously, if possible; if not, intramuscularly.

Change to oral therapy as soon as possible.

Especially in the malaria endemic areas of Africa, the following initial antimalarial medicines are recommended. Artesunate has been shown reduce mortality compared to quinine but it is important to use whichever the drug available locally:

- artesunate IV or IM;
- quinine (IV infusion or divided IM injection);

- artemether IM (should only be used if neither of the above alternatives are available as its absorption may be erratic).

First-line antimalarial drugs:

1. **Sodium artesunate IV or IM**

IV or IM artesunate Give 2.4 mg/kg IV (slow injection) or IM on admission (time 0), followed by 2.4mg/kg IV or IM at 12 hours and then at 24 hours and then once daily for a minimum of 3 days until the child can take oral treatment with an ACT.

OR **second choice**:

2. Intravenous IV quinine

Give 20 mg/kg of quinine salt (maximum 1.4 gm) in 5% glucose in a concentration of 1 mg of quinine to 1 ml of 5% glucose over 4-6 hours. If possible use an in-line infusion chamber (100-150 ml) to ensure that the loading dose does not go in too quickly. Alternatively ensure that the IV giving bag contains only the amount needed for each dose. There is a major risk of cardiac side effects if infused too quickly.

Subsequently give 10 mg/kg in 10 ml/kg fluid IV every 12 hours for 24 hours or longer if child remains unconscious. These latter doses MUST be given over at least 2 hours.
Never give quinine as an IV bolus. Infusion rate must not exceed a total of 5mg quinine salt/kg/hour.

If safe control over the rate of infusion of intravenous quinine is not possible (for example insufficient or untrained nursing staff), then give loading dose intramuscularly (with initial doses of 10mg/kg quinine salt 1M at 0 and 4 hours and then 12 hourly). For intramuscular injections, dilute the quinine solution for better absorption and less pain.

As soon as child is able to take orally, switch to quinine tablets 10 mg/kg every 8 hours for a total of 7 days **or** the locally available first line ACT treatment for malaria.

Side effects

- Common: cinchonism (tinnitus, hearing loss, nausea and vomiting, uneasiness, restlessness, dizziness, blur-ring of vision).
- Uncommon: hypoglycaemia, although this is a com-mon complication of severe malaria.
- Serious cardiovascular problems (QT prolongation) and neurological toxicity are rare.
- If overdosed by mistake with quinine tablets give acti-vated charcoal orally or by nasogastric tube as a suspension in water (1 g/kg).

OR **third choice:**

3. **Artemether IM**

Give 3.2 mg/kg IM as loading dose, then 1.6 mg/kg IM once daily (every 24 hours) for a minimum of 3 days until oral treatment can be taken. Use a 1 ml tuberculin syringe to give the small injection volume. (note absorption may be erratic and therefore only use if quinine and artesunate are not available) and if shocked do not use this drug as absorption is too unreliable.

4. Chloroquine IV

No longer dependably effective in most endemic areas. Avoid, as resistance in children is relatively high.
5 mg base/kg every 6 hours for a total of 25 mg base/kg (five doses) as infusion in 5% glucose (give over 2-4 hours).

Antimalarial treatment after IV or IM regimes have ended

Following parenteral administration usually for a minimum of 24 hours or until the child can take oral drugs, the treatment of severe malaria must be completed by giving a full course of one of the artemisinin-based combination therapies (ACT) described below. In some parts of the world oral quinine combined with clindamycin to complete 7 days of treatment is used

The following ACTs are recommended:

- artemether plus lumefantrine,
- artesunate plus amodiaquine,
- artesunate plus sulfadoxine-pyrimethamine.
- dihydroartemisinin plus piperaquine.
- artemether plus clindamycin
- artesunate plus mefloquine.

The choice of ACT in a country or region will be based on the level of resistance of the partner medicine in the combination.

In areas of multidrug resistance (east Asia), artesunate plus mefloquine, or artemether plus lumefantrine or dihydroartemisinin plus piperaquine are recommended; and in other areas without multidrug resistance (mainly Africa), any of the ACTs including those containing amodiaquine may still be effective. Every country has a national malaria policy in which the first line therapy is described and should be used.

If possible avoid mefloquine if patient has presented with impaired conscious level.

Treatment for HIV-infected patients with P. falciparum malaria

• Patients with HIV infection who develop malaria should receive prompt, effective antimalarial treatment regimens as recommended above

- **Treatment with ACT involving sulfadoxine-pyrimethamine should not be given to HIV-infected patients receiving cotrimoxazole (trimethoprim plus sulfamethoxazole) prophylaxis**
- **Treatment in HIV-infected patients on zidovudine or efavirenz should, if possible, avoid amodiaquine-containing ACT regimens.**

Treatment of falciparum malaria in malnourished patients

Although there are many reasons why antimalarial pharmacokinetics may be different in malnourished patients as compared with those who are well nourished, there is insufficient evidence to change current mg/kg body weight dosing recommendations.

Always check local guidelines on drug sensitivities.

With all anti-malarials, change to an oral therapy when the child can tolerate it.

Additional treatment where needed:

- Insert nasogastric tube to minimize the risk of aspiration pneumonia if the patient's level of consciousness is low. *This can also be used to give food to prevent hypoglycaemia if the child is unconscious for a long period and is unable to eat. Alternatively sucrose (sugar) can be placed under the tongue*
- Insert IV cannula and restore circulating volume.
    - **Fluids should be given with caution** and the need for them assessed on an individual basis after ascertaining the nutritional status and degree of dehydration present.

  - **In general, children with metabolic acidosis who have not previously received parenteral fluids are dehydrated and should be managed accordingly.**

- Give oxygen if SpO2 < 92% (to keep SpO2 94-98%) or if there is respiratory distress and no pulse oximeter available .
- Treat severe anaemia with a safe blood transfusion if the child is showing signs of decompensation.
- Give anticonvulsants (diazepam preferred) if the patient is fitting (see below) to prevent long term neurological damage. (Convulsion associated with cerebral malaria should be distinguished from febrile convulsions common in children <4 years. The child recovers rapidly (within a few minutes from a febrile convulsion). Convulsions are common before or after the onset of coma. They are significantly associated with morbidity and sequelae. They may present in a very subtle way – important signs include intermittent nystagmus, salivation, minor twitching of a single digit or a corner of the mouth and an irregular breathing pattern.

  Prophylactic anticonvulsants have been recommended in the past, but recent evidence suggests that **phenobarbital is harmful.**

- Paracetamol, 15 mg/kg of body weight 4–hourly, may also be given orally or rectally as an antipyretic.
- Use tepid sponging and fanning to try to keep the rectal temperature below 39°C. Relatives are usually happy to do this when instructed. .
- High dose IV or IM antibiotics should be given routinely in an unconscious or shocked patient.
- Avoid harmful ancillary drugs.

The patient will need intensive nursing care at least until they regain consciousness. The patient may urgently need glucose or a blood transfusion if hypoglycaemia or haemolysis is severe.

Management of associated causes of mortality in severe malaria

Some children with *P. falciparum* proceed to develop altered consciousness, severe anaemia, acidosis, or any combination of these. Where transmission of *P. falciparum* is endemic, malaria is the commonest cause of coma in children, especially in age range 1-5 years.

Cerebral malaria (coma, confusion, convulsions)

Coma develops rapidly, often within one or two days of onset of fever, sometimes within hours. Convulsions are usual and may be repeated. Clinical features suggest a metabolic encephalopathy, with raised intracranial pressure. Opisthotonos, decorticate or decerebrate posturing, hypotonia and conjugate eye movements are common. Oculovestibular reflexes and pupillary responses are usually intact. Papilloedema is found in a small minority of cases. A unique retinopathy with patchy retinal whitening and pallor of vessels is found. In fatal cases brain swelling is commonly present at autopsy, but cerebral herniation is not usually found even in patients who had undergone lumbar puncture.

Hypoglycaemia, acidosis, hyperpyrexia and convulsions (sometimes undetectable without EEG) are common accompaniments of cerebral malaria, and require appropriate management (see below).

No physical signs are diagnostic of coma due to malaria, and incidental parasitaemia is common in endemic areas, so other causes of coma must always be carefully sought, and if necessary treated on the basis of presumptive diagnosis.

Even with optimal treatment, the case fatality rate is 15-30%, and about 10% of survivors have residual neurological sequelae (hemiparesis, spasticity, cerebellar ataxia) that may partially or completely resolve over time.

Investigations

- Blood glucose (for example by blood glucose stick test).
- Lumbar puncture if meningitis suspected -contraindications include papilloedema or suspicion of raised intracranial pressure (irregular breathing and pupillary responses, posturing), or respiratory difficulty such that flexing the back would compromise respiration. **In such a situation, give intravenous antibiotics to treat meningitis.**

Management

Coma

Ensure the airway is open at all times and the patient breathing adequately. Give oxygen by face mask with a reservoir or nasal cannulae (to keep SpO2 94-98% if pulse oximeter available). If the child stops breathing give assisted ventilation with a bag mask of suitable size (500ml or 1600ml)

Ensure bag mask is available at all times.

Nurse in the recovery position to avoid aspiration of secretions or vomit

Exclude other treatable causes of coma (e.g. hypoglycaemia, bacterial meningitis).

- Treat convulsions (see below)
- Treat hypoglycaemia.

Convulsions

Convulsions are common before and after the onset of coma.

Ensure the airway is open and give oxygen by face mask with a reservoir or nasal cannulae.

If the child stops breathing give assisted ventilation with a bag mask of suitable size (500ml or 1600ml)

Examine all children with convulsions for hyperpyrexia and hypoglycaemia. Treat hypoglycaemia with IV/IO glucose if identified on blood test but also treat as for hypoglycaemia if blood glucose cannot be measured and child is drowsy, unconscious or fitting (see below).

Give anticonvulsant treatment with rectal diazepam or paraldehyde or IM paraldehyde.

If a fever of ≥ 39 ° C (≥ 102.2 ° F) give paracetamol rectally if available

Treat seizures lasting > 5 minutes with drugs. **Ensure bag mask is available at all times.**

Note: *seizure activity needs to be looked for carefully as it may just appear as a twitching of the thumb or mouth.*

Give intravenous diazepam:

Children: 0.3 mg/kg of body weight as an IV infusion over 2 minutes or 0.5 mg/kg of body weight intra-rectally.

Pregnant girls: 10 mg PR or by slow IV injection.

Do not exceed 10 mg /dose.

Alternatively, paraldehyde 0.1 ml/kg of body weight may be given by deep intramuscular injection or 0.4 ml/kg of body weight intra-rectally using a sterile glass syringe (a disposable plastic syringe may be used provided that the injection is given immediately after the paraldehyde is drawn up and the syringe is never reused).

Hypoglycaemia

Hypoglycaemia is common and is due to poor intake, increased metabolic needs of the patient and parasites and impaired hepatic gluconeogenesis. It is easily overlooked because clinical signs may mimic cerebral malaria.

Check for hypoglycaemia in patients who are unconscious, in shock or deteriorating. Also regulary (every hour in the first instance) check pregnant girls, children <5 years, and the malnourished, and all patients receiving quinine.

Hypoglycaemia: blood glucose < 2.5 mmol/L

Prevent hypoglycaemia with a maintenance quantity of 5% glucose in 0.9% saline or Hartmann's solution. If the child develops hypoglycaemia despite this, give maintenance as 10% glucose in 0.9% saline or Hartmann's solution. Do not exceed maintenance fluid requirements for the child's weight. If the child develops signs of fluid overload, stop the infusion; repeat the 10% glucose boluses (5 ml/kg) if there is hypoglycaemia by making regular checks of blood glucose levels.

If IV access is not possible and the child is hypoglycaemic, place an intraosseous (IO) needle.

Treat hypoglycaemia or suspected hypoglycaemia with IV glucose infusion/bolus:

Children: 1 ml/kg of 50% dextrose, diluted with an equal volume of infusion fluid (usually 0.9% sodium chloride) infused over 5 minutes (irritant to veins) OR 5ml/Kg of 10% glucose as a bolus.

Pregnant girls: 50 ml of 50% dextrose over 15 minutes.

Re-test 15 minutes after completion of infusion, and repeat infusion if blood glucose remains low. Repeat until blood glucose recovers, then infuse with 5–10% glucose in 0.9% saline or Hartmann's (according to hypoglycaemia risk) to prevent recurrence. Ensure regular feeding when oral intake can be sustained. Fluids used to treat hypoglycaemia must be included in daily fluid requirements.

If blood glucose cannot be measured and hypoglycaemia is a possibility, always give IV glucose as above.

If child still unable to swallow after 48 hours, start nasogastric feeds. When a gag reflex is present and the child is able to swallow, feed the child as soon as it is possible. For young children breastfeed every 3 hours, if possible, or give milk feeds of 15 ml/kg/3hourly if the child can swallow. If not able to feed without risk of aspiration, give milk, especially breast milk by nasogastric tube or sugar sublingually. Continue to monitor the blood glucose level, and treat accordingly (as above) if found to be <2.5 mmol/ litre or <45 mg/dl.

Hypoglycaemia is a major cause of death in severe malaria patients, especially in young children and pregnant girls. Remember that quinine will potentiate hypoglycaemia. Young children should receive regular feeding, including by NG tube, when unable to take oral foods.

Severe haemolytic anaemia

This is indicated by severe palmar pallor, often with a fast pulse rate, difficult breathing, confusion or restlessness. Signs of heart failure such as gallop rhythm, enlarged liver and, rarely, pulmonary oedema (fast breathing, fine basal crackles on auscultation) may be present (see above)

Severe haemolytic anaemia is <5gms Hb/dl or HCT < 15

Severe anaemia may be the presenting feature in malaria. Patients with severe anaemia, especially pregnant girls, should be tested for malaria.

Give a safe blood transfusion as soon as possible to:

- all children or pregnant girls with a haematocrit of ≤ 12% or Hb of ≤ 4 g/dl
- less severely anaemic children (haematocrit >12–15%; Hb 4–5 g/dl) with any of the following:
  - clinically detectable dehydration
  - shock
  - impaired consciousness
  - deep and laboured breathing
  - heart failure
  - very high parasitaemia (>10% of red cells parasitized).

Give packed cells (10-20 ml/kg body weight for children and 500ml for pregnant girls), if available, over 3–4 hours in preference to whole blood Allow red blood cells to settle at the bottom of the bag, and stop infusion when cells have been used.

If not available, give fresh whole blood (20 ml/kg body weight) over 3–4 hours.

A diuretic is not usually indicated (unless pulmonary oedema/fluid overload is developing) because many of these children have a low blood volume (hypovolaemia).

Check the respiratory rate and pulse rate every 15 minutes. If one of them rises, transfuse more slowly. If there is any evidence of fluid overload due to the blood transfusion, give IV furosemide (1–2 mg/kg body weight) up to a maximum total of 20 mg for a child and give 40mg IV in the pregnant girl.

After the transfusion, if the Hb remains low, repeat the transfusion.

In severely malnourished children, fluid overload is a common and serious complication. Give whole blood (10 ml/kg body weight rather than 20 ml/kg) once only and do not repeat the transfusion.

Perform microscopy following transfusion, and repeat or extend antimalarial treatment if parasitaemia is increasing.

Respiratory distress due to acidosis

This presents with deep, laboured breathing while the chest is clear on auscultation—sometimes accompanied by lower chest wall indrawing. It is caused by systemic metabolic acidosis (frequently lactic acidosis) and may develop in a fully conscious child, but more often in children with cerebral malaria or severe anaemia. Always exclude other causes such as pneumonia or pulmonary oedema.

Metabolic acidosis in severe malaria has been attributed to the combined effects of several factors that reduce oxygen delivery to tissues:

1. Increased production of lactic acid by parasites (through direct stimulation by cytokines)
2. Decreased clearance by the liver
3. Marked reductions in the deformability of uninfected RBCs may compromise blood flow through tissues
4. Dehydration and hypovolemia can exacerbates microvascular obstruction by reducing perfusion pressure
5. Destruction of RBCs and anaemia further compromises oxygen delivery.
6. Mean venous blood lactate concentrations have been found to be almost twice as high in fatal cases as in survivors and to correlate with levels of tumour necrosis factor and interleukin 1-alpha. The lactate concentrations fell rapidly in survivors but fell only slightly, or rose, in fatal

cases. Sustained hyperlactataemia has been found to be the best overall prognostic indicator of outcome

Treatment

Give oxygen to all (even if not hypoxaemic) and if pulse oximeter is available keep SpO2 94-98%. Correct reversible causes of acidosis, especially dehydration and severe anaemia.

- If Hb is ≥ 5 g/dl, give 10 ml/kg of 0.9% saline or Hartmanns solution IV as a bolus and then reassess.
- If Hb is <5 g/dl, give whole blood (10 ml/kg) over 30 minutes, and a further 10 ml/kg over 1–2 hours without diuretics. Check the respiratory rate and pulse rate every 15 minutes. If either of these shows any rise, transfuse more slowly to avoid precipitating pulmonary oedema.
- Monitor ECG for cardiac arrhythmias if possible
- The use of sodium bicarbonate is controversial and generally should be avoided

Respiratory distress due to pulmonary oedema

This is different to that due to acidosis and there is usually more chest recession, hypoxaemia (cyanosis, SpO2 <92%) basal lung crepitations, enlarging liver, gallop rhythm, raised JVP. It may be due to fluid overload often in the presence of severe anaemia. The treatment is to tilt the bed of the patient so that the venous blood to the heart is reduced and if the bed cannot be tilted sit the patient up, give frusemide 1-2 mg/Kg IV in a child and 40mg IV in a pregnant girl and proceed with a careful transfusion of packed blood cell. Repeat furosemide as needed.

Respiratory distress due to pulmonary aspiration or pneumonia

Prevent aspiration pneumonia immediately because it can be fatal. Place the patient on his/her side and ensure the airway is open. If safe to do so and maintain intubate to protect the airway if unconscious (U on APVU scale or GCS < 9).

- Give oxygen if the SaO2 is below 92% or, if you cannot do pulse oximetry, there is cyanosis, severe, lower chest wall indrawing or a respiratory rate of ≥ 70/minute. Keep SpO2 94-98%.
- Give IM or IV antibiotics as for pneumonia and add in metronidazole until the patient can take these orally, for a total of 7 days.

Shock

Most children with malaria have warm peripheries. Shock is unusual in malaria (algid malaria). Some patients may have a cold, clammy skin. Some of them may be in shock (increased heart rate, cold extremities, weak pulse, capillary refill longer than 3 seconds, low BP (late sign)). These features are not usually due to malaria alone.

If present consider septicaemia, do a blood culture and start a broad-spectrum antibiotic IV (penicillin and gentamicin **or** cefotaxime or ceftriaxone) in addition to antimalarials.

Management includes rapid fluid replacement:

- **Children**: sodium chloride 0.9% IV, 10 ml/kg as a rapid bolus, reassess and if no better or improving but still in shock consider further 10ml/Kg
- **Pregnant girls**: sodium chloride 0.9% IV, 500 ml as a rapid bolus then reassess.

If no improvement in capillary refill or tachycardia, repeat the infusion once or twice more, as required.

Give broad spectrum antibiotics to treat septicaemia and any associated infections.

Acute renal failure (ARF)

ARF is defined as an abrupt decline in the renal regulation of water, electrolytes and acid-base balance and continues to be an important factor contributing to the morbidity and mortality of malaria patients.

Oliguria or anuria is often associated with jaundice, anaemia and bleeding disorders.

Note: ARF is uncommon in children; dehydration is a more common cause of poor urine output.

- The basic principles of management are avoidance of life-threatening complications, maintenance of fluid and electrolyte balance, and nutritional support.
- Urinary catheterisation can be helpful if it can be safely undertaken so urine output can be accurately measured. Alternatively weigh nappies in young children.
- Acute renal failure is suspected when the **hourly** urine output is <0.4ml/kg of body weight/hr). Blood concentrations of urea and creatinine are usually raised.
- Make sure the patient is adequately hydrated, but avoid overload.
- If urine output continues to be low despite adequate hydration, peripheral perfusion, and normal blood pressure give furosemide 3mg/kg
- If renal failure is established, restrict fluid to insensible loss (30ml/kg/day) plus urine output
- Consider peritoneal dialysis if available.

Abnormal bleeding

- Transfuse with fresh blood
- Give vitamin K 10 mg IV or PO
- Avoid IM injections and NSAIDs

Co-existing infections

Treat any associated pneumonia, dysentery, etc.

Summary of supportive care for the treatment of severe malaria in hospital

- If unconscious, maintain a clear airway. Nurse in recovery position to avoid aspiration pneumonia and turn 2 hourly
- Do not allow child to lie in a wet bed and provide special care to pressure points. Turn the patient every 2 hours
- Give oxygen for patients in respiratory distress or with shock
- In children with no dehydration, ensure that they receive their daily fluid requirements but take care not to exceed the recommended limits. Be particularly careful when fluids are given IV.
- Treat convulsions and hypoglycaemia.
- When you cannot exclude meningitis, give appropriate antibiotic intravenously.
- If there is deep or laboured breathing suggestive of acidosis, give one bolus of 10ml/Kg intravenous fluid (normal saline or Hartmann's) to correct hypovolaemia and re-asses. A second bolus may be required.
- During rehydration, examine frequently for fluid over-load (increased liver size (probably the best sign), gallop rhythm, fine crackles at lung bases, raised jugular venous pressure and eyelid oedema in infants).
- In infants always use an in-line infusion chamber for intravenous rehydration. If this is not available and supervision is poor empty the IV fluid bag until only 200-300 mls is remaining then if it all goes in quickly it will be less harmful than if the whole bag being infused.
- If necessary use a nasogastric tube to rehydrate.
- Avoid giving drugs like corticosteroids and other anti-inflammatory drugs, urea, invert glucose, low-molecular dextran, heparin, adrenaline (epinephrine), prostacyclin and cyclosporine as they do not treat malaria and can be harmful
- Give safe blood transfusion where necessary with careful monitoring to prevent fluid overload. Packed cells should be used in children and pregnant girls where possible. If overload is suspected, give a single dose of furosemide
- If unconscious and you cannot exclude meningitis or in shock, administer a broad spectrum antibiotic to manage septicaemia, pneumonia or meningitis, which are often associated with cerebral malaria.

Summary of monitoring

- Check patient regularly and at least every 3 hours. A doctor (if available) should see the patient at least twice a day.
- The rate of IV infusion should be checked hourly.
- Patients with cold extremities, hypoglycaemia on admission, respiratory distress, and/or deep coma are at highest risk of death. It is particularly important that these children be kept under very close observation.
- Monitor and report immediately any change in the level of consciousness, convulsions, or changes in the patient's behaviour.
- Monitor the temperature, pulse rate, respiratory rate (and, if possible, blood pressure) every 6 hours, for at least the first 48 hours
- Fluid balance charts: unconscious patients may be catheterised (if safe to do so) to measure urine output and facilitate correct fluid balance and to detect possible renal failure.
- Frequent measurement of blood sugar (every hour, especially when receiving quinine and/or where the level of consciousness does not improve).
- If patient is conscious, regularly (4 hourly) determine blood sugar to exclude hypoglycaemia if the patient is not eating well. This is especially important in young children and pregnant women or those patients receiving quinine therapy.
- Check haemoglobin/ haematocrit daily.

- Plasma urea and electrolytes where possible and blood gas/lactate measurements when available.
- Check the rate of IV infusion regularly. If available, use a giving chamber with a volume of 100–150 ml. Be very careful about over-infusion of fluids from a 500 ml or 1 litre bottle or bag, especially if the child is not supervised all the time. Partially empty the IV bottle or bag. If the risk of over-infusion cannot be ruled out, rehydration using a nasogastric tube may be safer.
- Keep a careful record of fluid intake (including IV) and urine output (should be at least 1ml/Kg/hour).
- A daily slide to determine level of parasitaemia and to follow treatment efficacy.
- Regular haemoglobin measurement. The frequency will depend on the rate of red blood cell breakdown. This may be very rapid in cases of high parasite density.

Section 12 Quiz 17

Which of the following statements are true in a child with coma?

a) part of the primary assessment includes checking blood glucose
b) the Glasgow coma score is the quickest way of assessing disability
c) compromised airway, breathing or circulation may lead to coma
d) hypertension with bradycardia are serious signs
e) hyponatraemia should be avoided

Section 12 Quiz 18

When considering the causes of coma, which of the following statements are true?

a) malaria is a common cause in a 1 year old child
b) if meningitis is suspected, a lumbar puncture should always be performed before giving IV antibiotics
c) if malaria is suspected, IV quinine can cause cardiac side effects if given too quickly
d) shock is common if malaria is the cause
e) high flow oxygen should be given, whatever the cause.

ANSWERS

17. a,c,d,e **18.** a,c,d,e

Management of the infant or child with convulsion

NEVER FORGET GLUCOSE AND ALWAYS HAVE BAG-VALVE MASK IMMEDIATELY AVAILABLE

Remember, cerebral malaria, meningitis, including TB, HIV, metabolic disorders (more likely with consanguineous marriages) are common cause of convulsions

Convulsive status epilepticus (CSE) is a life threatening condition in which the brain is in a state of prolonged seizure. It is defined as a generalized convulsion lasting more than 30 minutes or recurrent convulsions which occur very frequently over a 30 minute period where the patient does not regain consciousness in between seizures.

The duration of the convulsion is very relevant as the longer the duration of the episode, the more difficult it becomes to control it. Convulsions that persist beyond 5 minutes may not stop spontaneously, Hence it is usual practice to institute anticonvulsive treatment when the episode has lasted 5 minutes or more.

Common causes of convulsions in children include

- Fever with a predisposition to febrile convulsions (usually between ages 6 months to 6 years),
- Meningitis
- Epilepsy
- Hypoxia
- Metabolic abnormalities.
- Abrupt withdrawl of anti-seizure medication
- Acute cerebral event /injury (eg. Haemorrhage or trauma)
- Ingestion of medication

Tonic-clonic status occurs in approximately 5% of patients with epilepsy. Up to 5% of children with febrile seizures will present with status epilepticus. The mortality rate of status epilepticus can be quite high (up to 20% in adults), especially if treatment is not initiated quickly. However with optimal management and adherence to a structured and standardized management plan, the mortality in children is much lower and patients can survive with minimal or no brain damage.

Management

This is focused on terminating the fit, preventing secondary damage from hypoxia or hypo-perfusion of the brain and identifying and treating the most likely underlying cause

Diagnostic pointers	
Fever	suggestive of infection, but also occurs with ecstasy, cocaine and salicylate poisoning
Hypothermia	associated with ingestion of barbiturates or alcohol
Rash	Purpuric suggestive of meningococcal disease
Bruising	Consider trauma, including non-accidental injury or bleeding disorder
Retinal bleed/bruises/fractures	Suggest subdural bleed; consider child abuse
Urinalysis	If available, check for evidence of poisoning or drug ingestion

Evaluation and immediate management of Status epilepticus

During a seizure

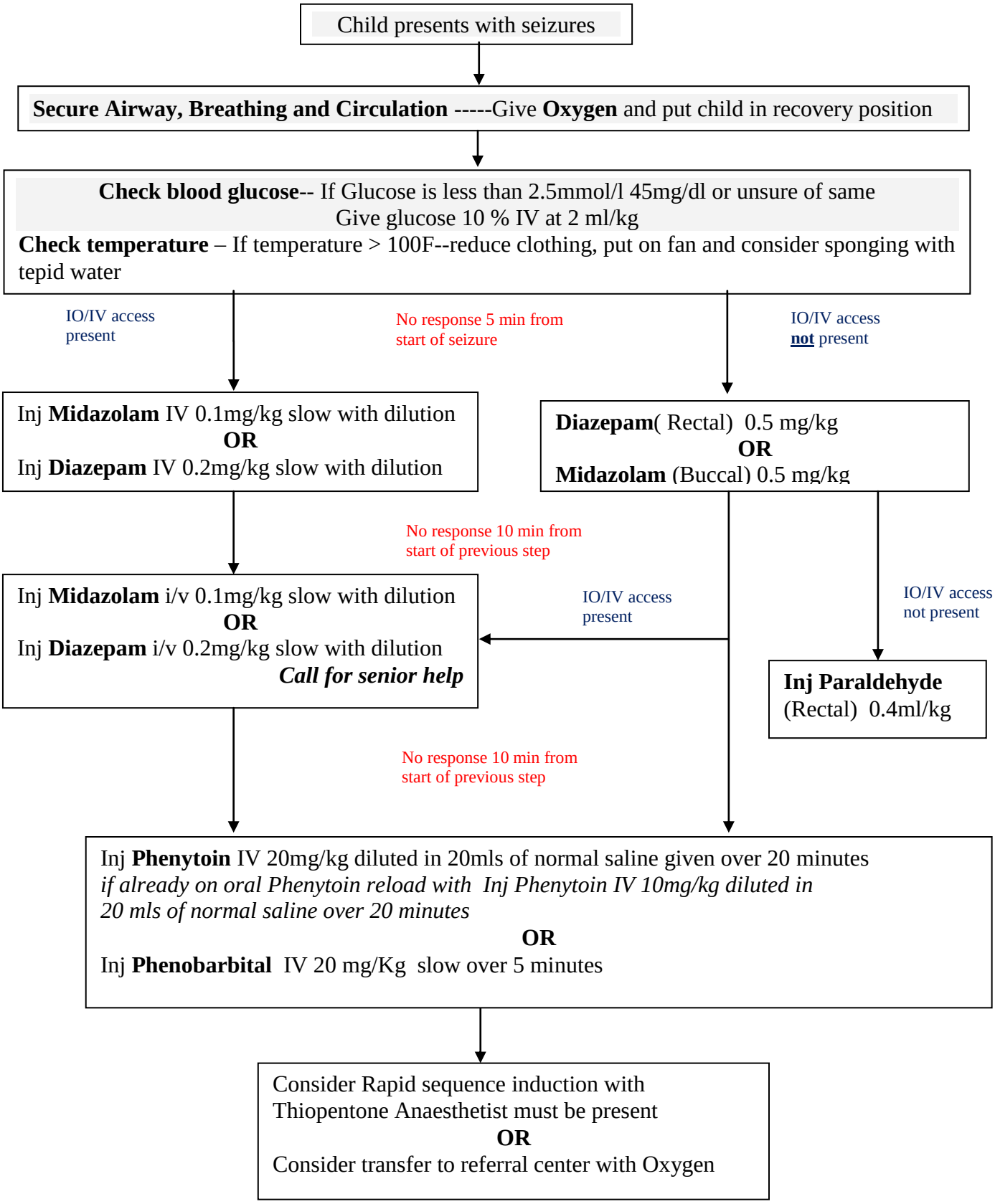
- Put the child into the recovery position.
- Ensure the airway is patent and there is adequate respiratory effort and circulatory volume. Institute corrective measures immediately if so required.
- If available apply an oxygen mask.
- If the seizure lasts more than 5 minutes (or if the duration is not known) anticonvulsant treatment should be initiated. Short recurrent seizures lasting less than 5 minutes should also be treated (see flow chart in Figure).
- Treat the fever if present by exposure, tepid sponging and rectal paracetamol *(Dose: 40 mg/kg loading dose, 20 mg/kg if <3 months).*
- Check glucose and treat if low < 3.0 mmol/litre (54 mg/dl). If in doubt or unable to check, it is safer to treat as if hypoglycaemia and give 10 % dextrose IV 2 ml/kg as an initial bolus followed by an infusion containing a glucose containing fluid to avoid the risk of rebound hypoglycaemia.
- **Must have available self inflating bag with non-return valve (eg Ambubag) and suitably sized face mask in case of excessive respiratory depression from benzodiazepines**.

Evaluation and immediate management of Status epilepticus

During a seizure

- Put the child onto a left lateral decubitus position.
- Ensure the airway is patent and there is adequate respiratory effort and circulatory volume. Institute corrective measures immediately if so required.
- If available apply an oxygen mask.
- If the seizure lasts more than 5 minutes (or if the duration is not known) anticonvulsant treatment should be initiated. Short recurrent seizures lasting less than 5 minutes should also be treated (see flow chart in Figure).
- Treat the fever if present by exposure, tepid sponging and rectal paracetamol *(Dose: 40 mg/kg loading dose, 20 mg/kg if <3 months).*
- Check glucose and treat if low < 2.5 mmol/litre (45 mg/dl). If in doubt or unable to check, it is safer to treat as if hypoglycaemia and give 10 % dextrose IV 2 ml/kg as an initial bolus followed by an infusion containing a glucose containing fluid to avoid the risk of rebound hypoglycaemia.
- **Must have available self inflating bag with non-return valve (eg Ambubag) and suitably sized face mask in case of excessive respiratory depression from benzodiazepines**.

Management of Status epilepticus:



Drugs

Lorazepam is a benzodiazapine with a quick onset of action and a longer duration of effect (12–24 hours) as compared to diazepam (less than 1 hour). It produces less respiratory depression as compared to other benzodiazepines, however absorption from the rectal route is poor. Lorazepam is not available in every country.

Dose: 0.05-0.1mg/kg/dose IV or IO (dose can be repeated)

Midazolam is an effective, quick acting anticonvulsant, which takes effect within minutes but has a shorter lasting effect (15-20 minutes). Most children do not convulse again once the seizure has been terminated.

Buccal midazolam is twice as effective as rectal diazepam, but both drugs produce the same degree of respiratory depression. This occurs only in about 5% of patients, is short lived and is usually easily managed with bag valve mask ventilatory support.

It can be given by the buccal or intravenous routes, however the ready made buccal midazolam may not be available in some countries. In such situations the standard IV preparation can be used instead via the buccal route. Simply draw the required dose in a syringe using a needle so as to filter off any glass fragments and after removing the needle apply the drug on the buccal mucosa between the lower lip and the gum.

Dose: 0.05-0.1mg/kg/dose IV/IO (dose may be repeated)
0.5mg/kg/dose Buccal application (dose may be repeated)

Diazepam is an effective, commonly used, readily available and quick acting anticonvulsant with similar characteristics to midazolam. It is widely used but may now be superseded by the more effective midazolam where the latter is available. The rectal dose is well absorbed.

Dose: 0.5mg/kg/dose rectally
0.1-0.2mg/kg/dose IV or IO (dose may be repeated)

Paraldehyde is an effective and cheap anticonvulsant with a sustained level of effect, however it may be difficult to find in some countries. Paraldehyde takes 10-15 minutes to take and its action is sustained for 2- 4 hours.

It is generally given by the rectal route after mixing up the required dose with an equal amount of any edible oil. (eg. olive oil). This mixture is then quickly pushed up the rectum using a simple feeding tube attached to a syringe. *Do not leave paraldehyde standing in a plastic syringe for longer than a few minutes as it dissolves plastic*. The intramuscular route can also be used but is very painful and can lead to abscess formation. This route is better avoided. Paraldehyde causes little respiratory depression. It should not be used in liver disease.

Dose: 0.4 ml/kg rectally

Phenytoin is a readily available anticonvulsant capable of producing very good results with little effect on respiration. It has a peak action within 1 hour with a long half life. Its action therefore is more sustained than diazepam.

It is given as an intravenous infusion mixed with 0.9% sodium chloride solution made up to a concentration of 10mg per ml given over a 20 minute period. Phenytoin can cause dysrhythmias and hypotension (more so if given rapidly), it is therefore important to monitor the electrocardiogram

(ECG) and blood pressure (BP) where available. In addition, local irritation, phlebitis, and dizziness may accompany intravenous administration.

If the child is known to be on oral phenytoin it is better to either avoid using Phenytoin (use Phenobarbitone instead) or to use a lower loading dose (ie 10 mg/kg).

Dose: 20 mg/kg IV infusion given over 20 minutes (Only use normal saline for dilution)

Phenobarbitone is a time tested anticonvulsant and readily available in many countries. It can be used to good effect in all age groups with little respiratory depression. It is given by the intravenous route as a slow injection over 5-15 minutes. It has a sustained effect lasting over 12-24 hours.

There is now evidence to suggest that Phenytoin and Phenobarbitone may have some synergistic effect when used sequentially. It is thought that one prime's the brain against the other thus producing a beneficial effect. Controversy however surrounds as to which drug should be used first.

Dose: 20mg/kg IV infusion over 5-10 minutes

Thiopental (Thiopentone) sodium is a drug better used by experienced staff who are familiar with it (usually anaesthetists) and capable of intubating difficult cases. It is a general anaesthetic agent with no analgesic properties and marked cardiorespiratory effects. Other antiepileptic medication must be continued .The child should not remain paralysed as continued seizure activity cannot universally be adequately monitored by cerebral function analysis monitoring. A paediatric neurologist should continue to give clinical advice and support.

General measures once seizures are controlled:

- **Maintain a normoglycaemic state** using 5% glucose containing solutions (10% in young infants) .Often children may show a hyperglycemic pattern following seizures as a stress induced response. This does not need correction with insulin.
- **Normal maintenance fluid volume** can be given to avoid hypoglycaemia and to maintain electrolyte balance. However evidence of raised intracranial pressure or increased antidiuretic hormone secretion should necessitate fluid restriction.
- **Assess and maintain electrolyte balance** maintaining serum sodium within the normal range (135-145 mmol/l). Avoid hyponatraemia by using normal saline or 0.45% saline.
- **Aspirate the stomach contents**.by inserting a gastric tube and perform gastric lavage if appropriate for specific drug ingestions
- **Regulate temperature**, ensuring temperatures above 37.5° C are avoided.
- **Treat raised intracranial pressure**, if relevant by
  - Supporting ventilation (maintain a *P* CO 2 of 4.5 – 5.5 kPa)
  - Maintaining a 20 ° head up position
  - Giving 20 % mannitol 250 – 500 mg/kg (1.25 – 2.5 ml/Kg) IV over 15 minutes. This may be repeated on a 2 hourly basis as required
  - Give dexamethasone 500 micrograms/kg twice daily (for oedema surrounding a space occupying lesion).
- **Catheterise the bladder** as distension may aggravate raised intracranial pressure.
- **Frequent reassessment of ABC** is mandatory as therapy may cause depression of ventilation or hypotension, especially if benzodiazepines or barbiturates have been used.
- If available a standard EEG can be done to establish cessation of electrical seizure activity.
- **Identify and treat the underlying cause** of the convulsion.

- Following seizure control there are several regimes for continued drug control of the convulsions but they are outside the scope of this text.

Febrile Convulsions

Definition a seizure in a child aged up to 6 years, caused by fever arising from infection or inflammation outside the central nervous system in a child who is otherwise neurologically normal. Simple febrile convulsions are generalized, tonic-clonic seizures. They usually last < 10 minutes (50% last < 3 minutes). A small proportion (5%) last more than 30 minutes.
This is a common condition with an estimated prevalence of 2-4% and there is often a family history. Long term effects are rare.

Management

- Temperature control
  - Paracetamol 20mg/kg and / or ibuprofen 4-10mg/kg
  - Tepid sponging
  - fanning
- Identification of the cause of infection – always check the urine

Any child with a prolonged or focal seizure, or who has not recovered within an hour, should be suspected of having serious pathology.

Although most children rapidly make a good recovery, it is important to have considered other causes of fever and/or convulsions before planning to discharge

If a child is being discharged home, make sure the parents

- understand what has happened
- know what treatment their child is on
- understand the importance of keeping the child's temperature down
- will bring the child back if there is a worsening in their condition

Causes of fever ± convulsions

- In an endemic area consider malaria
- Urinary tract infection
- Measles in the un-immunised child
- Meningitis or encephalitis
- Hypoglycaemia
- Metabolic abnormality
- Poisoning

Indications for admission after febrile convulsion

- Age < 18 months unless very clear focus of infection
- Signs of meningitis
- Child is drowsy, irritable or systemically unwell
- Recent or current treatment with antibiotics (partially treated meningitis can be missed)
- Complex convulsion, or delayed recovery
- If there are concerns the child may not be able to get back if deteriorates

The child with tetanus

Please see section 11 under neonatal tetanus

Severe Malnutrition in the Child

In children, there is a high mortality rate associated with malnutrition. This can be reduced a great deal by the delivery of good care.

Clinical evaluation of the severely malnourished child

Nutritional status is assessed according to weight for length/height; height for age; and the presence of oedema. Children who are below –3S.D. or who have oedema of both feet, are severely malnourished (see Table)

Mid upper arm circumference (MUAC) is a good way of identifying wasted children as it is relatively constant between 1 and 5 years of age when a MUAC of less than 12.5cm indicates malnutrition.

SEVERE ACUTE MALNUTRITION (SAM) Definitions			
SAM with complications *Combination of at least one item from each of the columns below*		SAM without complications *Combination of at least one item from each of the columns below*	
<80% of median Weight for Height (<-2 SD score)	Anorexia	<70% of median Weight for Height (<-3 SD score)	Good appetite
Bilateral pitting oedema	Lower respiratory infection	Bilateral pitting oedema	Clinically well
Mid-upper arm circumference <115 mm	High fever	Mid-upper arm circumference <115 mm	Alert
	Severe dehydration		
	Severe anaemia		
	Not alert		
MANAGEMENT			
INPATIENT CARE		OUTPATIENT CARE	
IMCI/WHO protocols		Therapeutic care	

Features

- Characterised by oedema or wasting (e.g. of the buttocks), anorexia and infection
- Anaemia is frequently present
- Biochemical abnormalities include : low protein, potassium, urea, magnesium and glucose
- Two overlapping clinical pictures are seen, marasmus and kwashiorkor.

Marasmus

- Affects young children
- Due to lack of calories over many weeks
- Extreme thinness with loss of subcutaneous fat and muscle mass
- Prominent bones and joints
- Sunken eyes
- Often hungry and active
- Weight for length < 70% median

Kwashiorkor

- Acute illness, appears over a few days
- Affects children < 4 yrs old
- Maybe be precipitated by acute illness – measles or diarrhoea
- Involves sodium retention and pitting oedema of peripheries
- Causes dermatosis and desquamation
- Dry, brittle hair
- Child is apathetic and feeds poorly
- Associated with persistent anorexia, diarrhoea and vomiting

Mortality from malnutrition can be reduced by correct early treatment. The common causes of early death are

- Hypoglycaemia
- Hypothermia
- Fluid and electrolyte imbalance – particularly hypokalaemia
- Infections and septic shock
- Failure to correct vitamin and micronutrient deficiencies
- Inappropriate IV fluid treatment, including blood transfusion

Harmful aspects of treatment for severe malnutrition

- Too much energy and protein given during first phase of treatment
- Diuretics given to treat oedema causing hypokalaemia
- Anaemia treated with iron early leading to free radical damage and infections
- Vitamin A and measles vaccine not given
- Albumin or amino acids infused
- High sodium ORS and intravenous fluids administered
- Routine antibiotics not given
- Failure to monitor food intake
- Lack of overnight feeding
- Hypoglycaemia not monitored and treated
- Hypothermia not monitored and treated
- Inadequate staffing and poor organisation of care

Principles of Treatment

Stabilisation phase (up to7 days)	**Transition over 48 hours**	**Catch up growth Phase (usually 14-21 days)**
Treat or prevent dehydration, hypoglycaemia, hypothermia		
Treat infection	Treat worms	
Correct electrolyte imbalance Correct micro-nutrient deficiencies		
Do not give iron	Do not give iron	Correct iron deficiency
DIET Maintenance intake	Moderate intake	High intake
Stimulate child	Stimulate child	Stimulate child
		Provide physical activities Prepare for discharge

- Treat dehydration cautiously
- Prevent hypoglycaemia and hypothermia
- Treat infection, congestive heart failure and severe anaemia
- Correct electrolyte and micronutrient deficiency
- Provide standard maintenance nutrition within first few days of treatment

- Remember potential for sodium overload and cardiac failure
- Remember signs of coincidental sepsis may be hidden

General Treatment

- Keep malnourished separate from patients with infections in a warm room without draughts
- wash minimally, with warm water and dry immediately
- avoid IV cannulae / infusions (unless in shock)
    - high risk of heart failure from fluid overload
    - risk of infection
    - give blood transfusion only when anaemia is life-threatening
    - remove IV cannulae immediately after treatment
- use a nasogastric tube for feeding if:
    - anorexia with intake of <80% prescribed
    - severe dehydration with inability to drink oral fluids
    - painful or severe mouth lesions (herpes, cancrum oris, severe oral/oesophageal thrush)
    - recurrent, frequent vomiting

Principles of therapy

Hypoglycaemia (< 2.5 mmol/litre (45mg/dl)

- Presume present if unable to test
- Treat with 50ml of 10% glucose or 50 ml of drinking water with 10 g of sugar via nasogastric tube or 5 ml/kg 10% glucose IV
- If IV or IO access is not immediately available and patient has reduced level of consciousness or is unconscious give sublingual sugar 1 teaspoon moistened with 1-2 drops of water. (Sublingual sugar appears to be a child-friendly, well-tolerated and effective promising method of raising blood glucose in severely ill children. More frequent repeated doses are needed to prevent relapse. **Children should be monitored for early swallowing which leads to delayed absorption, and in this case another dose of sugar should be given.** Sublingual sugar could be proposed as an immediate "first aid" measure while awaiting intravenous or intraosseous glucose).
- If sublingual sugar is given repeat doses at 20 minute intervals.
- Recheck the blood glucose in 20 minutes, and repeat the glucose (5 ml/kg IV/IO or sublingual sugar) if the level is low (<2.5 mmol/litre or <45 mg/dl).
- Prevention by 2 hourly feeds – day and night

Hypothermia

- Check with low reading thermometer and keep T > 36.5
- Treat with passive re-warming – e.g skin to skin contact with carer
- Prevent by keeping child warm, and dry and away from draughts
- Avoid prolonged medical examinations and washing

Dehydration

- Usually over estimated in malnutrition as reduced skin elasticity and sunken eyes are features of malnutrition
- Features suggestive of dehydration as well as malnutrition are
    - Frequent watery stools
    - Minimal urine output (no urine output for 12 hours or more)
    - Thirst
    - Weak pulse
- Treat with oral re-hydration (only give IV if in shock)
- Standard ORS has too much sodium and too little potassium – use ReSoMal
- Check for fluid overload
        - Liver enlargement; basal creps; raised JVP: rising pulse ± respiratory rate: oedema
- If overloaded, treat with fluid restriction NOT with diuretics

Electrolytes

- Malnourished patients have low potassium and magnesium and high total body sodium
- Treat with oral replacement
    - Potassium 3-4 mmol/kg /day
    - Magnesium 0.5 mmol/kg / day

Infection

- Clinical signs may be absent; suspect if hypoglycaemia or hypothermia
- Antibiotics for severe acute malnutrition
    a) In children with severe acute malnutrition without complications manage according to the current community case management guidelines.
    b) In children with severe acute malnutrition with complications, give parenteral antibiotics as follows:

        Benzyl penicillin (50 000 U/kg (30mg/Kg) IM/IV every 6 hours) or ampicillin (50 mg/kg IM/IV 6 hourly) for 2 days, then oral amoxicillin (15 mg/kg/dose every 8 hours for 5 days)

        AND

        Gentamicin (7.5 mg/kg IM/IV) once daily for 7 days.
- Note that doses based on actual body weight might be too low – increase by 10% in severe malnutrition
- Give measles immunisation if not previously immunised
- Treat specific infections –always consider malaria, TB, worms and HIV

Acute severe anaemia

- Transfuse at Hb < 4g/dl, or signs of heart failure and Hb 4-6 g/dl
- Partial exchange transfusion is better than giving whole blood or packed cells
    - Withdraw 2.5ml/kg anaemic blood and replace with 5ml/kg whole blood or packed cells
- If not exchanging, give 10ml/kg packed cells over 3-4 hours, with frusemide 1mg/kg

Congestive heart failure

- Serious and common; occurs several days after treatment started; due to cardiomyopathy secondary to malnutrition
- Often caused by over hydration, excess sodium, over transfusion, inadequate correction of potassium deficit
- Treat with fluid restriction and frusemide 1mg/kg

Micronutrients

- Single oral dose vitamin A on admission, plus daily supplements of zinc, potassium, magnesium and copper.
- Give zinc supplement of 10mg per day (elemental formula) up to 6 months of age and 20mg per day (elemental formula) for children > 1 year
- Folic acid 5mg stat and 1mg/day
- **DO NOT GIVE IRON during first 14 days of treatment**
- If xeropthalmia or measles give 3 doses of vitamin A

Nutrition management

- Start feeding as soon as possible
- Give small frequent meals of low osmolality, low sodium, low lactose and low protein
- Feed throughout the day and night

By careful attention to detail, and maintaining treatment throughout the day and night, severely malnourished children have a better chance of survival.

Section 12 Quiz 19

Which of the following are features of the malnourished child?

a) More than 3 standard deviations below weight for height
b) Mid upper arm circumference less than 12.5 cm in the age group 1 – 5 years
c) Hyponatremia
d) May be hungry and active
e) May be apathetic and reluctant to eat

Section 12 Quiz 20

Which of the following are common causes of death in severe malnutrition?

a) Hypoglycaemia
b) Sepsis
c) Iatrogenic
d) Hypokalaemia
e) Inappropriate blood transfusion

Section 12 Quiz 21

Which of the following are important aspects of treatment in severe malnutrition?

a) Iron supplements should be given early
b) Standard ORS should be given if the child is dehydrated
c) Particular care is needed to prevent hypothermia
d) NG feeding is only needed if there is recurrent vomiting
e) Feeding should continue regularly throughout the night
f) Diuretics are needed if oedema is present
g) Potassium and magnesium supplements may be needed
h) Antibiotics should be avoided unless there are obvious clinical signs of infection
i) If Hb is less than 4g/dL packed cell transfusion with frusemide is the best way of giving blood
j) Measles immunisation should be given if not previously immunised

ANSWERS:

1. abde 2. abcde 3. cdegij