

# Paediatric Anaesthesia For Beginners

Version 2: Dr J Fasham  
Edited by Dr L Hulatt  
Initial version by Dr T Lawson



Association of  
Paediatric Anaesthetists  
of Great Britain and  
Ireland

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## Definitions

Premature = Less than 37weeks

Extreme Prematurity = Less than 28weeks

Neonate = up to 44weeks from date of conception

Post-conceptual age = gestational age at birth + post-natal age

Low birth weight = Less than 2500g

Very low birth weight = Less than 1500g

Extremely low birth weight = Less than 1000g

Infants = 1month to 1 year

Child = 1-12 years

Adolescent/young person = 13-16 years

Normal ranges for children										
Age	Guide weight (kg)		Resp rate at rest breaths per minute (5 <sup>th</sup> -95 <sup>th</sup> centile)	Heart rate beats per minute (5 <sup>th</sup> – 95 <sup>th</sup> centile)	Systolic blood pressure (mmHg)					
	Boys	Girls			5 <sup>th</sup> centile	50 <sup>th</sup> centile	95 <sup>th</sup> centile			
Birth	3.5	3.5	25-50	120-170	65-75	80-90	105			
1 month	4.5	4.5								
3 months	6.5	6	25-45	115-160						
6 months	8	7	20-40	110-160						
12 months	9.5	9			70-75	85-95				
18 months	11	10	20-35	100-155	70-80	85-95	110			
2 years	12	12	20-30	100-150						
3 years	14	14		90-140						
4 years	16	16		80-135						
5 years	18	18		80-130						
6 years	21	20								
7 years	23	22	15-25	70-120				80-90	90-110	111-120
8 years	25	25								
9 years	28	28								
10 years	31	32								
11 years	35	35								
12 years	43	43	12-24	65-115	90-105	100-120	125-140			
14 years	50	50		60-110						
Adult	70	70								

## Formulae

There are several important formulae that you will need to memorise.

It is worth doing them for each patient you anaesthetise so that they become second nature

### Resuscitation

Weight (kg)	All purpose = $(\text{age in years} + 4) \times 2$ Tends to underestimate weights  APLS Age specific $< 1 \text{ year} = (\text{age in months} \times 0.5) + 4$ $1 - 5 \text{ years} = (\text{age in years} \times 2) + 8$ $6 - 12 \text{ years} = (\text{age in years} \times 3) + 7$
Electricity	4 Joules/kg
Tracheal tube	Uncuffed size = $(\text{age}/4) + 4$ Cuffed size = $(\text{age}/4) + 3.5$ Length (oral) = $(\text{age}/2) + 12$ Length (nasal) = $(\text{age}/2) + 15$
Fluid bolus	10 ml/kg of balanced crystalloid
Adrenaline	10 mcg/kg = 0.1ml/kg 1:10,000
Glucose	2 ml/kg of 10% dextrose

### Fluids

Bolus – 10ml/kg of balanced isotonic crystalloid

Normal Hourly Maintenance Requirement	Normal Daily Maintenance Requirement
4ml/kg for first 10 kg	100ml/kg for first 10kg
2ml/kg for second 10kg	50ml/kg for second 10kg
1ml/kg for every additional kg	20ml/kg for every additional kg

Nil By Mouth Deficit = Hourly requirement x number of hours NBM

### Dehydration Definitions

Dehydration without shock	= < 10% fluid loss	= slow replacement
Dehydration with shock	= > 10% fluid loss	= rapid replacement

Replacement fluid (ml) = % dehydrated x weight (kg) x 10

### Blood

Blood loss in theatre

4ml/kg red blood cells raises Hb by 10g/l

Major haemorrhage - use a 1:1 red blood cells: FFP ratio

Red blood cells	5 ml/kg
FFP	5 ml/kg
Platelets	3 ml/kg
Tranexamic acid	15mg/kg

## Paediatric Anatomy and Physiology

### Airway Anatomy

#### Neonates / Infants

- Head and Neck
  - Large Head with prominent occiput
  - Pillows are unhelpful as they may position the head and neck in a way to obstruct the airway
  - Relatively larger tongue
  - Easier to obstruct the airway
  - Short Neck and Small Mandible
  - Obligate nose breathers when <5months – narrow nasal passages.
- Larynx
  - Floppy anterior U- shaped epiglottis lifted out of the way on laryngoscopy
  - More anterior and cephalad larynx (C4)
  - Cricoid ring = narrowest part of the upper airway easy to damage mucosa if ETT is too tight
- Trachea
  - Short trachea (from cricoid to carina)
  - Easy endobronchial intubation
  - Soft tracheal cartilage
  - Can collapse with negative inspiratory pressure
- Lungs
  - Bronchi at same angles bronchial intubation as likely on both sides
  - Higher airway resistance (nasal passages are responsible for 50%)
- Chest
  - Horizontal ribs with no bucket handle movement
  - Weak respiratory muscles
  - Easy to fatigue if work of breathing is high
  - Diaphragm dependent ventilation
  - Any limitation of diaphragmatic movement has a large effect e.g. bowel obstruction

#### Toddlers

- Head and Neck
  - Head is more proportional to body size
  - Baby teeth begin to erupt (permanent teeth begin to erupt from 6y ears)
  - Jaw becomes larger
- Larynx
  - Epiglottis is less floppy and may not need to be lifted on laryngoscopy
- Chest
  - <7 years the diaphragm is the main muscle of respiration

## Respiratory

### All age groups

- Tidal volume 7-8ml/kg
- FRC 30ml/kg
- Dead space 2ml/kg

### Neonates / Infants

- Immature respiratory centres
- Apnoea risk
  - Term infant <44 weeks post conceptual age should stay overnight post surgery
  - Ex-premature infant <60 weeks post conceptual age should stay overnight post surgery
- Give opioids with care
- Lower airway compliance (stiff lungs) but compliant chest wall
- High respiratory rate
- High closing volume
  - risk of hypoxaemia
  - Small O<sub>2</sub> reservoir, high metabolic rate + oxygen consumption
  - Rapid desaturation

## Cardiovascular

### Neonates / Infants

- Sinus arrhythmia is common
- Stiff, poorly compliant ventricles with less contractile elements
- Reduced contractility
- Limited Starling Response: rate dependent cardiac output
- HR <60bpm = unable to support cardiac output
- High Vagal tone
  - prone to bradycardia

### Toddlers

- HR decreases
- Systolic BP rises

### School Age and above

- Systolic BP increases
- HR decreases
- Blood Volume: absolute increase but decrease relative to size
- Heart approaches full size

## Neurological

### Neonates / Infants

- General
  - Immature sympathetic nervous system → high vagal tone
  - Incomplete myelination → complete by age 2
  - Pain pathways are intact and functional
- Brain

- Immature BBB (more permeable)
- Higher cerebral metabolic rate, O<sub>2</sub> and glucose requirement
- CSF volume = 4ml/kg
- Skull sutures are open
- Spinal Cord / Column
  - Spinal cord ends at L3 at term, L2-3 at age 1
  - Intercristal line = L5/S1
  - Thin sacrococcygeal membrane

#### Toddlers

- Parasympathetic and sympathetic activity more equal
- BBB fully formed
- Spinal cord terminates at L1/2 at 8 years

#### School Age and above

- Fully developed nervous system by mid-adolescence

#### Hepatic / Renal / Gastrointestinal

##### Neonates / Infants

- Hepatic
  - Ductus Venosus = patent for 7-10 days post-birth
  - Phase 1 + 2 reactions are normal from 2-3months
  - Low hepatic storage reserves of platelets, glucose and bicarb
  - Can lead to coagulopathy, hypoglycaemia and acidosis
- Renal
  - Full number of nephrons are present at birth, however, they do not have full filtering / concentrating ability until 2-3 months
  - High renal vascular resistance at birth → falls at week 2 – 4
  - Low Renal Blood Flow at birth → rises at week 2-4
  - Low GFR at birth → adult levels by 1 year
  - Higher total body water than in older children
  - 80% in the neonate
  - The proportion of ECF to ICF differs
  - ECF decreases with age, whilst ICF increases with age

#### Musculoskeletal

- Neonates / Infants
  - Immature musculature → easy to fatigue
- Toddlers
  - Increased bone and muscle growth
  - Incomplete bone mineralisation
  - Immature musculature → easy to fatigue

#### Thermoregulation

- Neonates / Infants
  - Immature hypothalamus
  - Increased body surface area: weight



- Increased basal metabolic rate
- Poor insulation – thin skin, low fat and immature muscles
- → Reduced ability to shiver and produce endogenous heat
- High vagal tone → less able to vasoconstrict
- Non-shivering thermogenesis
- Brown fat = fat with high number of mitochondria  
large iron content makes it brown
- Noradrenaline stimulates triglyceride oxidation utilises oxygen and glucose to generate heat
- Poorly efficient

### Immunological

#### Neonates / Infants

- Reduced ability to synthesize Ig's. Rises to adult levels by 1 year
- ABO antibodies appear by 2months

#### Toddlers

- Immune system immature

#### School Age and above

- Lymphatic tissue at peak from age 10-12
- Then regresses to adult levels

### Haematopoietic

#### Neonates / Infants

- 80% of total Hb at birth = HbF → falls to 5-10% by 4months
- HbF shifts Oxy-Hb curve to the left (alkalosis is bad)
- Hb = 18g/dl at birth → 11g/dl at 3months
- Blood volume = 90ml/kg for neonates
- High lymphocyte and leucocyte count

#### Toddlers

- Blood volume = 80ml/kg

#### School Age and above

- Blood volume = 70ml/kg
- Normal adult values

### Endocrinological / Metabolic

#### Neonates

- Lower glycogen stores
- Immature pathways for gluconeogenesis
- Therefore hypoglycaemia occurs more easily and is less well tolerated

## Premature Infants

The overarching consequence of prematurity is that there is incomplete organ development at the time of birth and this is associated with increased morbidity and mortality.

### Respiratory

- Chronic Lung disease is common in very-low birth weight infants
- Increased susceptibility to respiratory infections
- Apnoea of Prematurity
  - Pause in breathing of >20secs or
  - Pause in breathing of <20secs with bradycardia +/- cyanosis
  - Prem/neonatal Response to hypoxia
    - Brief hyperventilation → apnoea + blunted response to hypercapnia
    - Typically returns to normal by 3weeks
    - this may take longer in prems – up to 60weeks post-conceptual age.
  - This is of key concern in ex-premature infants.
  - Ideally elective surgery should be delayed
- Respiratory Distress Syndrome
  - Inadequate surfactant production before 32-34weeks
  - Antenatal corticosteroids in preterm labour stimulates surfactant production and reduces incidence
  - Surfactant may need to be given after birth
- Bronchopulmonary Dysplasia
  - Affects neonates that receive oxygen / mechanical ventilation for >28days
  - Features include oxygen dependency, hypoxia, hypercarbia etc
  - Results in reduced lung compliance, increased oxygen requirements and reversible airway obstruction
- Respiratory Tract injury
  - Related to the number/duration of tracheal intubation(s)
  - Increased incidence of acquired subglottic stenosis

### Cardiovascular

- Patent Ductus Arteriosus
  - Usually closes within 3-4 days in 90% of well prems
  - Results in:
    - increased pulmonary blood flow
    - worsening RDS
    - cardiac failure
    - low diastolic pressure
  - Medical closure with Indomethacin
  - Surgical closure in failed medical treatment / NSAID contraindication
- Difficult venous access

### Nervous System

- Development of Pain Pathways
- Precise gestational age when a neonate can perceive pain is unknown. Although at 26 weeks gestation – prems respond to tissue damage by withdrawal + stress response
- Other common problems include:
  - Intraventricular Haemorrhages
  - Retinopathy of prematurity + Oxygen Toxicity

### Hepatic / Renal / Gastrointestinal

- Common problems
  - Gastro-oesophageal reflux
  - Necrotising enterocolitis
- Renal function depends on gestational age

### Thermoregulation / Metabolic

- Lower brown fat deposits compared to term neonates
- Glycogen stores / Gluconeogenesis pathways are underdeveloped

### Haematopoietic

- Hb concentration may be lower than at term (130-150g/l versus 180 - 200g/l)
- Blood volume - 100ml/kg for prems

## Paediatric Anaesthesia

- The key principles are PREPARATION and FLEXIBILITY.
- This ranges from establishing a rapport with a child and their parents to knowing emergency drug doses.
- There are also a few important differences from adult anaesthesia to remember

### Induction

- Lower FRC → more rapid desaturation
- Higher minute ventilation → faster uptake of inhalation agent
- Neonates and babies have an increased predisposition to apnoea

### Intubation

- Increased risk of bradycardia due to higher vagal tone
- Higher risk of laryngospasm and hypoxia

### Maintenance

- MAC varies depending on age
- If breathing spontaneously → changes in inspired concentration of inhalational agents rapidly affect child

### Emergence

- Higher metabolic and respiratory rates lead to more rapid emergence
- Risk of bradycardia and laryngospasm is the same as at induction

### Pre-operative Assessment

- This is your opportunity to make life easy for yourself.
- It is also often the part of the anaesthetic that most trainees have difficulty with.
- Being able to win over a shy or sceptical child is critical and will make the induction more pleasant for the child, their family and yourself.
- It is also important to flag up the potentially difficult child early e.g. to give enough time for pre-medicants to work.

### General Tips

- Smile
- Be happy, pleasant and non-threatening
- Take an interest in the child or what they are doing
- e.g. what toys they are playing with or characters on their clothing
- Try to stay at eye-level with the child
- Talk to the child first and foremost, but also try to involve the parents.
- USE APPROPRIATE LANGUAGE – the following are suggestions: -
  - Anaesthetists = Sleep doctors
  - Anaesthetic = Special sleep
  - Venflon / Cannula = Straw
  - Ametop = Magic Cream
  - Propofol = Penguin (cold) or Hedgehog milk

## The Psychology of Children

Age	Cognitive	Social	Emotional	Suggestions
Infant <9 months	Unable to discriminate between caregivers and strangers	Responds to facial expressions	Trust caregivers	Respond well to physical contact, rocking and talking
Toddlers 1-3 years	Separation anxiety Can discriminate between parents and strangers	Plays games with caregiver Stranger anxiety possible	Can start to become stubborn Attached to objects of security	Have a parent with them and involved in the anaesthetic room Bring object of security e.g. favourite teddy Watching programme on tablet/phone maybe helpful
Pre-school 3-5 years	Illogical/magical thinking Vivid imagination Poor understanding of time Accurate but suggestible memory	Cooperative play Tend to want to please adults	Better emotional control Curious	Avoid euphemisms and metaphors Good explanations
School aged 6-12 years	Communication much improved Logical thinking Better understanding of time Better coping skills	Change in appreciation of rules from strict adherence to negotiation Less fantasy play	Increased sensitivity Increased independence	Reassure patient Allow them to bring their own music or games into the anaesthetic room.
Young person >13 years	Logical and hypothetical thinking Perspective and insightful	Begin to distance themselves from parents	Increased self-confidence Can be emotionally labile Independent and desire control	Allow patient to play game on tablet/phone.

## History

### General

- Past anaesthetics – Problems and Family History
  - Was this a gas or IV induction?
  - How did they find the induction?
  - Review previous anaesthetic chart
- Presenting Complaint
  - Timing of injury – this is especially relevant in trauma
  - Pain – recent analgesics
  - Any nausea or vomiting
- Past medical history including: -
  - Neonatal history
  - Congenital syndromes and cardiac disease
  - Asthma or Cystic Fibrosis
  - Epilepsy
  - Developmental disorders, Trisomy 21, Cerebral Palsy, etc
- Recent coughs / colds / upset stomachs / vaccinations (see below)
- Drugs and Allergies
- Loose teeth

### History Specifics - Airway Syndromes

- Chonal Atresia
  - Congenital atresia of passage from nose to pharynx (uni or bi-lateral)
- Pierre-Robin Syndrome
  - Congenital anomaly of jaw (retrognathia)/ tongue / palate)
  - Airway obstruction when supine
  - Difficult intubation; improves with age as mandible grows
- Treacher-Collins Syndrome
  - Autosomal dominant disorder with retrognathia results
  - Difficult intubation; improves with age as mandible grows
- Goldenhar Syndrome
  - Congenital abnormalities of face (hemifacial microsomia), heart (VSD, TOF) and cervical vertebrae
  - Face mask ventilation may be difficult
  - Difficult intubation; worsens with age as facial asymmetry is more pronounced
- Mucopolysaccharidoses (E.g. Hurley's or Hunter's)
  - Intra-lysosomal accumulation of glycosaminoglycans
  - Stiffening of soft tissues
  - Difficult intubation; worsens with age
- Laryngomalacia
  - Unusually soft cartilaginous structures → dynamic obstruction
  - Usually resolves over first 6 months of life

### Congenital Cardiac Disease

- Thorough understanding of underlying anatomy / physiology is key
- Look for evidence of the four major complications of Congenital Heart Disease
  - Arrhythmias
  - Cardiac Failure
  - Cyanosis
  - Pulmonary Hypertension
- Other considerations
  - What are the O2 saturations in air
  - Is there failure to thrive
  - Does PVR or SVR require manipulation
  - Any chest infections?
  - Venous access issues

### Immunisation (APAGBI best practice guidance on immunisation and surgery (2021))

- The routine vaccination schedule should not usually be delayed because of elective surgery, especially in infants.
- Urgent surgery should not be delayed due to recent vaccination
- Inactivated vaccines - delay major elective surgery until 48 hours after vaccination because of the potential overlap between surgical complications and adverse effects of the vaccine.
- Live attenuated vaccines – no need to delay elective surgery but there remains a small possibility that a child may develop a fever at the time of admission for elective surgery and an assessment will be required.
- Vaccines may be administered after elective surgery after the child has recovered and is well
- Exclusion – immunocompromised children, for these patients seek expert advice

Age	Vaccination
8 weeks	6 in 1
	Rotavirus
	Men B
12 weeks	6 in 1 (2nd dose)
	PCV
	Rotavirus (2nd dose)
16 weeks	6 in 1 (3rd dose)
	Men B (2nd dose)
1 year	HiB/Men C
	MMR
	PCV (2nd dose)
	Men B (3rd dose)
2-10 years (annual)	Flu
3 years 4 months	4 in 1
	MMR (2nd dose)
> 5 years	SARS-Cov-2 (offered)
12 - 13 years	HPV
14 years	3 in 1
	Men ACWY

Vaccine	Type
6 in 1	DTaP (diphtheria, tetanus, acellular pertussis)
	Toxoid inactivated
	Hep B (hepatitis B)
	Subunit
	Hib (haemophilus type B)
4 in 1	Subunit, conjugate
	IPV (inactivated polio virus)
	Inactivated
3 in 1	DTaP – toxoid inactivated
	IPV - inactivated
HiB/MenC	Inactivated
HPV	Subunit conjugate
Men ACWY	Conjugate
Men B	Inactivated
MMR	Live attenuated

<https://www.nhs.uk/conditions/vaccinations/nhs-vaccinations-and-when-to-have-them/>  
accessed 09/02/2023

### Fasting

- Prolonged fasting in children can cause distress, dehydration, biochemical imbalance and hypoglycaemia.
- Gastric volume may even increase after a prolonged fast.
- Younger children have smaller glycogen store.
- Cerebral glucose requirement is higher in children.
  - Therefore hypoglycaemia can more easily result in neurological damage.

Food/drink	Minimum acceptable fasting times
Clear fluid	1 hour
Breast milk	3 hours
Formula milk if <1 years	4 hours
Food and cow's milk	6 hours



## Examination

- Often difficult due to lack of understanding/cooperation
- Where possible do an airway assessment
- If you have any concerns, discuss with the consultant
- Chest auscultation is recommended <2 years to check for heart murmurs.
- Look for potential veins if topical cutaneous anaesthesia has not been applied

### What if you detect a new murmur?

You need to determine whether it is likely to be an innocent or pathological murmur and discuss with the consultant

Murmurs in children	
Innocent	Pathological
Usually systolic	Pansystolic or diastolic
Quiet	Loud
No thrills	Thrills present
No associated signs/symptoms	Associated cardiac signs/symptoms
Normal exercise tolerance of growth	Abnormal exercise tolerance of growth
No cyanotic episodes	Cyanotic episodes

## Consent

- Consent should be obtained from the adult with parental responsibility for the child and where appropriate, from the child themselves.
- Who has parental responsibility varies in each country of the United Kingdom
- Use language the child can understand

### Age and Competence

- In the eyes of the law anyone under 18 years of age is deemed to be a child
- Children <16 years are presumed not to have capacity and consent is given by an individual with parental responsibility.
- Children <16 years who are deemed competent (Gillick/Fraser competence) are able to consent for themselves and should be encouraged to do so. It is good practice to encourage all children to participate in the discussion of consent and there is space on the consent form for the child to sign.
- Children between 16 and 17 years of age are presumed to have capacity and must consent for themselves. This can be overridden by the court in exceptional circumstances in the best interest of the child. Where these children lack capacity, an individual with parental responsibility can consent on their behalf.

### Life-threatening conditions

- Parental consent should be obtained wherever possible.
- Doctors may act in child's best interest to safeguard child's life/health if unable to obtain parental consent.

### Written consent

- Written consent is required for all procedures where general anaesthesia is required, in particular it is required for imaging procedures eg MRI where this should be completed by the referring clinician.

### Explanation

- Often best to describe both IV and Inhalation induction as the 1<sup>st</sup> and 2<sup>nd</sup> options
- Explain that one parent can accompany them to the anaesthetic room

### IV induction

- Things to explain to child
  - Take off the plaster and wipe away the magic cream
  - Put a little plastic straw in and stick it down
  - Give you some penguin or hedgehog milk to give you a nice sleep
- Things to explain to parents
  - Risks are the same as for adults – except for vomiting and laryngospasm.
  - Failure to site cannula and need to proceed to inhalation induction

### Inhalation Induction

- Things to explain to child
  - Give you a little space mask to hold - If the child is nervous it might be a good idea to bring a mask with you to pre-assessment get them to play with it before hand
  - Show them your balloon and explain you want them to try and blow it up and then suck all the air out of it – try to make it into a game
  - Gradually you'll drift off into a nice sleep
- Things to explain to parents
  - Children may become distressed and fight the mask – explain that when a child does this, they take deeper breaths and will often go to sleep more quickly
  - Children may become 'floppy' all of a sudden – this is normal
  - Children may twitch or make strange movements whilst they are asleep - this is normal

### Post-Operative Psychological Problems

- Children are vulnerable to psychological problems as a result of a difficult induction of anaesthesia.
- These may make subsequent interactions with healthcare more difficult.
- Hence the need for preparation and flexibility and why restraint during induction should be avoided wherever possible.
- Risk factors include: -
  - Age 2 – 3
  - Pre-operative withdrawn behaviour
  - Difficult and stressful induction e.g. restrained inhalation induction
  - Multiple previous procedures

## **Children with Additional or Special Needs**

- Coming into hospital is strange and potentially frightening event for children, this can be more so with children with learning disabilities (LD).
- There is a spectrum of LD and there many associated conditions, including: -
  - Autistic Spectrum
  - Down's Syndrome
  - Cerebral Palsy
- Such children pose unique challenges that require a flexible and holistic approach. Such challenges include: -
  - Cognitive
    - IQ is not always low
    - May find it difficult to: -
    - Understand what is being asked of them
    - Make themselves understood
    - Remember things
    - Understand other people's perspectives
    - Adapt to new or unfamiliar situations
    - Understand metaphors / fantasy – Autistic Spectrum children are very literal thinkers
    - Distinguish between appearance and reality
  - Behavioural
    - May not like being touch or having eye-contact
    - May be non-verbal or excessively verbal
    - May have a limited range or interests, preferred foods/drinks, etc
    - May show signs of repetitive or ritualistic behaviour
    - May lack coordination
    - May find it difficult to pay attention
  - Emotional
    - May become anxious or sad
    - May become uncooperative / aggressive
  - Social
    - May find it difficult to interact with other people
    - All of the above can impact on feeding, hygiene, dressing, transport etc
    - Attending hospital appointments poses a logistical challenge for carers

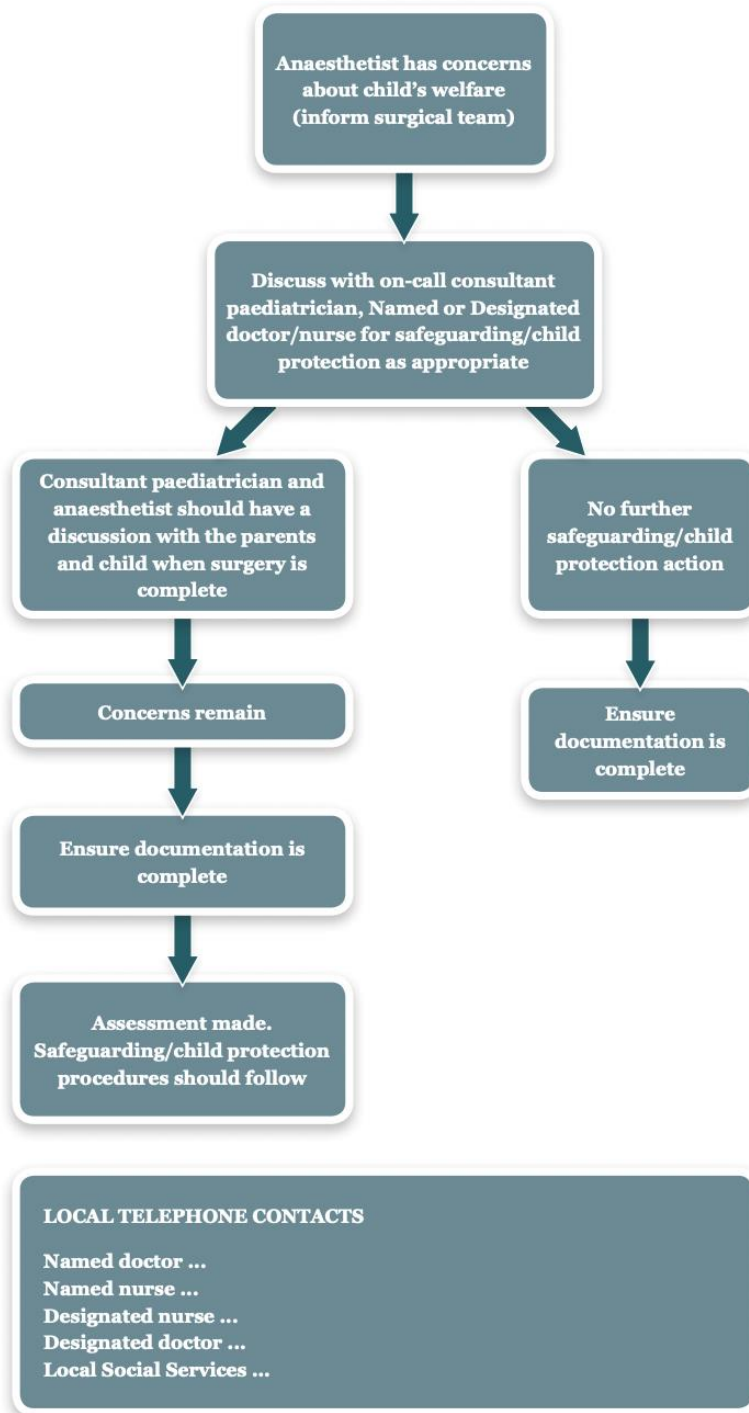
## **General Management Principles**

- As with everything else in paediatric anaesthesia the keys are FLEXIBILITY and PREPAREDNESS as part of a holistic approach
- Understand the type of LD you're dealing with and the specific needs of the child then adapt your practice
- E.g. warn the autistic child before touching them
- Discuss child's needs with parents beforehand to facilitate planning
- Be aware of communication difficulties
- Use simple words
- Avoid metaphors
- Picture cards may be available to help explain the process

## **Child safety**

- Safety of the child is paramount and overrides all other duties
- Features that may cause concern/suspicion of child abuse:
  - Unusual / excessive bruising (especially in a non-ambulant child/baby)
  - Cigarette burns
  - Bite marks
  - Unusual injuries in inaccessible places e.g. neck, ear, hands, feet, buttocks
  - Intra-oral trauma
  - Genital / Anal trauma (with no clear history offered at presentation)
  - Trauma with inadequate history
- Paediatricians should perform examinations, when physical abuse is suspected.
- Any concerns must be discussed with key child protection workers early
- Each trust typically has named doctors / nurses (everyone should know how to contact them)
- Further management needs to be agreed with paediatrician, surgeon and anaesthetist but led by the paediatrician
- Full documentation should be contemporaneous, written and signed by consultant
- Child Protection and the Anaesthetist, Safeguarding Children in the Operating Theatre (2014 joint statement from RCOA, AAGBI, APAGBI and RCPCH)
- Act in best interests of the child
- Be aware of child's right to be protected
- Respect the rights of the child to confidentiality
- Contact paediatrician with experience of child protection for advice
- (there is a paediatrician on-call for CP, or designated doctor/nurse)
- Be aware of local child protection mechanisms
- Be aware of the rights of those with parental responsibility

## CARE PATHWAY FOR ANAESTHETISTS TO REPORT SAFEGUARDING/CHILD PROTECTION CONCERNS



**CHILD  
PROTECTION  
AND THE  
ANAESTHETIST**  
SAFEGUARDING  
CHILDREN IN THE  
OPERATING THEATRE

Reproduced here with permission from the Royal College of Anaesthetists but the RCoA has not reviewed this as a whole.

## Pre-medication

- Generally trainees may prescribe premed analgesics
- Sedatives, antacids and antisialagogues may also be useful tend to be prescribed by consultants

## Analgesia

- Paracetamol 15mg/kg
- Ibuprofen 5-10 mg/kg

## Topical Cutaneous Anaesthetics

- The important thing is timing
- Both are applied directly to unbroken skin and covered with an occlusive dressing.

	EMLA Eutectic mixture of local anaesthetic	Ametop
Local anaesthesia	2.5% lidocaine + 2.5% prilocaine	4% tetracaine
Age	>1 year	> 1 months
Onset	60 – 120 minutes	40 minutes
Duration of action	30 – 60 minutes	Up to 4 hours

## Sedatives – discuss with a consultant

	Midazolam	Ketamine	Dexmedetomidine	Clonidine
Oral dose	0.5mg/kg (max 20mg) Mix in a very small amount of other liquid	3 – 6 mg/kg	N/A	4mcg/kg (max 200mcg)
Intranasal dose	0.1 – 0.2 mg/kg	1 -2 mg/kg	2-3 mcg/kg	N/A
Onset	20 – 30 minutes	30 – 60 minutes	25 minutes	45-60 minutes
Duration	45 – 60 minutes	1 – 3 hours	40-135 minutes	45-90 minutes
Notes	Some children may become boisterous rather than sedated	Can prolong recovery time. Can cause dysphoria/hallucinations. Can give with midazolam to reduce dysphoria.		Tasteless liquid. May not provide sufficient sedation. No amnesia

## The ill child at Pre-Assessment

- In general any active illness or infection may lead to the cancellation of an elective procedure.
- However, a significant grey area exists with an URTI. Respiratory complications during anaesthesia are up to 10 times more likely if a child has a respiratory tract infection, and can include: -
  - Coughing
  - Hypoxia
  - Laryngospasm
  - Dysrhythmias
  - Even myocarditis if viraemic
- When to consider cancellation (postpone for 2-4 weeks)
  - Fever >38C
  - Productive cough or purulent nasal discharge
  - Chest signs
  - Systemically unwell
  - Age <1year
  - Asthma
- If you are considering cancellation you MUST discuss with the consultant beforehand
- Factors to consider
  - Urgency of surgery
  - Type of surgery
  - Duration of surgery

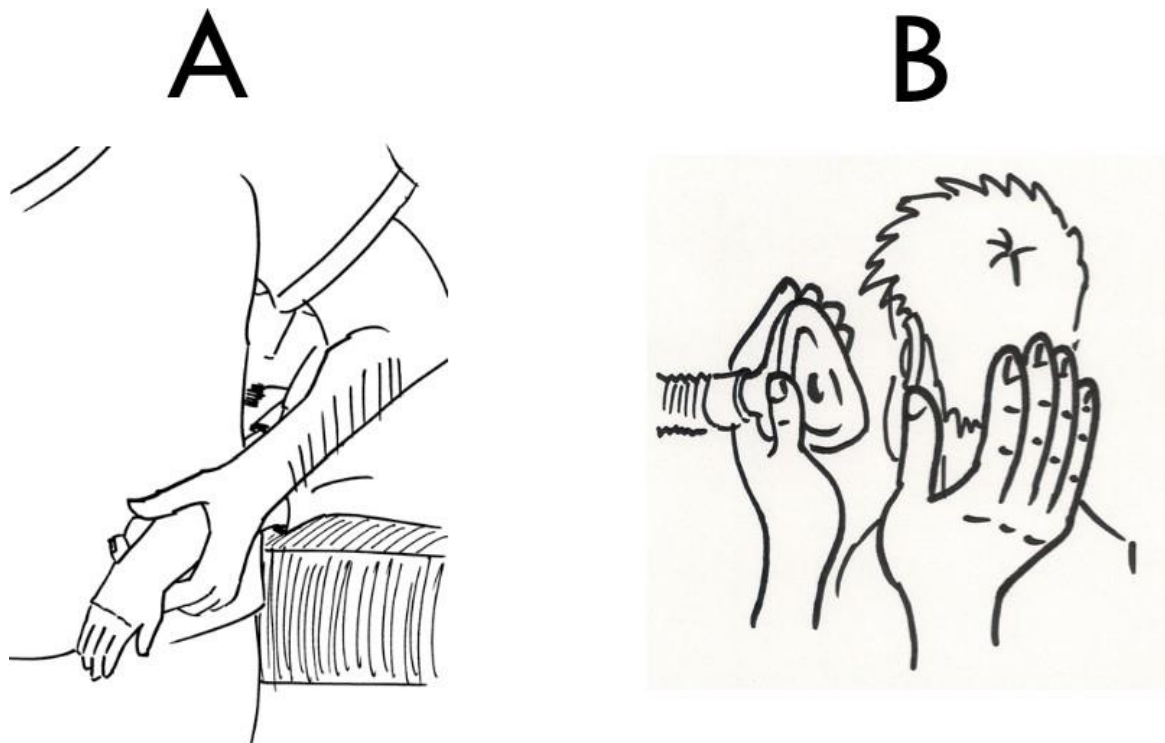
The decision to cancel is a joint one, made with our surgical colleagues

## The Anaesthetic Room and Induction

- The anaesthetic room is where a child (and often the parents') anxiety is at its peak.
- It is of vital importance to try and make the experience as positive for the child as possible.
- Any trauma inflicted in the anaesthetic room will reinforce already existing fears and make future anaesthetics more difficult

### Patient Positioning

- Neonates and children up to 6 months are usually anaesthetised on the bed with ambient heaters, etc – generally without parental presence.
- Infants may sit on parents lap
- Older children may lie on the bed
- The below diagrams show the ideal positioning in a parents lap for a) attempt at cannulation and b) inhalation induction



### Distraction

- In general an IV induction is the first-line choice for general anaesthesia.
- Understandably children do not like the idea of cannulation and distraction methods are useful to increase the likelihood of co-operation.
- Simple things like talking to the child about something that interests them or listening to music or playing games or watching videos on a tablet can really help.

### Cannulation

- Can be difficult even for the experienced anaesthetist
- Avoid repeated attempts, which will upset the child.
- The dorsum of the hand is the commonest site.
- Others = wrist, dorsum of the foot, saphenous and the scalp in babies.



- Use an appropriately sized cannula – typically 22G or smaller.
- Tips
  - In younger children with chubby hands, hold their whole hand and stretch the skin back – identifying a vein may be by feel rather than sight.
  - Try not to repeatedly tap veins, the whole process alerts the child to what is happening when you want their attention focused elsewhere
  - If you must, try squeezing the whole hand intermittently
  - Once cannulation is complete, you must hold on to the arm and keep it still, until the cannula is securely dressed.

### Intra-Osseous Access

- Should always be considered as an option for vascular access in emergencies
- APLS guidelines suggest that the IO access should be considered / obtained after 2 failed attempts at cannulation in an emergency scenario
- Sites
  - Varies depending on clinical situation and age of child
  - Generally the proximal tibia is the site of choice
  - 2-3cm below the tibial tuberosity
  - Care must be taken to avoid growth plates or joint spaces
  - Other sites include the
    - distal femur (3cm above lateral condyle)
    - iliac crests
    - humerus (> 6 years of age)
- Complications of insertion
  - Extravasation of drugs / fluids into soft tissues → compartment syndrome
  - Fractures
  - Osteomyelitis
  - Fat embolus
- Use
  - Almost everything can be administered via an IO needle, including blood, but will need to be bled or flushed through.
  - Bolusing through an IO needle may be painful in the child if fully conscious.

### Monitoring

- The minimum monitoring during induction is pulse oximetry – placed once child has lost awareness
- Proceeding to full AAGBI monitoring as soon as possible.

### Inhalational Induction

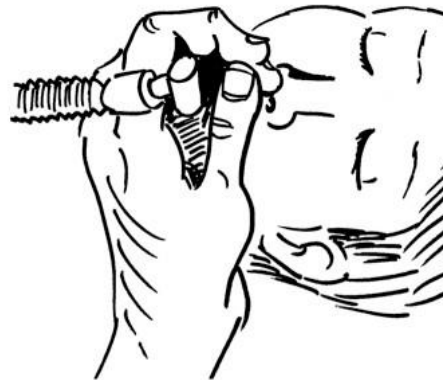
- Probably the most important technique you will learn
- Indications
  - Potentially difficult airways – where distress may cause acute airway loss e.g. epiglottitis
  - Patient or parental request
  - If venous access is likely to be difficult.
- Two basic types: cooperative and uncooperative inductions
- Cooperative induction

- Begin by showing the child the mask before hand
- Options for induction
  - Let the child breathe normally and concentrate on distraction techniques
  - Try to make the experience into a game – show them the bag and encourage them to try and suck all of the air out and then blow it up
- Two options for holding administering volatile
  - Hold mask on face with one hand and support the occiput with the other.
  - Hold the breathing system minus the mask between your thumb and forefinger, and cup your hand around the child's mouth – this may make it easier to follow a child's head if they start to move around.

**A**



**B**



- Nitrous oxide may be helpful as a co-induction agent because it has no smell or taste and speeds up induction. Its use has decreased due to environmental concerns.
- Slowly introduce Sevoflurane over the next 20-30 seconds increasing from 2% → 4% → 8%
- Maintain mask seal and support head until child loses consciousness
- In a coordinated effort with parent and assistant, lift child onto the bed and begin to support the airway
- A good sign that the child is deep enough is the associated reduction in heart rate
- Once deep enough – reduce inspired % and flow rates to appropriate

#### Uncooperative Induction

- Always explain the process to the parents
- Consider if the child is young (<3years) and unlikely to cooperate.
- As above but start with Sevoflurane on 8%
- If child is extremely uncooperative, consider abandoning procedure if elective – as you will only traumatise the child further

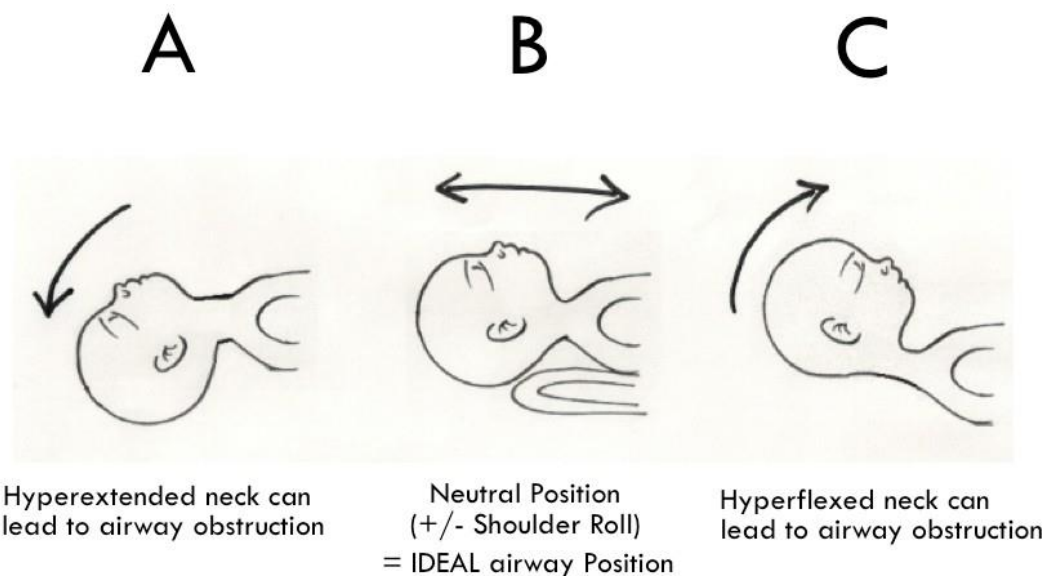
- Consider postponing surgery and pre-medicating with an anxiolytic or sedative agent before trying again
- As with all other times during anaesthesia AVOID unnecessary stimulation – if you stimulate a child when they are light you may cause laryngospasm, breath holding, etc

### Intravenous Induction

- Propofol administration can be painful. This can be reframed as cold e.g. feels like ice cream
- IV lidocaine can be used to reduce pain:
  - Giving a small IV bolus of lidocaine and waiting before giving Propofol
  - Or mix a small volume of lidocaine with propofol in the same syringe.
- In young children, unlike adults, there is no window of opportunity to quickly insert an LMA after giving Propofol – this is because it redistributes too quickly.
- WAIT until deep enough on an inhalational agent before attempting insertion

### Airway Manoeuvres and Equipment

- Most children's airways should be relatively easy to manage.
- However, if difficulty is encountered, don't hesitate to switch to a two-handed technique or seek help
- Infants' heads should be kept in a neutral position, which is often easiest by removing any pillows – which flex the neck too much.
- However, a shoulder roll may be required to get a neutral position – because of the large occiput.



- In older children the 'sniffing the morning air' position is desired.
- Keep fingers on the mandible – compressing the soft tissues under the jaw can cause airway obstruction
- The ideal airway manoeuvre is a combination of jaw thrust and chin lift, keeping the mouth open
- Ventilation with the reservoir bag – should be of an appropriate tidal volume and rate (think, what should be normal for this age?)
- Be careful not to inflate the stomach – this is very easy in smaller children

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## Airways

### Oropharyngeal airways

- In children < 8 years insert concave side down – to avoid damaging the palate
- In children > 8 years insert concave side up (as in adults)
- Sized by the distance between the angle of the jaw to the incisors

Size	Age	Colour
3.5	Neonate	Light Green
5.0	Infant	Blue
5.5	Small child	Grey
6.5	Child	Brown
7.0	Large child/ small adult	White
8.0	Adult	Green

### Supraglottic airways

- Size is determined by the weight of the patient
- Pharyngeal reflexes must be sufficiently depressed before insertion
  - wait until the patient is deep on inhalation agents before insertion
  - do NOT insert immediately after IV induction as you can cause laryngospasm.

Device size	Patient weight LMA	Patient weight iGel
1	< 5kg	2 – 5kg
1.5	5 – 10kg	5 – 12kg
2	10 - 20kg	10 – 25kg
2.5	20 – 30kg	25 – 35kg
3	30kg – small adult	30 – 60kg
4	Average adult	50 – 90kg
5	Large adult	>90 kg

## Endotracheal tubes

### Uncuffed endotracheal tubes

- Choosing to use an uncuffed tube depends on the anaesthetist and the operation.
- Allows internal tube diameter to be maximised → reduces air resistance
- Aim to allow a small audible leak to minimise risk of tracheal mucosal damage
- Disadvantages
- Aspiration is still possible

- Pollution (i.e. anaesthetic vapours escape via leak)
- Control of the leak may be difficult if high pressures are required (a throat pack may help in this instance)

Weight/age	Tube size
<2 kg	2.5
2-4kg	3.0
Neonate	3.5
3months – 1 year	4.0
>2 years	$(\text{age}/4) + 4$

#### Cuffed endotracheal tube

- Generally used when there is: a shared airway, soiled airway, difficult ventilation and critical care cases.
- Reduces the risk of aspiration
- Tube size =  $(\text{Age}/4) + 3.5$ 
  - I.e. cuffed tubes should be half a size smaller than uncuffed tubes for the same age child
- Cuff pressure must NOT exceed 20cmH<sub>2</sub>O

#### Tube Length

- ETTs are purposely made longer than necessary
- The paediatric airway has two important differences that are important here: -
  - The trachea is shorter than in the adult
  - The bronchi divide off the carina at the same angle
- Endobronchial intubation is more likely and equally likely on both sides
  - Hence the need to auscultate to confirm position
- Formula
  - Length (cm) for oral tubes =  $(\text{Age}/2) + 12$
  - Length (cm) for nasal tubes =  $(\text{Age}/2) + 15$
- ETTs should be inserted so that the black mark on the tube is just beyond the cords at laryngoscopy

#### Airtrags

- Paediatric airtrags are also available for both oral and nasal intubation

	Size	Colour	Tube size	Minimum mouth opening
Infant	0	Grey	2.5 – 3.5 cuffed or uncuffed	12.5 mm
Paediatric	1	Purple	4.0 – 5.5	12.5 mm
Small adult	2	Green	6.0 – 7.5	16 mm

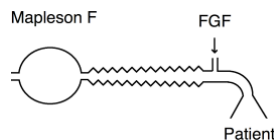
#### Laryngoscopy

- There are two laryngoscope blades which are typically used:
  - Straight blades (there are several different types e.g. Miller)
    - Used to lift the epiglottis out of the way
  - Curved (Macintosh) blade
    - Inserted into the vallecula

- You should use the blade you have most experience with.
- As a rule of thumb: -
  - Use a straight blade in children under 1 year of age
  - Use a curved blade in children over 1 year of age
- The keys to laryngoscopy in paediatrics are to: -
  - Only attempt it when the child is sufficiently, deeply anaesthetised
  - Be gentle, to try and limit airway trauma
  - Laryngoscopy is vagally stimulating and can cause two major problems
    - Laryngospasm
    - Bradycardia
- REMEMBER to beware of wobbly teeth!!!

## **Paediatric Breathing Systems**

Choice of breathing system will depend on age and weight of child and anaesthetist preference. Commonly used breathing systems are a circle and Mapleson F



Mapleson F

- Mapleson F is also known as a Jackson-Rees modification to the Ayre's T-piece
- It is a Mapleson E system with an open-ended reservoir bag
- Low resistance and low dead space system
- Advantages
  - Used for spontaneous, assisted and controlled ventilation in all ages
  - Can provide PEEP/CPAP by partially occluding end of the bag
- Disadvantages
  - Less efficient if >20kg
  - Fresh gas flow is high to prevent rebreathing
  - Scavenging is difficult
- Spontaneous ventilation
  - Minimum gas flow 4l/min
  - Up to 3x patient's minute volume

## **Common peri-operative critical events in children**

- Desaturation - due to a combination of increased work of breathing, small FRC (low intrapulmonary O<sub>2</sub> reserve), higher basal metabolic rate and diaphragm dependence. Other causes include: - endobronchial intubation, reduced diaphragmatic compliance from stomach inflation, etc
- Laryngospasm – due to high parasympathetic tone, most likely during light anaesthesia or vagally stimulating procedures e.g. laryngoscopy or extubation
- Bradycardia – due to high parasympathetic tone, most likely during vagally stimulating procedures e.g. laryngoscopy, extubation and squint surgery

## **Peri-operative Fluids**

- Whilst the following formulae are useful guides, remember that therapy should always be guided by the dynamic clinical situation.
- Hypotonic solutions should be avoided because of the risk of hyponatraemia post-op (secondary to post-op ADH release and water retention)

### **Fluids**

- Bolus – 10ml/kg of balanced isotonic crystalloid

Normal Hourly Maintenance Requirement	Normal Daily Maintenance Requirement
4ml/kg for first 10 kg	100ml/kg for first 10kg
2ml/kg for second 10kg	50ml/kg for second 10kg
1ml/kg for every additional kg	20ml/kg for every additional kg

- Nil By Mouth Deficit = Hourly requirement x number of hours NBM
- Dehydration Definitions
  - Dehydration without shock = < 10% fluid loss = slow replacement
  - Dehydration with shock = > 10% fluid loss = rapid replacement
- Replacement fluid (ml) = % dehydrated x weight (kg) x 10
- Use an Isotonic fluid e.g. 0.9%NaCl, Hartmann's Solution or a colloid +/- KCL
- Or blood if required – depending on haematocrit
- Losses should be measured, wherever possible, and replaced 2-4hourly

### **Glucose**

- Glucose may need to be monitored and require replacement in the following situations:
  - Premature babies and neonates – increased glucose requirements
  - Low body weight
  - Prolonged surgery
- A generally accepted treatment limit for hypoglycaemia is <3mmol/L
- Hypoglycaemia Treatment
  - Bolus of 2ml/kg of 10% Dextrose
  - Infusion of 10% Dextrose at 4-6ml/kg/hour
- It is important to monitor for hyperglycaemia as well, since this can cause a hyperosmolar state leading to diuresis and intraventricular haemorrhage

### **Positioning**

- This is largely dictated by the type of surgery, but it remains important to check pressure areas and ensure easy access to cannulae.

### **Extubation and Emergence**

- Laryngeal reflexes are more pronounced in younger children
- Maintain anaesthesia until the child has been transferred back to their bed
- Younger patients are often recovered in the left lateral position and older children may be better sat up.
- Avoid unnecessary stimulation as it can result in laryngospasm, etc
- What happens next depends on what type of airway has been used

### **LMAs**

- These can either be removed in theatre or left in-situ whilst the child is transferred to recovery (varies between centre and consultant)
- The decision depends on several factors: -
  - Local policy
  - Perceived difficulty of managing the airway
  - Type of surgery e.g. ENT- possible cord irritation from blood/secretion
  - Use of peri-operative opioids (that may suppress laryngeal reflexes)

### **ETTs**

- The aim is to AVOID laryngospasm or other critical events
- Maintain anaesthesia until return of neuromuscular function
- Younger patients are often extubated in the left lateral position and older children may be better sat up.
- Avoid unnecessary stimulation
- Two options – extubate awake or deep (awake is preferred for novices)

### **Recovery**

- Children usually recover quickly and can be discharged rapidly
- Discharge criteria include: -
  - Restoration of consciousness and appropriate activity for patient's age
  - Stable vital signs
  - Adequate control of nausea and vomiting and pain
  - No surgical or anaesthetic complications
  - Handover of patient information, including details of surgery, possible post-op events and instructions
  - Advice for parents for after discharge including follow-up



## **Paediatric Regional Anaesthesia**

The maximum dose of Bupivacaine is 2mg/kg

### **Caudal Epidural**

- Indications
  - Lower abdominal, pelvic, perineal, penile and lower limb surgery
- Block
  - Sensory > motor > autonomic
- Procedure
  - Identify the sacrococcygeal membrane – apex of equilateral triangle, base of which is formed by the two posterior superior iliac spines
  - Using a cannula aim cephalad at an angle of 45 degrees until a 'give' is felt
  - Flatten / straighten out trajectory and advance cannula no more than 2cm
- Dose - Infants = 0.5-1.25ml/kg of 0.25% bupivacaine or less
- Clonidine (1mcg/kg) can be used to extend the duration of the block
- Complications (rare)
  - Common
    - Motor block
  - Rare
    - Urinary retention
    - Hypotension
    - Infection
    - Inadvertent dural puncture
    - Intravascular injection

### **Regional anaesthesia**

There is an increasing use of regional anaesthesia in paediatrics. This is beyond the scope of this document.

## Paediatric Pharmacology

- Larger volume of distribution for water-soluble drugs (higher proportion of body weight is water – prems = 90%, neonates = 80%)
- Lower total plasma protein concentration (especially alpha1-acidglycoprotein)
- Neonates have little fat or muscle tissue
- Immature hepatic and renal function leading to prolonged elimination (especially in neonates)

### Pharmacokinetics

- Most drugs are metabolised and eliminated slowly
- Tend to accumulate with repeated doses
- Reduced clearance

### Absorption

- Inhalational and IV drugs are absorbed normally
- IM / SC depots are slowly absorbed in neonates

### Distribution

- High cardiac output → rapid distribution
- Protein binding is reduced in neonates and young infants → increased free concentrations
- Increased volume of distribution of highly ionized drugs (e.g. neuromuscular blockers) due to increased body water and extracellular fluid volume
- Less developed BBB → greater uptake of partially ionized drugs e.g. morphine

### Metabolism

- Higher basal metabolic rate
- Immature liver function → less 1<sup>st</sup> pass effect
- Older infants and children show rapid elimination
- Hofmann degradation is age-independent

### Excretion

- Mostly via kidneys
- GFR relative to surface area is reduced – but increase to adult levels within 1<sup>st</sup> year
- Proximal tubule secretion reaches adult level by 6months

## Drugs used in Paediatrics

### Emergency Drugs

- Atropine = 20mcg/kg
- Glycopyrrolate = 10mcg/kg
- Adrenaline = 10mcg/kg = 0.1ml/kg of 1:10,000 arrest dose

### Intravenous Anaesthetic Agents

#### Propofol

- For induction, sedation and TIVA (in the short-term).
- 'Contraindicated' for long-term infusion in ICU due to so-called Propofol Infusion Syndrome (metabolic acidosis, rhabdomyolysis and cardiac failure / arrest) – seen in children sedated on ICU
- Propofol Induction Dose = 2-5mg/kg
- Propofol TIVA is increasing in its use. There are models designed for paediatrics including: Paedfusor and Kataria. There are additional combinations that can be used
- Ketamine
  - IV = 1-2mg/kg
    - Duration = 5-10mins
  - IM = 5-10mg/kg
    - Onset 3-5mins
    - Duration = 15-30mins
  - May be used in unstable patients and in critical care

### Volatile Anaesthetic Agents

- All cause some cardiovascular depression and bronchial smooth muscle relaxation
- MAC values vary with age
- Sevoflurane
  - Commonest agent used for inhalation induction
  - High concentrations → apnoea
  - After maintenance some children can become delirious
  - Less irritant means it can be used at 8% concentration from the start

	MAC	
Age	Sevoflurane	Isoflurane
Neonate	3.3	1.6
Infant	3.2	1.9

### Muscle Relaxants and Reversal

- Suxamethonium = 2mg/kg (3mg/kg in neonates)
  - Onset 60 seconds
  - Duration 4-6mins
  - Used mostly as part of a RSI
  - Fasciculation may not be seen in small children
- Atracurium = 0.5mg/kg

- Rocuronium = 0.6mg/kg
  - RSI dose – 1mg/kg
- Neostigmine = 50mcg/kg
  - dilute 1amp of reversal (2.5mg neostigmine + 500mcg Glycopyrrolate) in 5mls
  - give 0.1ml/kg (1ml/10kg)
- Sugammadex = 2mg/kg
  - Sugammadex is not recommended under 2 years
  - Its use for immediate reversal of deep neuromuscular blockade has not been studied in children.

### Opioids and Naloxone

- Fentanyl = 2-4mcg/kg – typically 1mcg/kg on induction
- Morphine = 0.1mg/kg
- Remifentanyl
  - As a bolus to facilitate intubation = 0.1-1mcg/kg
    - Bradycardia and muscular rigidity can occur
  - As an infusion = 0.25-0.5mcg/kg/min
- Naloxone = 4mcg/kg

### Other Analgesics

- Paracetamol
  - consult BNF for further details
  - Maximum 24 hour dosage (in divided doses)
    - Neonates = 30mg/kg
    - Infants – 50kg = 60mg/kg
    - >12 years and >50kg = 4g/day
- Ibuprofen
  - Not to be used in children under 3months or under 5kg
  - Dose = 5-10mg/kg (maximum 400mg) 6hourly
- Diclofenac
  - Not to be used in children under 3months or under 5kg
  - PO = 1mg/kg 8hourly
  - IV = 1mg/kg
  - PR = 1-2mg/kg
  - Maximum by all routes = 3mg/kg/day
- Codeine
  - Rarely used in children due to safety concerns.
  - It is contra-indicated in: patients <12 years, OSA, known CYP2D6 ultra-rapid metaboliser and breast-feeding mothers.

## Post-Operative Nausea and Vomiting – APAGBI 2016 guidelines

- Risk Factors
  - Patient factors
    - Age – rare under 3 years, risk increases from age 3 until adolescence
    - History of PONV and/or motion sickness
    - Increased incidence in post-pubertal girls
  - Surgical factors
    - Strabismus surgery
    - Tonsillectomy +/- Adenoidectomy
    - Surgical procedures >30mins duration
  - Anaesthetic factors
    - Use of Volatile Anaesthetics
    - Use of Opioids
    - Use of Anticholinesterase
    - N2O is NOT associated with high risk of POV
- Antiemetics
  - Ondansetron is effective with procedures associated with high risk of PONV.
    - Ondansetron dose 0.15mg/kg
    - Route and timing does not effect efficacy
  - Dexamethasone is effective, especially for preventing late PONV (>6hr)
    - Dexamethasone dose 0.15mg/kg
  - Dexamethasone and ondansetron used in combination increase in effectiveness of reducing PONV in children.

## **A Basic Approach to Paediatric Emergencies and Critical Care**

### Airway

- Position
  - Infant – neutral, Child – sniffing morning air
- Look Listen and feel
- Give oxygen
- Airway manoeuvres and adjuncts
- Intubation if needed

### Breathing

- Look listen and feel
  - Any respiratory distress
  - Recession
  - Accessory muscle use
  - Nostril flaring
  - Gasping (often a pre-terminal sign of severe hypoxia)
  - Grunting
  - Breath sounds
    - Inspiratory noises – stridor – upper airway problem
    - Expiratory noises – wheeze – lower airway problem
  - Assess skin colour
  - Cyanosis – late, pre-terminal sign
- Mental state
  - Hypoxia and hypercapnia can cause agitation or drowsiness

### Circulation

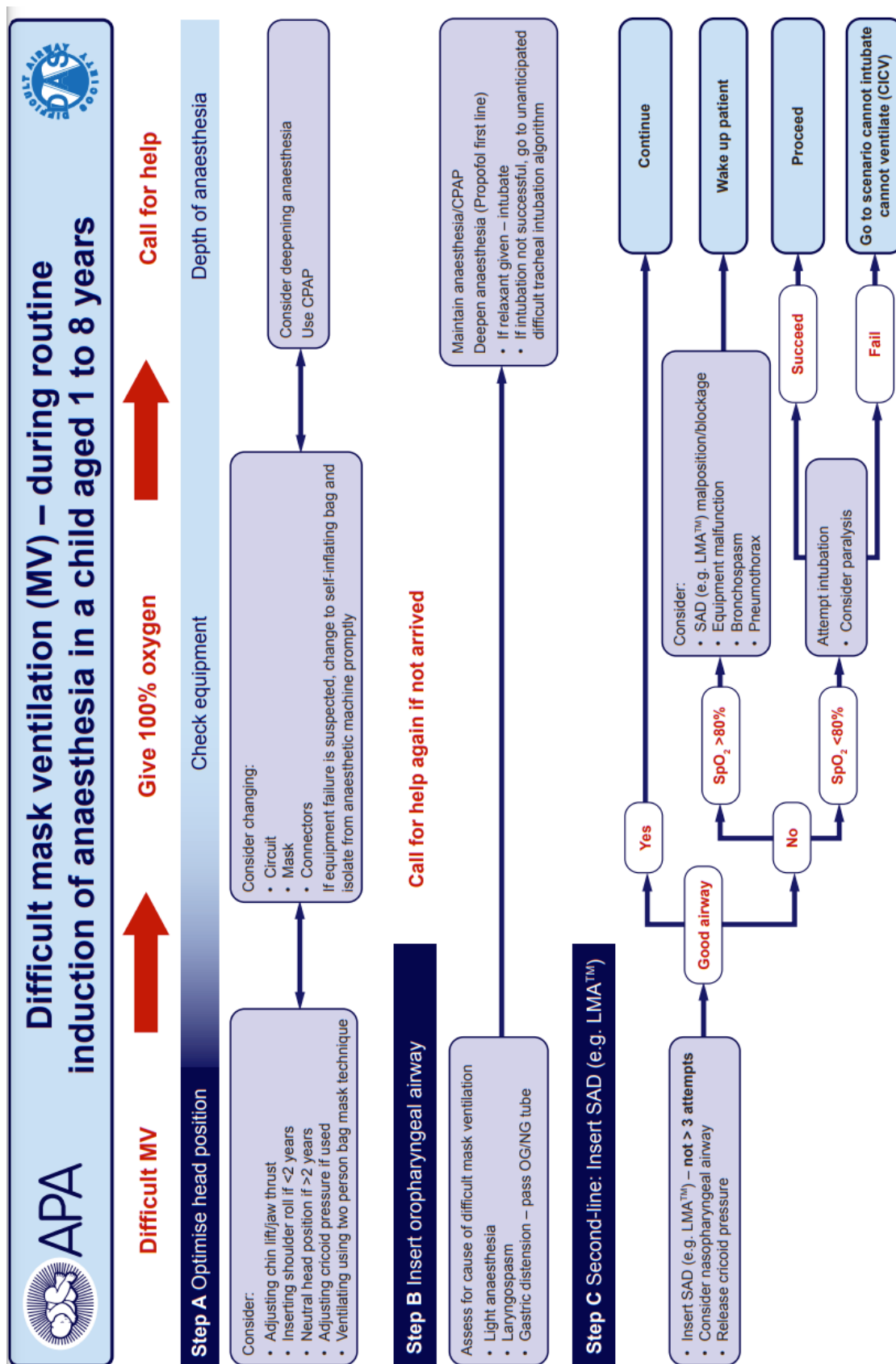
- Pulses
  - Bradycardia in infants is usually a preterminal sign
  - Sites to check
  - Infant – brachial or femoral
  - Child and older – carotid
- Capillary refill time
  - Assess centrally over sternum
  - Press for 5 seconds, refill should occur within 2 seconds
- Fluid bolus
  - 20ml/kg crystalloid (less if cardiac concerns)

### Disability

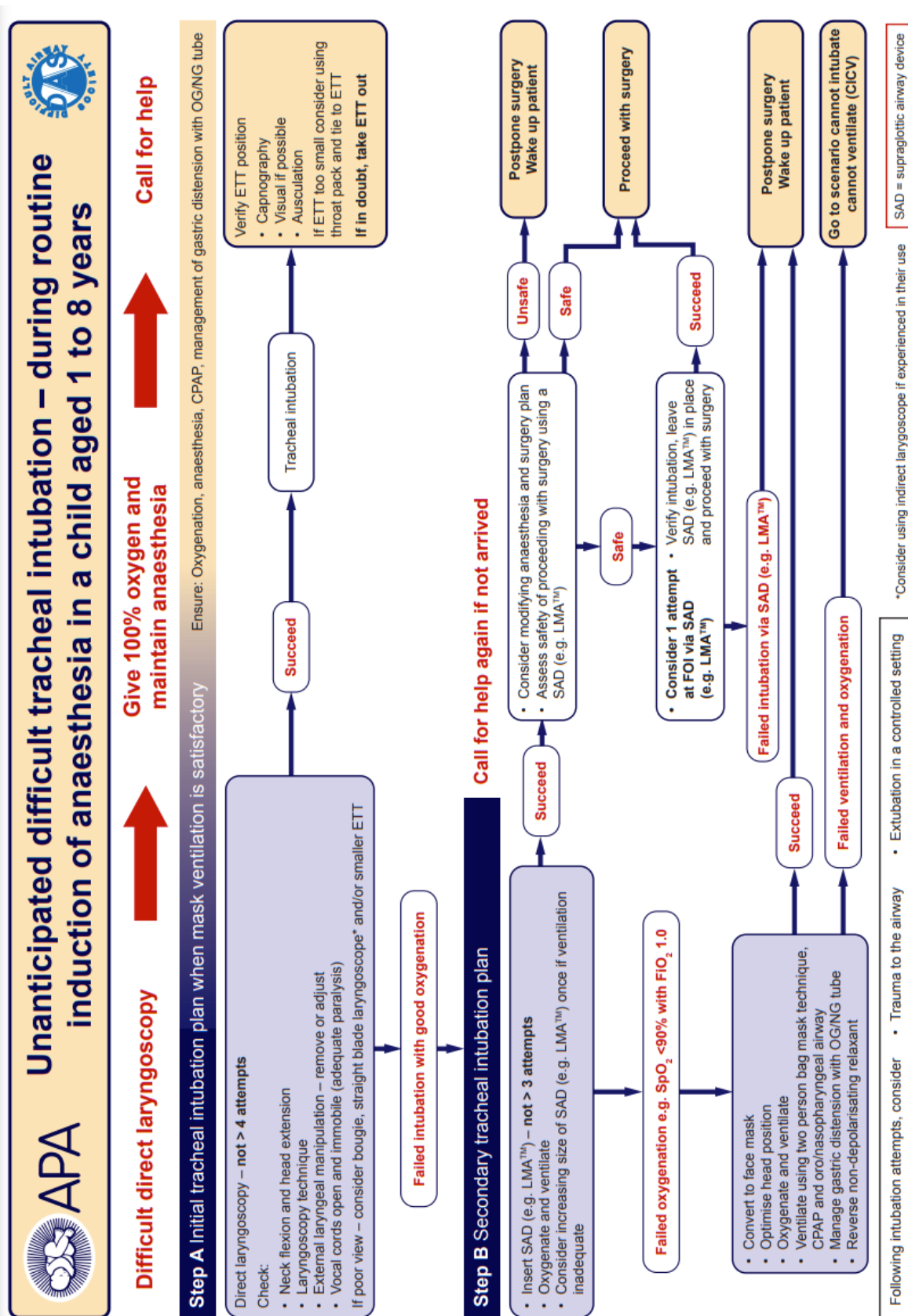
- AVPU
- Check glucose

### Exposure

Check temperature and keep warm

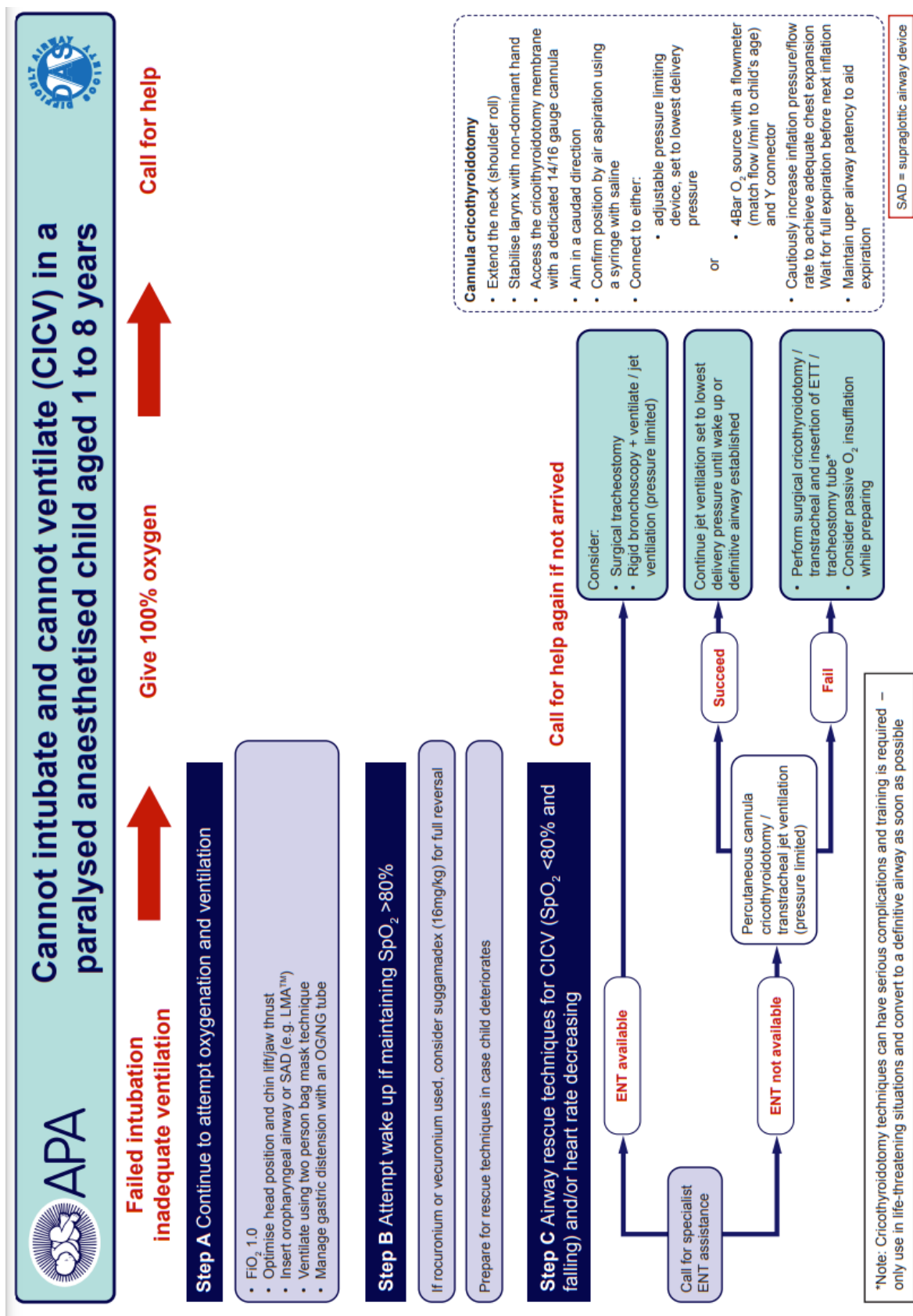


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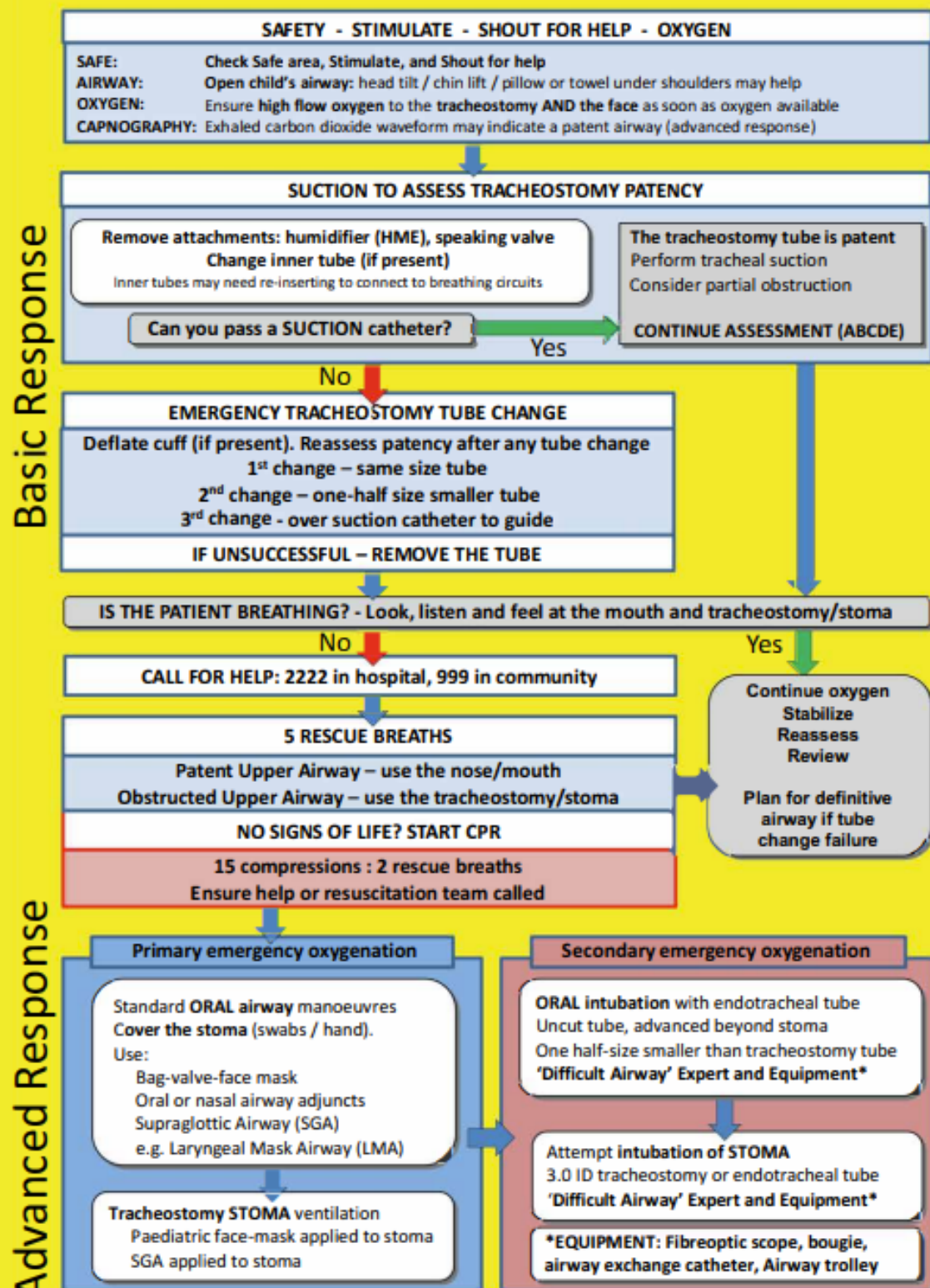
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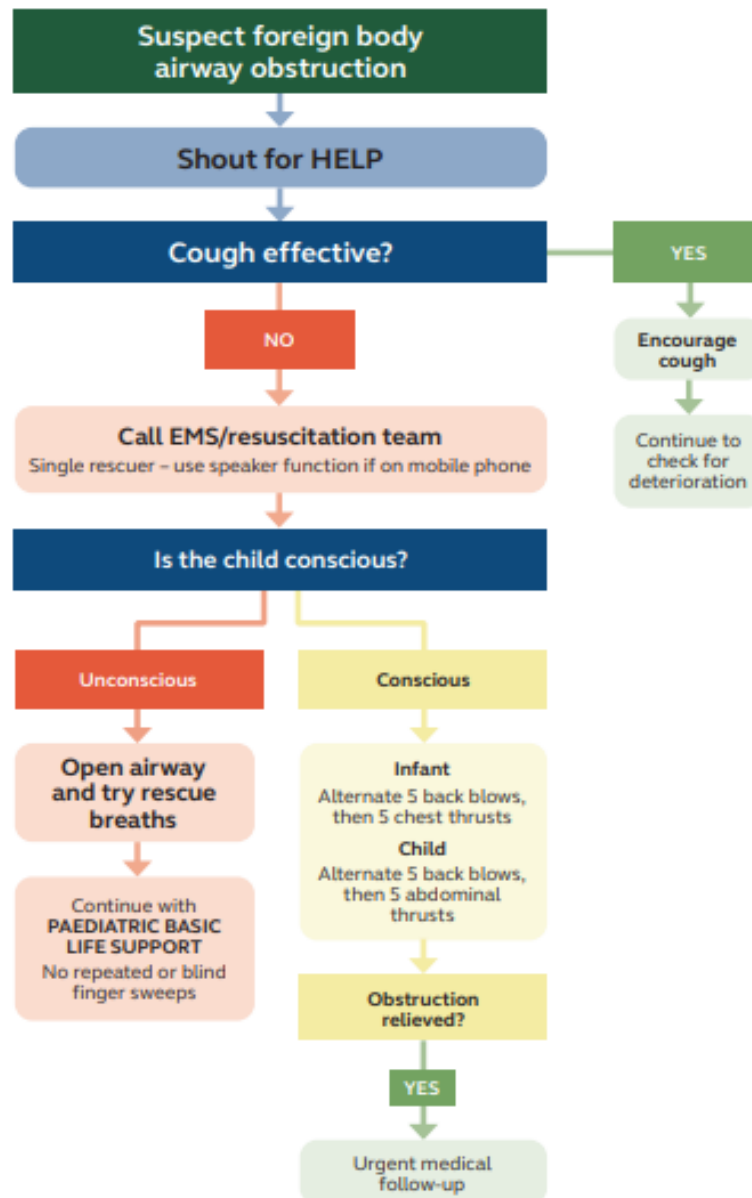
## Emergency Paediatric Tracheostomy Management



NTSP (Paediatric Working Group) [www.tracheostomy.org.uk](http://www.tracheostomy.org.uk) Review January 2022

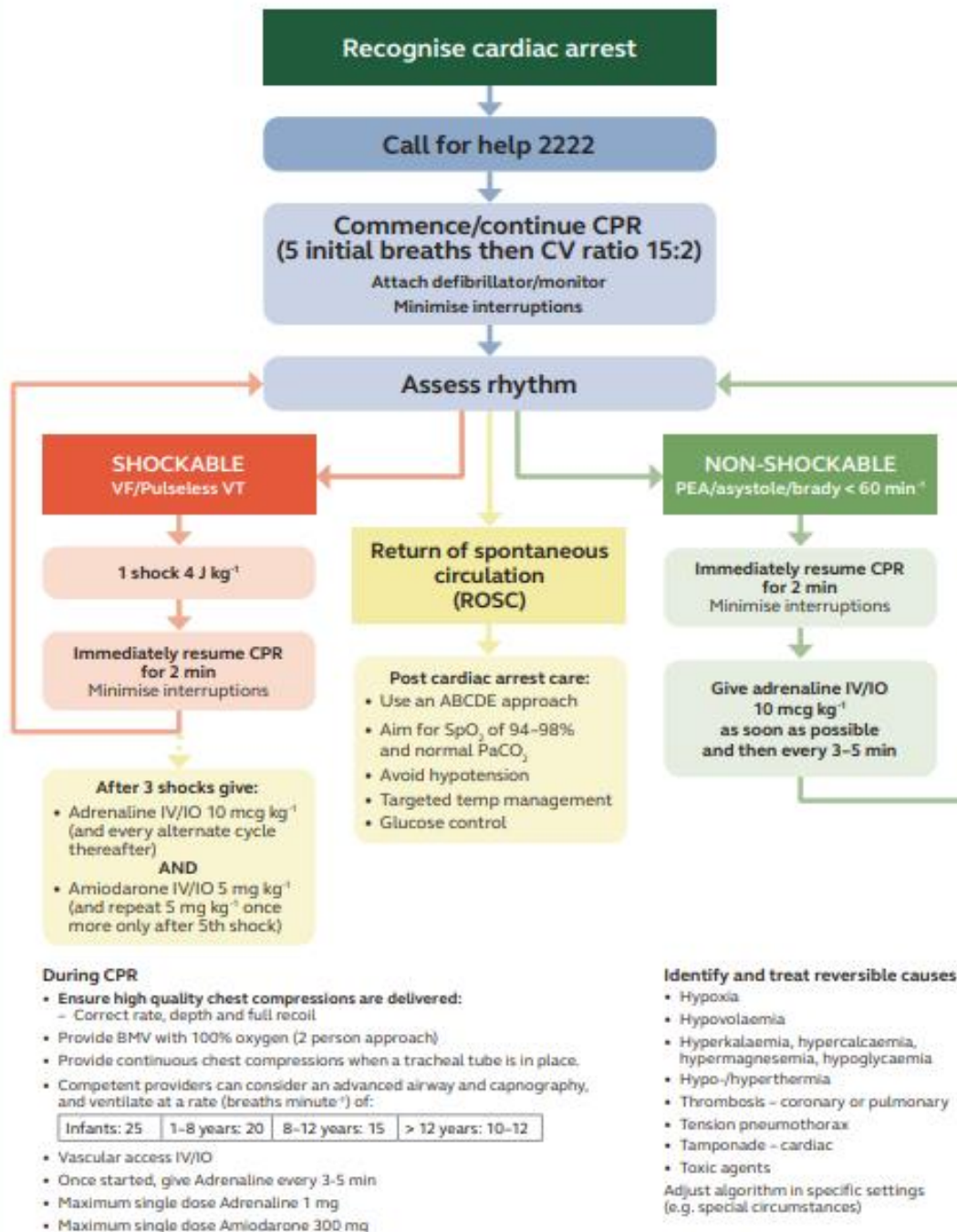
the National Tracheostomy Safety Project website [www.tracheostomy.org](http://www.tracheostomy.org)

## Paediatric foreign body airway obstruction



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## Paediatric advanced life support



## Anaphylaxis

Presentation – variable	Potential triggering agents in anaesthesia
Bronchospasm Hypotension Tachy- or bradycardia Angioedema (often absent in severe cases) Cardiac arrest Cutaneous flushing (with other signs)	Antibiotics Neuromuscular blocking agents Chlorhexidine

### Immediate management

- Stop triggering agent if able
- Call for help, 100% oxygen and ABC assessment
- A+B – intubation may be difficult if airway swelling
- C - Patients can be very hypotensive –
  - consider leg raise if able
  - NAP 6 recommends starting CPR if very low output state
- Adrenaline bolus
 

Age	IM adrenaline (1:1,000)	IV adrenaline (1:100,000)
<6 months	100-150mcg (0.1-0.15ml)	5mcg (0.5ml)
6 months – 6 years	150mcg (0.15ml)	10mcg (1ml)
6-12 years	300mcg (0.3ml)	25mcg (2.5ml)
>12 years	500mcg (0.5ml)	50mcg (5ml)
Catch all dose	10mcg/kg	1mcg/kg (0.1ml/kg)
- Consider starting an adrenaline infusion after 3 boluses
  - 1:100,000 (1ml 1:1,000 added to 100ml 0.9% sodium chloride)
  - 0.5-1mcg/kg/hour, titrate to effect
- If hypotension is unresponsive to adrenaline, consider alternative vasopressor
- Fluid bolus 10ml/crystalloid, which may need repeating
- Chlorphenamine and steroids no longer feature in immediate algorithms.

### Refractory anaphylaxis

- A+B – bronchospasm
  - Nebulized salbutamol and ipratropium
  - Consider IV salbutamol or aminophylline
  - Inhalational anaesthesia
- C – hypotension may be refractory to treatment
  - Consider starting an adrenaline infusion after 3 boluses
    - 1:100,000 (1ml 1:1,000 in 100ml 0.9% saline)
    - 0.5-1mcg/kg/hour, titrated to effect
  - Consider alternative vasopressor if unresponsive to adrenaline
  - Consider steroids if refractory to treatment/shock
- Consider transfer to critical care area

Investigations - clotted blood sample for serum tryptase investigation ASAP, 1-2 hours and >24 hours.

## Acute Asthma

This has been included for its relevance to critical care

Moderate asthma	Acute severe asthma	Life threatening asthma
Normal mental state	Agitated, distressed	Confused, drowsy, exhausted
Ability to talk in sentences or vocalise as normal	Can't complete sentences in 1 breath	Unable to talk
Some accessory muscle use	Moderate to marked accessory muscle use	Maximal accessory muscle use (poor respiratory effort is pre-terminal)
O <sub>2</sub> saturations > 92% in air	O <sub>2</sub> saturations < 92% in air	O <sub>2</sub> saturations < 92% in air
PEF ≥ 50% of best or predicted	PEF 33-50% of best or predicted	PEF <33% of best or predicted
Moderate tachycardia	Severe tachycardia	Severe tachycardia
		Silent chest
		Cyanosis
		Hypotension

## Management

- ABC 100% O<sub>2</sub>
  - Aim for SpO<sub>2</sub> 94-98%
  - Slow ventilation – allowing full exhalation to prevent gas trapping
  - Beta-2-agonist
    - Nebulised salbutamol with ipratropium bromide every 20minutes for first 2 hours.
- |             |                   |                   |
|-------------|-------------------|-------------------|
| Salbutamol  | <5 years – 2.5mg  | >5 years – 5mg    |
| Ipratropium | <2 years – 125mcg | >2 years – 250mcg |
- Single IV bolus dose
      - <2 years – 5mcg/kg
      - >2 years – 15mcg/kg
      - Infusion – 1-5mcg/kg/min (monitor potassium)
  - Steroids
    - Oral prednisolone 1mg/kg
    - IV hydrocortisone 4mg/kg every 4 hours
  - Magnesium
    - 25-40mg/kg over 20 minutes
  - Aminophylline
    - 5mg/kg over 20 minutes followed by 1mg/kg/hr infusion
    - Consider if child is not responding to maximal doses of bronchodilators and steroids
  - If Intubating consider:
    - IV ketamine
    - Sevoflurane

## **Stridor and Acute upper airway obstructions**

### **General management**

- Don't startle the child and precipitate complete obstruction, this includes attempting IV access

### **Epiglottitis**

- Life threatening emergency
- Most commonly 2-3 years

#### Presentation

- Quiet stridor, drooling, leaning forward, fever. Child looks sick
- Stridor is a late sign

#### Specific management – involve ENT early

- Intubation
  - 60% need urgent intubation
  - It will be difficult
  - Use smaller ETT
  - Inhalational induction
- Antibiotics – consult local guidelines
  - Cefotaxime 50mg/kg IV BD or ceftriaxone
- Usually extubated at 24-36 hours and recover in 3-5 days

### **Croup**

- 6 months – 2 years

#### Presentation

- Harsh stridor with respiratory distress and barking cough
- Lots of secretions

#### Specific management

- Most respond to conservative management
- Nebulised adrenaline 400mcg/kg (max 5mg)
- Steroids – IV dexamethasone 0.25mg/kg
- Intubation rarely required (1%)
  - Usually straightforward but may need smaller ETT
- Secretions often require frequent suctioning

### **Inhaled foreign body**

May present acutely or after several days

CXR may show hyperinflation but often doesn't show foreign body.

This is managed in a similar way to microlaryngoscopy and bronchoscopy

- Nebulised adrenaline may reduce airway oedema
- Inhalation induction
- 10% lidocaine to cords
- Rigid laryngoscopy/ bronchoscopy by ENT surgeon
- Try to avoid IPPV until FB removed
- Consider post op dexamethasone

## Laryngospasm

Narrowing/closure of the glottis by the cords due to laryngeal muscle spasm.  
It is usually due to stimulation in a light plane of anaesthesia

### Presentations

- Stridor if partial desaturation
- Silent if complete obstruction
- Difficult ventilation with flat capnograph
- Desaturation/cyanosis
- Bradycardia

### Treatment

- Call for help
- Remove stimulus including supraglottic airway device
- Clear and open airway
- Jaw thrust and remove all other stimulus, oropharyngeal or nasal airway may be needed.
- 100% oxygen and CPAP
- Deepen anaesthesia with propofol bolus
- Remove blood/secretions from airway
- Neuromuscular blocking drugs
  - Suxamethonium – short acting and usually drawn up ready
    - 1-2mg IV
    - 2-4mg IM if no IV access
  - Beware of bradycardia – give atropine 10-20mg/kg



## Bleeding Tonsil

This can be a difficult situation with a number of potential problems:

- Blood loss and hypovolaemia
- residual anaesthesia
- blood in the airway – difficult airway
- full stomach (blood)

### Pre-op

- Get senior help
- Normally there is time to resuscitate before surgery
- Assess airway
  - It is very likely going to be more difficult
  - Give oxygen
- Assess cardiovascular status
  - Difficult to assess the degree of blood loss as may swallow blood
  - Start fluids if needed
  - Consider coagulopathy
- Check previous anaesthetic chart
- Investigations
  - Full blood count
  - Coagulation
  - Group and Save/cross match

### Induction

- 2 anaesthetists
- 2 Yankeur catheters – 1 may get blocked
- Good IV access
- RSI
- Position – sat up or on side depending on post-anaesthesia sedation. Turn on to back with cricoid applied once anaesthetised.

### Intra-op

- Large bore orogastric tube post intubation to empty stomach
- IPPV and neuromuscular blockade
- Analgesia but remember residual analgesia from previous anaesthetic
- Avoid NSAIDs
- Anti-emetics

### Post-op

- Awake extubation with full neuromuscular reversal
- Extubate in the left lateral position
- Consider HDU if necessary

## Cardiac Arrhythmia

See APLS guidelines for full algorithm

Age	Bradycardia	Sinus tachycardia	SVT
Infant	< 80	180 – 220	>220
Child	< 60	160 – 180	>180

### Bradycardia

- Consider causes: hypoxia/ischaemia, vagal stimulation, raised ICP, poisoning
- Treatment
  - Ensure adequate oxygenation
  - Cease vagal stimulation if applicable.
  - If vagal stimulation is the cause, consider atropine (10 - 20mcg/kg)
  - If no response to oxygenation or atropine consider adrenaline (10mcg/kg)
  - In neonates/infants, heart rate <60 requires CPR

### Sinus tachycardia

- Treat the cause and identify the precipitant

### Supraventricular tachycardia

- Synchronised cardioversion with appropriate sedation and analgesia
  - 1<sup>st</sup> shock 1 J/kg
  - 2<sup>nd</sup> shock 2J/kg
- Chemical cardioversion if delay in synchronised cardioversion
- Adenosine

	Neonate	Infant	1-11 years	12 17 years
1 <sup>st</sup> dose	150mcg/kg	150mcg/kg	100mcg/kg	3mg
increase dose every 1-2 min	50-100 mcg/kg	50-100 mcg/kg	50-100mcg/kg	6mg
Max single dose	300 mcg/kg	500mcg/kg	500mcg/kg	12mg
Maximum dose			12mg	12mg

### Broad complex tachycardia

- Conscious
  - Synchronised cardioversion with appropriate sedation and analgesia
- Unconscious
  - Immediate synchronised cardioversion
- Torsades de pointes
  - Magnesium 25-50mg/kg (max 2g) over 15-20 minutes

## Convulsive Status Epilepticus

Convulsive Status Epilepticus is a seizure that continues > 5min. After 5 min seizures are unlikely to terminate spontaneously.

Seizure starts	Confirm clinically Check ABC, high flow oxygen, attach monitoring Check blood glucose If patient known to have epilepsy, there may be an individualised seizure plan.		
5 min	<b>1<sup>st</sup> line agents</b> Midazolam 0.3 – 0.5 mg/kg buccally Lorazepam 0.1mg/kg IV or IO <i>2 doses of benzodiazepine max (including pre-hospital doses)</i>		
10-15 min	2 <sup>nd</sup> dose of first line agent		
15-35 min	<b>2<sup>nd</sup> line agents</b> (use one of the drugs below according to local protocol)		
	Levetiracetam	30–60mg/kg (max 3g)	Over 5 min
	Phenytoin	20mg/kg	Over 20 min ECG monitoring
	Phenobarbital	20mg/kg	Over 20 min
Call anaesthetist/ICU/PICU			
20-40 min	If ready for intubation and ventilation – proceed to 3 <sup>rd</sup> line drugs If not ready for intubation and ventilation = administer alternative 2 <sup>nd</sup> line drug		
	<b>3<sup>rd</sup> line agents</b> – intubation and ventilation. The guidelines do not recommend one induction agent over another.		

## Paediatric Sepsis

### Recognition

- Assess with ABCDE approach
- Sepsis is diagnosed if there is evidence of infection as the cause of acute illness plus at least 2 of the following:
  - Core temperature <36C or >38C
  - White cell counted elevated or depressed for age
  - Inappropriate tachycardia
  - Altered mental state
  - Reduced peripheral perfusion

Warm shock	Cold shock	Difficult to differentiate the two clinically
High cardiac output Low SVR	Low cardiac output High SVR	

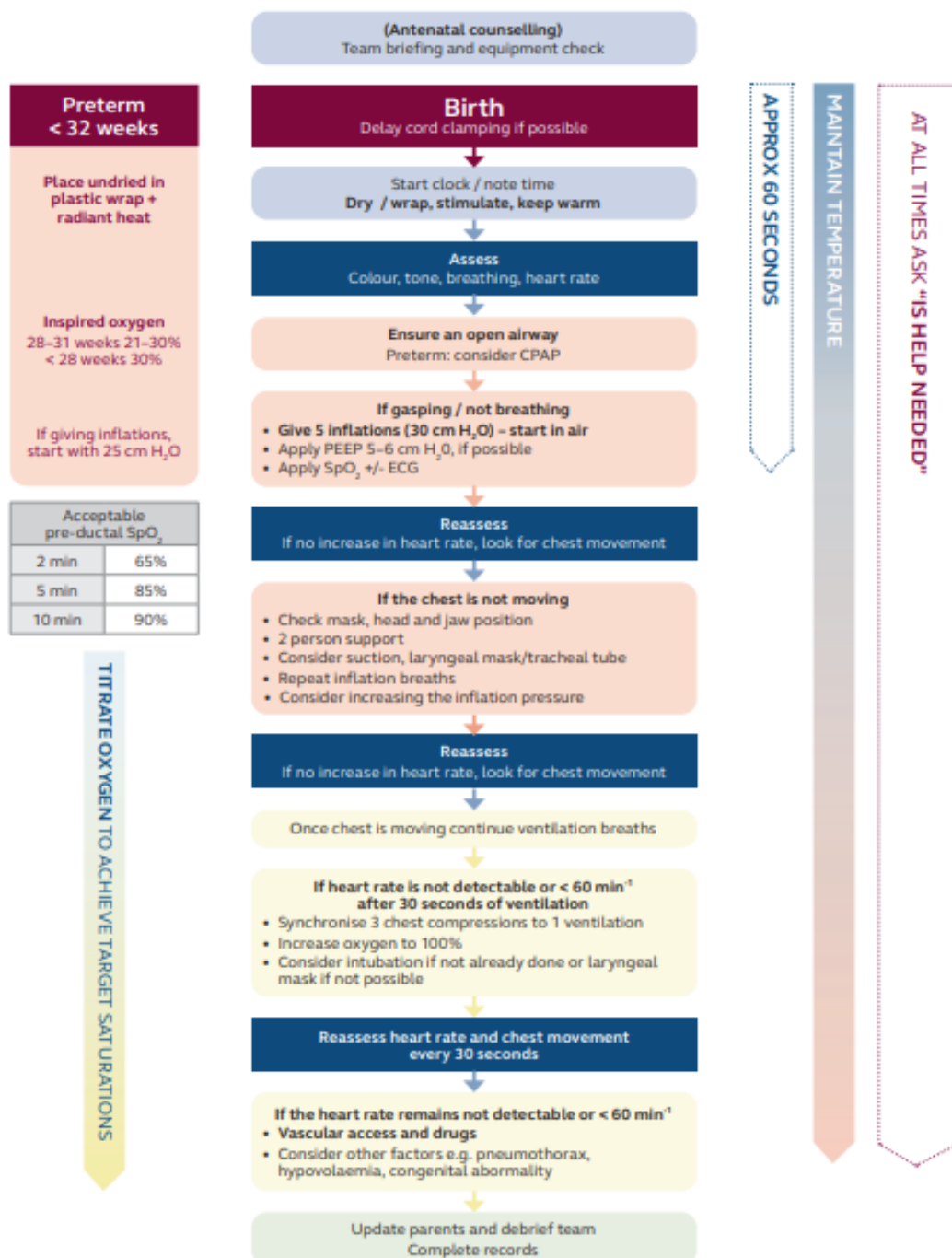
### Immediate resuscitation (10-15 min)

- If no signs of fluid overload, **10ml/kg balanced crystalloid IV** bolus over 5-10 minutes
- Reassess after each bolus up to 60ml/kg fluid or until perfusion improved
- Watch for signs of fluid overload – stop IV fluids and start inotropic support
- Correct hypoglycaemia and hypocalcaemia
- Start **broad-spectrum antibiotics** based on local guidelines
- Is source control required?
- Do you need help? PICU or retrieval service
- If mechanical ventilation is needed, give fluid resuscitation prior to intubation to reduced cardiovascular instability during induction.

### Not responding to initial resuscitation (15-60 min)

- Start inotrope infusion (preferably central but peripheral IV/IO if essential)
- **Adrenaline 0.05 – 0.3mcg/kg/min**
- **Noradrenaline (not peripheral IV) 0.05 mcg/kg/min**
- Titrate inotropes upwards as needed

## Newborn life support



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## Commonly used drugs

Drug	Dose
Propofol	2-5mg/kg
Ketamine	IV 1-2mg/kg IM 5-10mg/kg
Midazolam	Sedation 0.5-1mg/kg PO (max 20mg)
Suxamethonium	1-2mg/kg
Atracurium	0.5mg/kg
Rocuronium	0.6-1mg/kg
Paracetamol	PO 15mg/kg QDS
Ibuprofen	PO 5-10mg/kg QDS
Diclofenac	PO/PR 1-2mg/kg IV 1mg/kg
Morphine	IV 0.1mg/kg PO 0.2-0.5mg/kg 4 hourly (max 30mg)
Fentanyl	1-2mcg/kg
Alfentanil	10-20 mcg/kg
Dexamethasone	150mcg/kg
Ondansetron	150mcg/kg TDS
Cyclizine	1mg/kg TDS
Atropine	20mcg/kg
Glycopyrrolate	10mcg/kg
Adrenaline	Bolus 10mcg/kg (0.1ml 1:10,000) arrest dose Nebuliser 0.4mg/kg (max 5mg)
Noradrenaline	Infusion 0.05 – 1mcg/kg/min
Neostigmine	50mcg/kg Dilute 1 ampoule of reversal into 5ml, give 0.1ml/kg
Sugammadex	2mg/kg
Naloxone	4mcg/kg
Amiodarone	5mg/kg
Calcium 10%	0.2ml/kg
Magnesium	25-50mg/kg
Salbutamol	Nebuliser <5 years 2.5mg Nebuliser >5 years 5mg IV bolus <2 years 5mcg/kg IV bolus >2 years 15mcg/kg Infusion 1-5mcg/kg/min

## Stage 1 outcomes for paediatrics

Key capability	Examples of evidence	Suggested supervision level	Cross links with other domains
Safeguarding			
Explains local procedures for safeguarding vulnerable children and adults	Involvement with cases where there are safeguarding issues with children or adult attendance at local mandatory training E-learning - child protection	Not applicable	Professional Behaviours and Communication Education and training
Recognises potential forms of abuse of vulnerable adult and children and the various contexts in which they may occur			
Perioperative Medicine and Health Promotion			
Explains the specific perioperative care requirements of children including anxiety management	SLEs throughout stage of training across range of paediatric surgical specialties.	2a - supervisor in theatre suite, available to guide aspects of activity through monitoring at regular intervals	General Anaesthesia
General Anaesthesia			
Explains the principles of paediatric anaesthesia taking into account the anatomical, physiological, psychological and pharmacological differences from adults and their implications for safe anaesthetic practice	SLEs throughout stage of training across relevant paediatric cases.	ASA 1-2 children aged 5-10: 2a - supervisor in theatre suite, available to guide aspects of activity through monitoring at regular intervals.	Perioperative Medicine and Health Promotion
Provides safe general anaesthesia for ASA 1- 2 children 5 years and over with local supervision and 10 years with distant supervision undergoing non-complex elective and emergency surgery.		ASA 1-2 children aged over 10: 2b - supervisor within hospital for queries, able to provide prompt direction/assistance.	
Intensive Care Medicine			
Recognises the acutely ill child and initiates management of paediatric emergencies	SLEs throughout stage of training for relevant cases Simulation training including paediatric resuscitation courses.	FICM capability level 1	Resuscitation and Transfer