

## Anaesthesia and congenital abnormalities

K Ganeshalingam and T Liversedge\*

\*Correspondence Email: Tim.Liversedge@gosh.nhs.uk

There are many congenital abnormalities that affect children and where children may require surgery in childhood. Many conditions affect multiple systems, so it is important for the anaesthetist to have a thorough understanding of the problems that may be encountered. This article will consider Down syndrome and other congenital syndromes of relevance to the paediatric anaesthetist.

### DOWN SYNDROME (TRISOMY 21)

Down syndrome (DS) is associated with major congenital abnormalities including cardiac lesions, craniofacial abnormalities and intellectual impairment. It is the commonest chromosomal abnormality with an incidence of 1 in 740 live births in the UK.<sup>1</sup> First described by John Langdon Down in 1866,<sup>2</sup> the association between DS and trisomy of chromosome 21 was identified in 1959.<sup>3</sup> 95% of people with DS have trisomy 21, 3-4% have an unbalanced translocation for all or part of chromosome 21 or mosaic trisomy 21.<sup>4</sup> There is higher incidence with increasing maternal age (1 in 1600 at 25 years old, 1 in 40 at 43 years old).<sup>5</sup> The diagnosis of DS is made by chromosome analysis, either antenatally when risk factors are identified or postnatally in infants with the characteristic features of the condition.

Fifty years ago, 30% children with DS died in their first month, 53% in their first year, and 70% in their first 10 years.<sup>6</sup> Today, 1-year survival is 90% or more, with 45% surviving to 60 years old in some countries.<sup>5</sup> This increase in 1-year survival is partly due to improving surgical techniques and more aggressive treatment of life-threatening abnormalities.<sup>5</sup> However, outcomes differ throughout the world. Children with DS present for surgery and general anaesthesia throughout childhood and many of the features of DS have significance for the conduct of anaesthesia.

### Clinical features and anaesthetic implications of DS

The characteristic phenotypic features of patients with DS include:

- Flat occiput, short neck, small low set ears,

a flat nasal bridge, midface hypoplasia and a protruding tongue.

- Prominent epicanthic folds, upwardly slanting palpebral fissures.
- Generalised hypotonia and joint laxity.
- Single transverse palmar crease and wide 1st and 2nd toe gap.
- Brushfield spots (light coloured spots near the periphery of the iris).

Children are often low birthweight and small in infancy; however there is a tendency to be overweight by 3-4 years and to obesity in adolescence. This may in part be due to their reduced resting metabolic rate.<sup>3</sup> Venous access may therefore be difficult. Small stature, hypotonia and increased ligament laxity require vigilance during positioning under anaesthesia. Hearing impairment, ophthalmological and dermatological problems, dental disease and orthodontic problems contribute to the many surgical interventions required, and also carry implications for development of children with DS.

### Cardiovascular

Up to half of children with DS have congenital cardiac lesions.<sup>3</sup> DS is the condition most frequently associated with congenital heart disease, therefore all children with DS who require anaesthesia should be assessed for signs and symptoms of cardiac disease. The commonest lesions are:

- Atrioventricular septal defect (AVSD) (45%)
- Ventricular septal defect (VSD) (35%)
- Atrial septal defect (ASD) (8%)
- Patent ductus arteriosus (PDA) (7%)
- Tetralogy of Fallot (TOF) (4%)
- Pulmonary vascular disease (PVD).

Children with DS develop pulmonary vascular disease and pulmonary hypertension in the presence of cardiac defects with a left to right shunt at an earlier stage than children without DS and the same defects.<sup>7</sup> Pulmonary vascular disease (PVD) may also occur in

### Summary

This article reviews some of the congenital conditions a paediatric anaesthetist can expect to encounter, with an emphasis on Down syndrome.

Many conditions affect multiple systems, so it is important to have a thorough understanding of the potential problems. Children presenting for surgery should be assessed carefully, with particular attention to the cardiorespiratory system and the airway.

It is not possible to cover all syndromes in one article, but a Google search on the internet provides an invaluable resource when faced with a child with a rare congenital syndrome.

**K Ganeshalingam**  
SpR Anaesthesia  
Barts and the London  
School of Anaesthesia  
London

**T Liversedge**  
Consultant Paediatric  
Anaesthetist  
Great Ormond Street  
Hospital NHS  
Foundation Trust  
London

the absence of cardiac lesions as a result of hypoxaemia due to chronic pulmonary infections, hypoventilation due to muscle hypotonia, and obstructive sleep apnoea. It is recommended that all newborns with DS be assessed with an echocardiogram by a paediatric cardiologist by 6 weeks old, and a plan of action be put in place early for those with a cardiac defect.<sup>5</sup> This is not always practical in low and middle income (LMIC) settings; careful auscultation and pulse oximetry, especially if both of these are repeated, will inform a discussion with a specialist centre about which patients should be seen early. Morbidity and mortality for uncorrected lesions is high. Surgical correction of AVSD should take place by 6 months of age, before the development of PVD, with some authorities recommending correction by 4 months for optimum outcome.<sup>5</sup> 46% of adolescents and young adults with DS develop mitral valve prolapse with or without tricuspid valve prolapse and 17% will develop aortic regurgitation;<sup>2,3</sup> repeat echocardiographic screening should be undertaken for those requiring anaesthesia as adolescents, young adults and in later life. Conduction defects can occur following surgical repair of defects.<sup>4</sup>

### *Respiratory/airway*

Airway management during anaesthesia can be challenging and there is a higher incidence of perioperative respiratory complications in patients with DS:

- The incidence of obstructive sleep apnoea (OSA) is 50-75%.<sup>5</sup> This is related to the craniofacial abnormalities and pharyngeal hypotonia seen in DS and will be worsened in the presence of hypertrophy, inflammation and infection of the tonsils and adenoids (children with DS will frequently present for adenotonsillectomy). Patients with DS require close observation for obstruction post anaesthesia,
- Recurrent respiratory tract infections,
- Macroglossia, small mouth, midface hypoplasia, mild mandibular hypoplasia, oropharyngeal hypotonia,
- Adenotonsillar hypertrophy,
- Subglottic or tracheal stenosis is seen in 2-6% of patients.

### *Musculoskeletal*

- Craniocervical instability,
- Generalised poor muscle tone.

Craniocervical instability is a feature of DS and may be due to laxity of the transverse ligament and abnormalities of C1 (atlas) or C2 (axis) vertebrae. Asymptomatic atlantoaxial dislocation occurs in 12 to 20%, however spinal cord compression is rare.<sup>2</sup> Any history of neck pain, limited neck mobility or head tilt, change in gait pattern, clumsiness, abnormal neurological reflexes, abnormal sensation or the presence of bladder and bowel dysfunction suggest the possibility of cervical spine pathology. Diagnosis of cervical spine instability is difficult. Lateral flexion, extension and odontoid cervical spine radiographs are poorly predictive of cord compression. Atlantoaxial instability (AAI) is defined by an anterior atlantodental interval (AADI) greater than 4-5mm (the distance between the posterior border of the anterior arch of the atlas and the anterior

border of the odontoid peg). Where history or examination reveals any signs or symptoms suspicious of cervical cord compression, elective surgery should be postponed and specialist referral made.<sup>8</sup> For urgent surgery in this setting, standard precautions should be taken to immobilise the cervical spine.<sup>8</sup> There have been a number of case reports of cervical spinal cord injury related to anaesthesia and surgery.<sup>8</sup> If the patient has no clinical evidence of cervical cord compression, but requires prolonged positioning in a non-neutral position or difficult laryngoscopy is anticipated, it is recommended that radiological evidence of cervical spine stability be obtained.<sup>8</sup> Some centres conduct routine screening with upright lateral cervical spine Xrays, but this is not universally recommended.<sup>7</sup> In the absence of abnormal neurological signs and symptoms on history and examination, avoidance of forced neck flexion, extension or rotation under anaesthesia should be adequate.<sup>7</sup>

### *Central Nervous System*

- Developmental delay and moderate to severe learning disability,
- Microcephaly,
- Epilepsy (10%).

A degree of intellectual impairment and developmental delay is universal. There is a higher incidence of behavioural disorders and autism.

### *Gastrointestinal*

Gastrointestinal abnormalities are a frequent association with DS and a common reason for surgery in early life.<sup>7</sup>

- Duodenal atresia is the most common association,
- Gastro-oesophageal reflux,
- Hirschsprung's disease.

Tracheoesophageal fistula, pyloric stenosis and imperforate anus may also occur.

### *Endocrine*

Hypothyroidism occurs in up to half of affected individuals.<sup>5</sup>

Screening for thyroid disease should be undertaken at birth, 6 months and yearly thereafter. 1% children and adolescents with DS develop diabetes mellitus.<sup>3</sup> Relatively low catecholamine levels and diminished sympathetic nervous system activity have been reported.<sup>7</sup>

### *Haematological/immunological*

- Acute lymphoblastic leukaemia, acute myeloid leukaemia,
- Polycythaemia in neonates,
- Impaired cellular immunity with increased susceptibility to infections.

## **Preoperative evaluation of a child with Down syndrome**

Thorough pre-operative evaluation includes a detailed history taken from the parent or carer and examination of the child, performed with particular emphasis on the cardiovascular and respiratory

systems, airway and cervical spine. The degree of cooperation from the child will vary with age and severity of learning disability.

Cardiovascular evaluation includes assessment for symptoms and signs of congenital heart disease, an ECG, and an echocardiogram and cardiology opinion where appropriate. Symptoms suggestive of congenital heart disease (CHD) include failure to thrive, dyspnoea, poor exercise tolerance, recurrent respiratory infections, cyanotic spells, syncope and chest pain. Signs include tachycardia, tachypnoea, cyanosis, finger clubbing, heart murmurs, precordial thrills, cardiomegaly, hepatomegaly, and decreased or absent femoral pulses.

You must assess the airway and evaluate for features of craniocervical instability. History and examination of the respiratory system should search for features of OSA, subglottic or tracheal stenosis and respiratory tract infection.

Children with DS are generally gentle, cheerful and outgoing, but may have a tendency to hyperactivity and will have limited understanding compared to a normal child of the same age. A clear explanation of the anaesthetic plan should be given to the parent or carer, and explain to the child in appropriate language. As with other children with developmental delay and associated behavioural disorders, careful preoperative preparation is essential, enlisting the help of parents, in order to try to gain the child's trust and cooperation. Premedication may be necessary more frequently due to limited understanding, developmental delay and a higher incidence of behavioural disorders. Premedicate with caution in the presence of severe OSA. Preoperatively the child and parent should be given the choice of either inhalational or intravenous induction as appropriate and prepared accordingly. A supportive parent or carer can often be of great benefit to the child at induction. Intravenous access can be more challenging in children with DS, so inspect potential cannulation sites carefully and apply topical local anaesthetic cream at an appropriate preoperative interval. Antacid premedication may be beneficial in those with gastro-oesophageal reflux disease. Antimuscarinics (atropine or glycopyrrolate) may be indicated for their antisialogogue effect and to attenuate a bradycardic response on induction of anaesthesia.

No abnormal responses to anaesthetics or other agents have been documented;<sup>6</sup> nor has a reported excessive heart rate response to atropine,<sup>7,9</sup> Vagal block with atropine may in fact be beneficial for several reasons including the higher reported incidence of bradycardia on induction of anaesthesia,<sup>4</sup> the chronotropic effects in the presence of low plasma catecholamine concentrations and for its antisialogogue effects.<sup>7</sup>

### **Intraoperative considerations in Down syndrome**

Routine monitoring should be used as for any other case. If inhalational anaesthesia is chosen skilled assistance should be present at induction to maintain the airway while intravenous access is obtained - this allows for the challenging nature of the airway, higher incidence of airway obstruction on induction and the occurrence of severe bradycardia on induction. Children with DS are prone to infection and all invasive lines should be inserted under full aseptic precautions.

In a retrospective review of anaesthesia for patients with DS for noncardiac surgery, severe bradycardia occurred in 3.66% cases during induction of anaesthesia.<sup>4</sup> This may be associated with significant haemodynamic instability in children, who are more reliant on heart rate to preserve cardiac output. Intravenous atropine should be readily available on induction, and pre-treatment may be indicated, for instance if halothane is used.

The same study found a 1.83% incidence of airway obstruction on induction of anaesthesia and 0.54% incidence of difficult intubation.<sup>4</sup> Be prepared for potentially difficult bag-mask ventilation, laryngoscopy and/or intubation. Appropriately-sized oro/naso-pharyngeal airways and laryngeal mask airway must be immediately available to rescue a potentially difficult airway. A smaller endotracheal tube (ETT) than predicted by age/weight is frequently required in the presence of subglottic or tracheal stenosis. There is also a higher incidence of airway obstruction on emergence and an increased incidence of post-extubation stridor (1.83%).<sup>4</sup> Intubation should be carried out with minimal manipulation of the craniocervical spine by an experienced anaesthetist if there is a suspicion of atlantoaxial instability.

During positioning avoid excessive neck movement. During procedures such as laryngoscopy, rigid bronchoscopy and oesophagoscopy, attempt to maintain the neck in a neutral position avoiding excessive extension or flexion. Table tilt may be preferable to neck rotation, although a study investigating the safety of neck rotation for ear surgery concluded that patients with DS who have no neurological symptoms and normal cervical spine radiographs do not appear to be at high risk with neck rotation up to 60 degrees.<sup>11</sup>

Routine antibiotic prophylaxis against infective endocarditis is no longer recommended.<sup>12</sup>

Adequate analgesia is important as postoperative pain assessment and management can be challenging due to intellectual impairment. The use of regional anaesthetic techniques may be challenging in obese patients with behavioural difficulties but the benefits include avoiding the respiratory depressant effects of opioids and improved compliance with chest physiotherapy.

### **Postoperative considerations in Down syndrome**

Patients should be observed closely in the recovery room until full recovery from anaesthesia, as there is a higher incidence of airway obstruction. Hypotonia may affect the ability to maintain the airway, which may require simple airway manoeuvres (head tilt, chin lift or jaw thrust) or positioning the child in the lateral position to maintain airway patency. Where craniocervical instability is suspected or present, only the jaw thrust manoeuvre should be used. Use of airway adjuncts (oropharyngeal or nasopharyngeal airway) may be helpful depending on the child's level of consciousness. There is a higher incidence of post-extubation stridor in children with DS. This is managed with humidified oxygen, nebulised epinephrine (adrenaline) and intravenous dexamethasone. Postoperative agitation can be problematic, occasionally requiring sedation to prevent harm. This may be limited by the presence of parents or carers in combination with effective analgesia. Postoperative chest infections are more frequent in patients with DS.

## Summary – Down syndrome

DS is the commonest congenital abnormality and is associated with defects concerning for safe anaesthetic management including congenital cardiac disease, craniofacial abnormalities, cranio-cervical instability and intellectual impairment. There is a higher incidence of perioperative respiratory complications including airway obstruction and postextubation stridor. Rarely neurological problems may occur due to atlantoaxial subluxation. Children with DS presenting for surgery require careful preoperative evaluation and perioperative care to minimise these risks

## CONGENITAL CONDITIONS AFFECTING THE AIRWAY

Many congenital syndromes present challenges with airway management due to difficulty with one or more of maintaining a mask airway, mask ventilation and intubation.

There are distinct anatomical features associated with difficult airway management in children, each producing its own challenges:<sup>10</sup>

- Macroglossia (large tongue)
- Micro/retrognathia (small or receding mandible)
- Limited mouth opening
- Midface hypoplasia
- Cervical spine instability/limited motion
- Abnormal soft tissue airway structures and other facial abnormalities impairing mask fit.

It is important to perform comprehensive preoperative evaluation of the child's airway in order to plan management. Features possibly indicating airway compromise are poor feeding, apnoea, airway obstruction (OSA, stridor), respiratory failure, subcostal or intercostal muscle recession, tracheal tug, use of accessory muscles and pulmonary hypertension.

Examination should seek the features above and make an assessment of jaw protrusion, Mallampati score, mouth opening, dentition, nasal patency, neck abnormalities and restriction of movement. Formal airway assessment is often difficult in uncooperative children. Review previous anaesthetic records for details of mask ventilation, Cormack and Lehane laryngoscopy grade, special techniques used during airway management and any difficulties experienced. All of the conditions described here may be associated with awkward direct laryngoscopy, and alternate means of glottic visualization (e.g. fibre-optic or video-laryngoscopy) plus airway 'rescue' devices (e.g. supraglottic airway) should be immediately available. It is essential that the anaesthetist has an assistant when managing a child with a difficult airway; it is particularly important to address this in settings where the anaesthetist usually operates alone without a specifically trained anaesthetic assistant.

## Cleft lip and/or palate

This is a relatively common abnormality and may be an isolated finding or associated with a number of different syndromes. It may contribute to difficult laryngoscopy particularly if associated with micrognathia or other craniofacial abnormalities. A more 'lateral' approach for direct laryngoscopy may be helpful. Following palate

repair, the tongue may cause airway obstruction, so these children should be extubated when they are fully awake and observed closely for impending airway obstruction.

## Pierre Robin sequence

Features of this syndrome are micrognathia, posterior displacement of the tongue, cleft palate and an association with congenital heart disease (commonly VSD, PDA, ASD). With severe micrognathia there can be life threatening airway obstruction soon after birth requiring prone positioning, a nasopharyngeal airway and in very severe cases, intubation or tracheostomy. Upper airway obstruction often occurs after induction of anaesthesia, necessitating the use of airway adjuncts or a LMA to maintain the airway. Direct laryngoscopy can be very difficult. With age and growth of the mandible these children usually become easier to manage. It often occurs in otherwise normal children but can occur as a feature of a multiple malformation syndrome.

## Goldenhar syndrome

Features of this syndrome are asymmetrical hypoplasia of malar, maxillary and mandible (hemifacial microsomia), associated with epibulbar dermoids, congenital heart disease (VSD, TOF) and cervical vertebral defects. Face mask ventilation is challenging due to poor mask seal and intubation may be difficult due to mandibular hypoplasia and limited mouth opening especially in the setting of right sided hemifacial microsomia and a short immobile neck. The facial asymmetry may worsen as the child grows, increasing the difficulties associated with airway management.

## Treacher Collins syndrome

This condition is characterised by bilateral malar, maxillary and mandibular hypoplasia, small mouth, temporo-mandibular joint abnormalities, downslanting palpebral fissures, defect of the lower eyelid and malformation of the external ear.<sup>2</sup> Direct laryngoscopy and intubation may be very difficult and become more so with increasing age. There is an association with cleft palate and cardiac anomalies.

## Syndromic craniosynostosis

Apert, Crouzon, Pfeiffer and Saethre-Chotzen are the commonest syndromes. They are characterized by prematurely fused skull-bone sutures and involvement of the facial skeleton, which can result in upper airway obstruction and raised intracranial pressure. Almost 50% have OSA and there is risk of airway obstruction on induction of anaesthesia, difficult mask ventilation and perioperative respiratory complications. Difficult laryngoscopy is unusual.

## Mucopolysaccharidoses

These are classified into the following sub-types:

- I H: Hurler syndrome
- I S: Scheie syndrome; previously classified Type V
- I HS: Hurler-Scheie compound
- II: Hunter syndrome
- III: Sanfilippo syndrome



IV:	Morquio syndrome	
V:	Formerly Scheie syndrome	
VI:	Maroteaux-Lamy syndrome	
VII:	$\alpha$ -Glucuronidase deficiency	
Type I H, I HS, II, VII		Affects bones and intellect
Type III		Affects intellect only
Type I S, IV, VI		Affects bones only

The mucopolysaccharidoses (MPS) are lysosomal storage disorders caused by enzyme defects that result in accumulation of glycosaminoglycans in cellular lysosomes throughout the body. This results in coarse facial features, airway abnormalities, organomegaly, cardiac dysfunction, joint and bone deformities, visual, auditory and intellectual impairment. The consequences of deposition in the soft tissues of the mouth and pharynx are macroglossia, thickened oropharyngeal and nasal mucosae, adenoidal and tonsillar hypertrophy, copious secretions and a narrow trachea. Deposition in joints and bones can result in a short, immobile and potentially unstable neck and reduced temporo-mandibular joint movement. All of the above can combine to make airway management and intubation extremely difficult. The most challenging are those with Hurler (MPS I) and Hunter (MPS II) syndromes. These conditions are progressive and lethal, but the natural history of airway disease may be altered by successful bone marrow transplantation. Spontaneous ventilation should be maintained until the airway has been secured; however airway obstruction can occur early during inhalational induction. Placement of LMA airway in these patients may be difficult, require several attempts, and be only partially effective or ineffective. While managing the airway, it is important to maintain the neck in a neutral position as there may be cervical spine involvement, as in Morquio syndrome (MPS IV). Spinal cord compression may occur due to thickening of the dura and to odontoid hypoplasia. Preoperative MRI scans (without anaesthesia) of the spinal cord may be appropriate in affected individuals.

### Beckwith-Wiedemann syndrome

This is a syndrome of macrosomia, visceromegaly, macroglossia, omphalocele and hypoglycaemia. Cor pulmonale may result from chronic airway obstruction. Cardiomegaly may be part of the visceromegaly which may also involve other organs. Macroglossia can cause upper airway obstruction and may complicate direct laryngoscopy; partial glossectomy is occasionally required. Serum glucose should be monitored perioperatively.

### Klippel-Feil syndrome

This condition is due to a failure of cervical vertebrae segmentation during foetal development. These children have a short neck with low hairline and neck rigidity due to fusion of 2 or more of the cervical vertebrae, most commonly C2 and C3.<sup>2</sup> Direct laryngoscopy/intubation may be very difficult.

## CONDITIONS ASSOCIATED WITH CONGENITAL HEART DISEASE

Cardiac disease is a frequent association of a number of congenital abnormalities. Careful evaluation of the cardiovascular system should be undertaken when other major abnormalities are present. Aside from DS, other conditions of note include:

### Turner syndrome

Females with short stature, short webbed neck, ovarian dysgenesis<sup>2,10</sup> and XO karyotype. 30% have a bicuspid aortic valve and 10% coarctation. Micrognathia may predispose to airway difficulty. 50% have renal abnormalities; therefore take caution with renally excreted drugs.

### Noonan syndrome

These individuals have phenotypic similarities to Turner syndrome; short stature and short or webbed neck. Cardiac defects associated with this condition are pulmonary valve stenosis (62%), hypertrophic cardiomyopathy (20%), ASD, TOF, aortic coarctation, mitral valve anomalies and atrioventricular canal defects.<sup>2,10</sup> Other associations are micrognathia, hydronephrosis and platelet dysfunction. Preoperative assessment should focus on possible difficulty with intubation, cardiac anomalies and renal function.

### CHARGE association

This is an association of the following abnormalities:<sup>2</sup>

- **C:** ocular Coloboma (80-90%)
- **H:** Heart defect (TOF, PDA, double outlet right ventricle, VSD, ASD, right-sided aortic arch-75-80%)
- **A:** choanal Atresia (58%), growth (70%)
- **R:** developmental Retardation (100%)
- **G:** Genital anomalies (75%)
- **E:** Ear anomalies or deafness (90%)

Tailor the anaesthetic according to the individual lesions present.

### VACTERR (or VACTERL) association

This is an association of the following abnormalities:<sup>2</sup>

- **V:** Vertebral anomalies (70%)
- **A:** anal Atresia (80%)
- **C:** VSD and other Cardiac defects (53%)
- **T-E:** Trachea-oEsophageal fistula (70%)
- **Renal anomalies** (53%)
- **Radial dysplasia** (or L for limb) (65%)

Again, anaesthetic management is dictated by the specific lesions present.

### Di George syndrome (22q11.2 deletion syndrome)

Chromosome 22 microdeletions result in the failure of the 3rd and 4th embryological pharyngeal pouches to differentiate into thymus and parathyroid glands. Hypoplasia/aplasia of the thymus results in deficiency in T-cell-mediated immunity leading to a susceptibility to

fungal and viral infections and hypoplasia/absence of parathyroids results in severe hypocalcaemia with tetany and seizures in early infancy. Cardiac defects are present in 85% and DiGeorge syndrome is the second most common cause of congenital heart disease, most commonly VSD (62%), right aortic arch (52%), TOF (21%), aberrant left subclavian artery, truncus arteriosus, double aortic arch and interrupted aortic arch.<sup>2,10</sup> Affected individuals commonly have micrognathia, cleft palate and choanal atresia. Micrognathia may make intubation difficult and a short trachea predisposes to inadvertent endobronchial intubation. Serum calcium should be checked preoperatively, blood products should be irradiated to prevent a graft versus host reaction and meticulous sterile technique is important when caring for these children.

## OTHER CONGENITAL CONDITIONS OF IMPORTANCE TO THE PAEDIATRIC ANAESTHETIST

### Neuromuscular disease

These conditions can be divided into the following categories:<sup>13</sup>

- Myasthenic syndromes (abnormalities in the release or action of acetylcholine),
- Channelopathies (abnormalities in the post-synaptic membrane or the sarcoplasmic reticulum),
- Dystrophies / myotonias (abnormalities in the myofibrils),
- Mitochondrial myopathies (abnormalities in mitochondria).

Important congenital conditions in this group of disorders include:

#### *Duchenne muscular dystrophy*

Duchenne muscular dystrophy (DMD) is seen in 1 in 3500 live male births in the UK. It is an X-linked recessive disorder. This condition is associated with rapidly progressive weakness presenting between 2 and 5 years of age with sufferers usually wheelchair bound by the age of 12. Myocardial degeneration leads to cardiac failure and respiratory muscle weakness results in ventilatory failure. Death usually occurs by third or fourth decade. There is a weak recommendation that volatile agents be avoided due to the risk of anaesthesia-induced rhabdomyolysis. Succinylcholine (suxamethonium) must NOT be used due to risk of hyperkalaemia.

#### *Myotonic dystrophies*

These are a group of hereditary diseases of skeletal muscle associated with sustained contraction after stimulation. Dystrophia myotonica is the commonest form and typically presents in late adolescence; 50% develop cardiac conduction defects. Other diseases in this group are myotonia congenita, which presents at birth or early childhood and paramyotonia congenita, which also presents in early childhood and is induced by exposure to cold. Succinylcholine can induce generalised myotonia and is contraindicated in these conditions. If muscle spasm occurs (e.g. masseter spasm), lignocaine directly injected into the muscle may prove useful.

#### *Mitochondrial myopathies*

These are a heterogeneous group of conditions with a collective

incidence of 1 in 4000.<sup>13</sup> Clinical features are a consequence of defects in electron transport or oxidative phosphorylation and tissues that are most metabolically active such as the nervous system and muscles are most affected.<sup>10</sup> The three basic categories are:

- Respiratory chain deficiencies,
- Mitochondrial DNA mutations including mitochondrial encephalopathy, lactic acidosis and stroke-like episodes (MELAS), mitochondrial neuro-gastrointestinal encephalopathy (MNGIE), myoclonic epilepsy with ragged red fibres (MERRF),
- Mitochondrial deletions such as Kearns-Sayre syndrome.

The severest forms present in the neonatal period with profound weakness, acidosis, liver/renal failure and substantial neurological impairment. Optimal anaesthetic technique for this group of conditions remains controversial although propofol may best be avoided, particularly by infusion.

Pre-operative work-up will depend on the clinical condition of the patient but should include a full cardiorespiratory evaluation including (in severe cases) arterial blood gases, pulmonary function tests and where appropriate assessment of other organ function with measurement of electrolytes, glucose, lactate, pyruvate, creatinine kinase, liver function and renal function.<sup>10</sup>

#### *Malignant hyperthermia*

Three conditions with a definite link with malignant hyperthermia are central core disease, King-Denborough syndrome and Evans Myopathy.<sup>13</sup>

#### **Inherited metabolic disorders**

These are caused by genetic defects resulting in the absence/dysfunction of structural proteins or enzymes. Some conditions present significant challenges to anaesthesia. Symptoms and signs may be related to accumulation of intermediate metabolites proximal to the blocked enzyme that may be toxic or inappropriately stored within cells and/or deficiency of a metabolite downstream of the blocked enzyme. They are broadly classified into the following categories:<sup>14</sup>

- Disorders of amino acid (and branched-chain amino acid) metabolism
- Urea cycle disorders
- Organic acidaemias
- Disorders of carbohydrate metabolism e.g. glycogen storage diseases
- Lysosomal storage disorders
- Disorders of fatty acid oxidation.

Conditions of particular concern to the anaesthetist are the mucopolysaccharidoses (described above); glycogen storage disorders, which prevent the production of glucose from glycogen and cause the accumulation of glycogen within tissues such as liver and muscle;

and organic acidaemias (propionic and methylmalonic acidaemia). As a general principle, keep children with inherited metabolic disorders well hydrated, and take care to avoid hypoglycaemia during starvation. Children with organic acidaemias are treated with a protein-restricted diet, and children with glycogen storage diseases are particularly prone to hypoglycaemia.

### Epidermolysis bullosa

This is an inherited group of skin disorders characterised by cleavage at the dermal-epidermal junction resulting in erosions and blisters from seemingly minor trauma to skin or mucous membranes.

There are three main forms of epidermolysis bullosa (EB), each with several subtypes:

- *Simplex*: This is usually a relatively mild form with rapid healing and little scarring,
- *Lethalis*: This is a junctional epidermolysis bullosa. This is a severe form of the condition that presents at birth, leading to extensive scarring and death usually before the age of 2,
- *Dystrophic*: This is a rare but severe form of the disease. Lesions are slow to heal with extensive scarring resulting in strictures of the mouth, pharynx, larynx and oesophagus, limb contractures and fusion of the digits. Blistering / strictures of oesophagus and oropharynx can lead to decreased oral intake and nutrition leading to growth retardation and anaemia. Infections are common and antibiotic prophylaxis may be necessary. Adrenal suppression can occur due to use of powerful topical steroids or oral steroids necessitating perioperative steroid replacement. There is an association with dilated cardiomyopathy.

Children with EB must be assessed carefully preoperatively, with particular reference to the airway. Airway management may be difficult as a result of oral lesions, limited mouth opening, adhesion of the tongue and pharyngeal strictures. Care must be taken to avoid trauma to skin or mucous membranes. Frictional shearing forces must be avoided. Allow the patient to position himself or herself if possible. Avoid intubation and instrumentation of the airway or lubricate the ETT and laryngoscope generously and select an endotracheal tube at least 0.5mm smaller than predicted by age/size. If a LMA is used ensure that it is lubricated and it may be appropriate to select a smaller size. Use a lubricated face-mask for inhalational induction and lubricate gloves or apply paraffin gauze to the mask as well as the face. Do not use adhesive tape on the skin. Secure intravenous access and ECG dots with low-adherence dressings such as Mepiform or Mepitel, which are silicone based. If these are unavailable, an unfolded gauze swab smeared with paraffin gel makes a sticky dressing that doesn't shear the skin. This may be kept in place with a crepe bandage. Padding should be applied under the non-invasive blood pressure cuff. Oropharyngeal secretions can be cleared with lubricated soft suction catheters under low pressure, avoiding contact with the mucosa.<sup>15</sup> Anaesthesia for this group of patients can be extremely challenging but with meticulous attention to detail good outcomes are possible.

### Osteogenesis imperfecta

This is an inherited disorder of connective tissue principally involving bones, making them fragile. There are several forms of osteogenesis imperfecta (OI). The two main forms are OI tarda (type I) and congenita (type II).

- *OI Tarda* presents with pathological fractures, blue sclera and deafness. Osteoporosis can result in kyphoscoliosis and restrictive lung disease. Fragility of vessels leads to subcutaneous haemorrhage. Dentine deficiency results in carious, fragile teeth. Extreme care must be taken with positioning and moving patients; fractures have been reported from minimal manipulation, including application of a blood pressure cuff.<sup>16</sup> Careful laryngoscopy should avoid neck hyperextension and dental damage. Intravenous access can be difficult to maintain due to fragile vessels. OI is associated with abnormal platelet function which may exacerbate perioperative bleeding.
- *OI Congenita* is the more severe form and usually presents as a stillbirth or proves rapidly fatal.

### CONCLUSION

In this article we have reviewed some of the congenital conditions a paediatric anaesthetist can expect to encounter occasionally. Children presenting for surgery should be assessed carefully, with particular attention to the cardiorespiratory system and the airway. It is not possible to cover all syndromes in one article, but a Google search on the Internet provides an invaluable resource for the paediatric anaesthetist faced with a child with a rare congenital syndrome.

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