Anaesthesia for the “syndromic” child

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Introduction
Often called “funny looking kids” in the corridors and tearooms of hospitals worldwide, these children may challenge the paediatric anaesthesiologist. So what makes a child look funny? Is it the child’s face or body stature that does not conform to the clinician’s concept of normal? Is it that the child is too fat, too short, too tall, too hairy, too stiff, too floppy, too distorted? Or is it simply that the child has features of a genetic, metabolic, or dysmorphic syndrome that the clinician, through ignorance, labels as funny looking. Far from being funny, these disorders may have significant anaesthetic implications, and ignorance may lead to a disastrous outcome when these children undergo surgery or diagnostic procedures.

Invariably a “syndromic” child seen at a preoperative visit is labelled with a diagnosis rather than a constellation of signs and symptoms seeking a unifying diagnosis from a knowledgeable clinician or geneticist. There are many references that will provide information for the named “syndrome” or disorder. However the unlabelled or undiagnosed “syndromic” or “dysmorphic” child remains a challenge.

It is impossible to cover all syndromes or features that may at some time be described as funny looking. However, this article outlines an approach partly based on personal experience, to the dysmorphic child, by demonstrating links between certain common features and their relevance to the anaesthesiologist.

Significance
Broadly speaking, the anaesthetic implications include anatomical malformations of the airway, functional disorders of organ systems, and aberrations from the expected response to anaesthetics.

Three to seven per cent of all babies born have at least one congenital abnormality. Many of these interfere with normal body function and can lead to a lifelong handicap or even early demise.

Seventy-five per cent of these congenital defects affect the cranio-facial complex (cranial vault, neck or oral cavity). Several studies have shown that about one third of paediatric inpatients are hospitalised because of a congenital anomaly. When the incidence (i.e. an estimate of the occurrence of a disease in a given population) of the ten most frequent congenital anomalies are considered cumulatively, the probability of encountering at least one case of any of these diseases increases to 1:200.

Specific recognisable alterations of cranio-facial form, structure, and function are often associated with various congenital disorders and syndromes. Many malformations can occur alone, or as part of a larger malformation. They may be caused by a single gene defect, a defect in a combination of genes, or purely an environmental insult. Dysmorphic syndromes (as a result of a metabolic defect) and dysplastic syndromes (as result of abnormalities in cell division) all find expression in the cranio-facial complex as well as the rest of the body.

Pathogenetic mechanisms
There are four major modes of pathogenesis, and each have different clinical implications. Deformations are those anomalies caused by unusual mechanical pressure on the developing foetus (twins, abnormal uterus, oligohydramnios). Dysplasias are usually seen as compression of soft tissue e.g. compression of the jaw (micrognathia), bowing of legs in breech, abnormalities of joint excursion. These usually resolve with time. Disruptions also affect structures that were undergoing normal development and growth in utero. But some outside agent causes destruction of tissue in a clearly defined local area that does not conform with normal embryonic development. Examples include mechanical stress (amniotic bands) or intrauterine viral infection (rubella, herpes) and tissue ischaemia of any cause. Dysplasia refers to structural defects resulting from abnormal cellular organisation or function that as a rule affects just one tissue type throughout the body. Most dysplasias are caused by mutant genes that affect intracellular pathways of intermediary metabolism. They are often not visible at birth but develop after a few months and worsen with age (achondroplasia, ectodermal-dysplasia, dysostosis, metaphyseal dysplasia). Mucopolysaccharidoses and some glycoegen storage diseases differ in that they affect a number of tissues that share the same metabolic pathway. Malformation is a term reserved for the permanent change produced by an intrinsic abnormality of development in a body structure in utero, in which multiple tissue types can be involved. The malformative process produces a wide variety of effects resulting in a structure that may be too small, too large, disorganised or of different shape e.g. cleft lip or palate.

A birth defect association refers to a non-random combination of anomalies in which the individual components occur together more frequently than would be expected by chance e.g. VATER, VACTERL and CHARGE associations. The child does not necessarily have to have all the components, and may often only have one. A complex is a group of anomalies affecting several different structures that lie in close proximity e.g. hemi-facial microsomia, Poland anomaly and sirenomelia (mermaid). In a syndrome and sequence the components occur together more consistently in varying degrees of severity and affect widely separated parts of the body e.g. myelo-meningocele associated with hydrocephalus and paralysis of the lower limbs and loss of bladder and anal sphincter control. A dysmorphic syndrome is a recognised pattern of congenital anomalies whose unique combination sets them apart from other abnormalities. The pattern is unique, not its parts. Most are very rare.

“Dysmorphic face” and the difficult airway
Optimal management of the airway is an essential component of basic life support, resuscitation and anaesthesia. Congenital anomalies or chromosomal abnormalities may have unique anatomical and patho-physiological derangements of the upper

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Airway that may make airway maintenance and intubation difficult. This may be more pronounced in neonates and small infants with these defects.

An understanding of the embryological development of the face, upper airway, head and neck will assist the anaesthesiologist in recognising and managing a difficult airway. Maldevelopment of the branchial arches in the early embryonic period can lead to the triad of microgeny, mandibular hypoplasia and retrognathia. In addition an awareness of associated defects affecting the central nervous system or cardio-respiratory system may influence both the management and the subsequent outcome. Other congenital anomalies for example muscle disorders may influence the choice of drug used to facilitate intubation.

Embryological development – upper airway: The early embryo consists of a bi-laminar disc of ectoderm and endoderm. The embryonic disc folds upon itself to form the primitive gut. At the cephalic end the laryngo-tracheal groove forms as an outgrowth of the foregut into the dorsally aligned mesodermal beds. Laterally, the foregut is limited by a thick wall of mesoderm in which the branchial or pharyngeal pouches develop. The paired branchial arches develop sequentially between the third and eighth week. Between the branchial arches externally are the branchial clefts that are matched internally by the pharyngeal pouches. The mesoderm gives rise to the false cartilages and bones with their attached muscles. The muscle components of each arch are supplied by the corresponding nerve of that arch. These paired arches are involved in formation of the oral cavity, mandible, zygoma, temporal bone, and parotid gland.

The first branchial arch develops into the maxilla and mandible (which form by division of Meckel's cartilage), the zygoma, malleus, incus and the sphenomandibular ligament. The first branchial cleft gives rise to the external auditory canal. The parotid and upper part of the pinna also develop from the first arch.

The second branchial arch gives rise to the muscles of facial expression, including the platysma, the posterior belly of the digastric muscle, the stapedius and stylohyoid (all supplied by the facial nerve). Reichert's cartilage gives rise to the stylohyoid process, the formation of the middle and external ears, the temporal bone, the helix, antihelix and lobe of the pinna, and the upper body and lesser cornu of the hyoid bone. Abnormalities of the pinna may serve as an anatomical marker and the upper body and lesser cornu of the hyoid bone also develop from the second branchial arch and consists of microstomia, abnormalities of the pinna, absence of the external auditory canal, middle ear abnormalities and hypoplasia of the mandible. In addition they have associated vertebral defects (see below).

Anomalies of the second branchial arch and cleft are common and usually consist of a branchial fistula that opens anterior to the sternostoid muscle. The presence of a branchial fistula preauricular sinus or skin tag may also serve as a marker for a potential difficult intubation as they develop from the faulty fusion of the components of the first or second branchial arch.

The craniocervical junction consists of the foramen magnum, the atlas and the axis. The occipital bone is formed by fusion of four occipital sclerotomes – the most caudal of which is the proatlas. The primitive proatlas divides into an anterior segment, which develops into the occipital condyles, and a posterior segment that fuses with the atlas to form its rostral articular facets. If this fusion fails, a rare anomaly with horizontal instability results. The proatlas also forms the tip of the dens (ossiculum terminale). The atlas is derived from the first cervical sclerotome and the proatlas. The body of the atlas disappears and gives rise to the dens. The axis is developed from the C1 sclerotome (the dens), the C2 sclerotome (two neural arches and body) and the proatlas (ossiculum terminale). Failure of the dens to fuse with its body results in the os odontoideum.

Both these odontoid abnormalities, ossiculum terminale and os odontoideum, are associated with an incompetent cruciate ligament and hence atlanto-occipital instability. Patients with Hurlers syndrome may be unstable because of the associated odontoid hypoplasia.

The occipito-atlanto-axial joints are complex and detailed description is beyond the scope of this paper. However the atlanto-axial joints have convex articular surfaces with horizontal orientation. Because these convex surfaces are not exactly reciprocal, a telescoping effect occurs on rotation of the head. There is limited movement in the atlanto-axial joint and head-spine motion is basically between the occipital condyles and C2 vertebra. Because of the intervening C1-C2 convex joint there is decreased stability at the cranio-vertebral junction with extension, flexion and rotation. Hypermobility of the occipito-atlantal joint may progressively increase in patients with congenital high cervical fusion. This may lead to basilar invagination associated with the Klippel Feil anomaly for example.

The development of the neck musculature is inadequate to supplement joint stability until approximately 8 years of age. Before this age laxity of the ligamentous tissue permits excessive movement of the occipito-atlanto-axial articulation. Forward gliding of the skull in relation to the spine occurs if hypoplastic occipital condyles are present. This may be seen in Conradi syndrome, Morquios syndrome and spondylo-epiphyseal dysplasia – conditions often associated with ossiculum terminale.

The lymphatic drainage of the occipito-atlanto-axial joints is through the retropharyngeal glands to the deep cervical lymphatic chain. C1-C2 subluxation may develop secondary to nasa-pharyngeal infections particularly in those children with cervical vertebral anomalies.

Children with Down's syndrome (Trisomy 21) may suffer atlanto-axial subluxation because they have lax transverse ligaments and in addition may have poorly formed odontoid processes.

The branchial arches are also involved in the development of the heart and major vessels. Many of the syndromes with
craniofacial defects have associated cardiac defects (ASD, VSD, Tetralogy of Fallot, Coarctation aorta).

**Too floppy – too stiff**

Many muscle disorders may have associated oculofoacial abnormalities in addition to skeletal abnormalities. Congenital myopathy may be recognised in a floppy child with delayed milestones and recurrent chest infections. These children have typical myopathic facial features that include ptosis, down slanting palpebral fissures, expressionless faces and a fish mouth. Myotonia dystrophica has similar facial features and may have frontal bulging in the older child. Conduction abnormalities are common, oesophageal reflux and recurrent chest infections are some of the anaesthetic considerations.

Muscular dystrophy (Duchenne) have myocardial involvement in 70% cases but only a small proportion (10%) are symptomatic. The link to malignant hyperthermia (MH) is no longer considered relevant but sudden cardiac arrest with the use of suxamethonium is well recognised. Rhabomyolysis may occur with volatile agents, particularly halothane.

Rare syndromes, such as Freeman-Sheldon syndrome (whistling face), Schwarz-Jampel syndrome (clown face), and arthrogryposis multiplex congenita have characteristic facial features. The facial stiffness or trismus seen in these children may contribute to a difficult intubation. A link to malignant hyperthermia, although described, is unlikely. Propofol infusion and regional anaesthesia is probably the safest option in these cases because many muscle disorders have similar facial features and MH associated disorders such as Central core disease, or King Denborough syndrome is probably the safest option in these cases because many muscle disorders have similar facial features and MH associated disorders such as Central core disease, or King Denborough syndrome may be difficult to exclude. Intravenous access may be difficult in children with muscle disorders.

**Too fat**

Obesity is an ever-increasing problem in modern society and seems to be reaching epidemic proportions in industrialised first world countries, where the incidence has doubled in the last decade. Older children and adolescents are particularly affected. Obese children are twice as likely to have a critical incident as obese adults and almost 10 times more likely than normal children. BMI (body mass index) widely used in adults has recently been adapted to define obesity in children. The Cole reference curves cater for the influence of age and gender on BMI. Obesity is the result of excessive caloric intake, low energy expenditure, extra-efficient calorie use or a combination of these factors. Only 5% of all obesity can be attributed to cerebral dysfunction, endocrine dysfunction or hereditary diseases. Syndromes such as Prader-Willi, Cushing’s, Frohlichs and Laurence-Moon-Biedl syndrome make up only 1% of all overweight children.

Obese children have a range of respiratory complications. These include a greater incidence of respiratory infections, greater frequency of exercise-induced bronchospasm, symptoms of severe asthma, sleep apnoea, and a reduction in all respiratory variables which may lead to ventilation perfusion mismatch and hypoxaemia (Pickwickian syndrome). A number of anatomical variables (fleshy cheeks, large tongue, copious folds of palatal, pharyngeal and supra-laryngeal tissue) may narrow the airway and contribute to difficult airway management and intubation.

Cardiovascular disease and atherosclerosis is not evident in childhood but hypertension is. Non-insulin-dependent diabetes is becoming more prevalent particularly in children with a family history of diabetes. Gastric emptying times in obese children are similar to normal children but gastro-oesophageal reflux may be seen in a minority of obese children. The risk of aspiration, however, is low.

**Organ (dys)function**

Abnormal or insufficient function of an organ system in dysmorphic children or those with a metabolic disorder may increase the anaesthetic related risks.

Disorders affecting the function central nervous dysfunction include mental retardation, dysautonomia, epilepsy, dysphagia and abnormal muscle tone. These may predispose to haemodynamic instability, elevated risk of aspiration, abnormal response to muscle relaxants.

Metabolic disorders affecting liver dysfunction may be prone to hypoglycaemia (glycogen storage disease), metabolic acidosis or clotting defects. Clotting abnormalities (Klippel Trenaunay-Weber syndrome) may contraindicate the use of regional techniques.

Cardiac defects may occur in isolation or part of a complex congenital disorder. Depending on the severity, cardiovascular dysfunction may lead to haemodynamic instability, arrhythmias, cardiac decompensation and inadequate tissue perfusion.

**Conclusion**

Many congenital anomalies are interrelated. The presence of one anomaly should prompt the anaesthesiologist to search for others - particularly those that may influence anaesthetic outcome. No child has ever benefited from being labelled a “funny looking kid”. Recognition of patterns will help to exclude the important life-threatening anomalies that can influence choice of anaesthetic and long-term outcome.

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