Specific Genetic Diseases at Risk for Sedation/Anesthesia Complications

Merlin G. Butler, MD, PhD, FACMG, Blaine G. Hayes, BS, Melanie M. Hathaway, BA, BS, and Michael L. Begleiter, MS, CGC

Section of Medical Genetics and Molecular Medicine, Children's Mercy Hospitals and Clinics, Kansas City, Missouri

We reviewed of a number of genetic diseases known or at risk for sedation or anesthesia complications. Some of these conditions are relatively common (e.g., Down's syndrome) whereas others are rare or present with multiple congenital anomalies that have an impact on health care delivery. We listed complications, recommended presedation evaluations, and included checklist items to assist the health care provider administering sedation and anesthesia. A better recognition and awareness of risk factors associated with specific genetic diseases should lessen the likelihood of complications during these procedures.

(Anesth Analg 2000;91:837–55)

Patients with common or uncommon genetic disorders, with or without multiple congenital anomalies, present unique challenges to the health care provider responsible for administering sedation and anesthesia during surgical or technical procedures. Patients affected with heritable diseases often have special health-related needs requiring attention before successful sedation or anesthesia. It is important for health care providers, including nurses and physicians treating these patients, to recognize risk factors and potential complications before sedation or anesthesia.

A brief description of potential problematic genetic disorders and associated complications is presented that may manifest during sedation or anesthesia. Recommendations for presedation evaluation and checklist items are given that may have an impact on the delivery of care for these patients. This review is not intended as a comprehensive survey of all genetic diseases with possible complications relating to anesthesia, but it does list specific conditions with known or potential risks for complications. In addition, specific recommendations are given to provide strategies to alleviate possible problems.

Accepted for publication June 9, 2000.

Address correspondence and reprint requests to Merlin G. Butler, MD, PhD, Section of Medical Genetics and Molecular Medicine, Children's Mercy Hospitals and Clinics, 2401 Gillham Rd., Kansas City, MO 64108. Address e-mail to mgbutler@cmh.edu.

Methods

The genetic diseases described in this report were chosen by five selection processes: 1) searching for potential risk factors (e.g., severe hypotonia, airway obstruction, vertebral anomalies) for sedation and/or anesthesia in the 15 most common genetic disorders from a Canadian population survey of genetic diseases reported by Baird et al. (1); this survey identified the most common genetic disorders in specific etiologic categories, including single gene (autosomal dominant, autosomal recessive, and X-linked), chromosomal and multifactorial; 2) by personal experience or verbal communication with health care providers from major medical centers providing care for patients with genetic conditions; 3) searching for potential risk factors for sedation and/or anesthesia in the ten most common genetic diseases referred for genetic services reported from a major medical center in the United States (2); 4) reviewing the most current edition of *Smith's Recognizable Patterns of Human Malformation* (3), a principle textbook used in the clinical practice of genetics, and identifying those diseases with features (e.g., anatomic airway obstruction) that may complicate sedation/anesthesia procedures; and 5) an online computer search of the medical literature by using Medline and other computer health databases searching for reported sedation/anesthesia complications in patients with genetic diseases. One hundred sixty-three conditions were identified and summarized in tabular form in this article.

0003-2999/00

Results

The results of this survey, including sedation and anesthesia considerations/complications for patients with selected genetic disorders, are summarized in Table 1, which is arranged alphabetically by disease. The disorder and its etiology are listed in Table 1. A brief description of each condition is given along with potential sedation and anesthesia complications. Recommendations for presedation evaluation are also given, and references are cited. Items that may have an impact on the delivery of care to the patient include a difficult airway as a result of upper or lower airway obstruction or defects (e.g., cleft lip/palate, small chin or mouth, macroglossia, choanal stenosis/atresia, tracheomalacia, tracheoesophageal fistula, craniofacial deformities); altered respiratory mechanisms caused by skeletal anomalies (e.g., small chest, rib, sternal, or vertebral anomalies); bronchopulmonary hypoplasia or altered respiratory drive; gastric reflux; cardiovascular disorder (arrhythmia or structural defect); neuromuscular problems (e.g., myotonia, muscular dystrophy or weakness; central nervous system defects); and liver and kidney disease. Comments are made regarding adverse effects of opioids, neuromuscular drugs and succinylcholine reported in the literature. Caution should be taken with the use of specific drugs in patients with liver disease (e.g., liver is the major site for biotransformation for most opioids) and at risk for decreased drug clearance. Adverse reactions to succinylcholine consist primarily of an extension of its pharmacological action and can cause prolonged muscle relaxation. Adverse reactions may include cardiac arrhythmias, malignant hyperthermia, hyper/hypotension, hyperkalemia, respiratory depression, muscle fasciculation and pain, joint rigidity, acute renal failure, excessive salivation, and rash. Therefore, patients with genetic conditions affecting certain organ systems (e.g., heart, liver, kidney) should be monitored more closely for these reactions. Drugs that may enhance the neuromuscular blocking action of succinylcholine should be noted, including several medications that may be prescribed for patients with genetic disorders. These may include nonpenicillin antibiotics, β-blockers, procainamide, lithium carbonate, glucocorticoids, metoclopromide, terbutaline, and monoamine oxidase inhibitors.

Discussion

This study gives a brief overview of potential sedation and anesthesia complications with recommendations for presedation evaluation that health care providers may encounter when administering anesthesia or sedation to patients with specific genetic disorders. Checklist items are given involving several major organ systems that have a direct impact on the administration of anesthesia or sedation for each genetic condition described. This review should allow the anesthesiologists to be alerted to potential risk factors and recommendations for presedation evaluation for each patient with the specific genetic condition listed. Special attention should be given to the checklist items (particularly liver and renal problems) when sedation/anesthetics are used that require normal liver function and renal clearance for optimal use and how the organ system involvement may have an impact on their drug selection and administration. Those patients with muscular dystrophies (e.g., Duchenne's), myotonic dystrophy, or central cord disease may be at risk for developing malignant hyperthermia. This listing is not intended to be a comprehensive review of all genetic diseases, but it focuses attention on conditions with known risk factors identified through personal experience/communication and a review of medical reports, textbooks, and surveys of rare and more common genetic conditions that may be encountered by the health care providers administering sedation or anesthesia.

The most prevalent concern is airway obstruction/defects and management issues followed by altered respiratory mechanisms (see Table 1). Careful intubation and close monitoring of the airway are necessary to guard against serious complications or obstructions in several diseases as a result of anatomic problems or neurologic impairment. Other major factors encountered are vertebral and rib abnormalities, craniofacial anomalies, and/or increased hyperextensibility caused by skeletal or connective tissue disorders. Proper positioning and supportive care of the patient's head during intubation and surgical or invasive procedures should prevent most spinal nerve injuries and possible paralysis in these patients. Hypertension is also noted as a risk factor for a number of genetic disorders, caused by metabolic conditions, adverse effects of anesthesia medications. or congenital anatomical problems (e.g., cardiovascular or renal). When dealing with hypertensive patients, the standard protocol of monitoring cardiovascular, renal, and pulmonary function on a continuing basis should be closely followed. In addition, possible adverse reactions to certain medications that may cause cardiac arrhythmias, rigidity, hypertension, prolonged sedation, acute renal failure, and respiratory distress must be monitored in patients with specific genetic diseases. As indicated in Table 1, several conditions with multiple organ system involvement may present with early death (e.g., trisomy 13 and 18).

The uncooperative patient can also be a challenge, specifically, those with mental deficiency, psychiatric diagnoses, or aberrant behavior. Special attention must be given to make the patient feel as comfortable

Table 1. Sedation and Anesthesia Considerations/Complications for Patients with Selected Genetic Disorders

				Checklist Items						
Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Aarskog Syndrome: X-linked recessive; FGDY1 gene mapped to Xp11.21	Growth and mental deficiencies, dental anomalies, mild pectus, hypertelorism, shawl scrotum, brachydactyly	Structural: Cleft lip/palate, cervical vertebral anomalies (including hypoplasia and synostosis of cervical vertebrae), cardiac and renal defects	Radiologic evaluation for vertebral anomalies; renal and cardiac evaluation	X	X		X			X
Achondrogenesis, Type I: autosomal recessive; mutations in sulfate transporter gene allelic to diastrophic dysplasia	Severe micromelia, incomplete ossification of lower spine, early lethal condition	Structural: Micrognathia, poorly ossified vertebral bodies, multiple rib anomalies	Radiologic evaluation for rib and vertebral anomalies	X	X					
Achondrogenesis II-Hypochondrogenesis Type II (Langer-Saldino Achondrogenesis, Hypochondrogenesis): sporadic; mutations of COL2A1 gene which codes for type II collagen	Extremely short stature, short limbs, large calvarium, short ribs, variable degrees of failure of ossification of lumbar spine, cervical spine, sacrum, ischial and pubic bones; early lethal condition	Structural: Cleft soft palate, micrognathia, failed ossification of lumbar and cervical spine Pulmonary: Severe hypoplasia	Radiologic evaluation for rib and vertebral anomalies; pulmonary evaluation	X	X					
Acrodysostosis: autosomal dominant	Growth and mental deficiencies, short hands with peripheral dysostosis, small nose	Structural: Vertebral defects (may collapse), spinal canal stenosis, nasal hypoplasia, pronathism, renal anomalies Neuro: Hydrocephalus	Radiologic evaluation for vertebral anomalies; neurologic and renal evaluations	X				X		X
Aicardi Syndrome: X-linked dominant; lethal in males	Structural brain anomalies including agenesis of corpus callosum, microcephaly, mental deficiency, optic nerve colobomata, rib anomalies	Structural: Hemivertebrae, butterfly and block vertebrae, cleft lip/palate Neuro: Infantile spasms, hypotonia Misc: Growth hormone and cortisol deficiencies	Radiologic evaluation for vertebral and CNS anomalies; check cortisol levels	X	X			X	X	
Achondroplasis: autosomal dominant; 90% from new mutation of FGFR3 gene at 4p16.3	Short-limbed dwarfism, retardation of endochondrial bone formation, low nasal bridge, spinal canal stenosis, hyperextensibility (3)	Structural: Diminished air entry in lungs, fine basal crepitations, anteriorly placed epiglottis, difficulty in intubation, lumbar lordosis, narrowing of spinal cord, small chest (11) Behavioral: Very high anxiety (11)	Radiologic evaluation of foramen ovale; preoxygenation before anesthesia, administration of oxygen after extubation; use of Sellick's maneuver to guard against regurgitation; avoid use of subarachnoid blockade in elderly patients (11)	X	X	X		X		
Alpha-Thalassemia/ Mental Retardation Syndrome: X-linked recessive	Severe mental retardation, characteristic face and genital abnormalities (3)	Structural: Large tongue, hemivertebra, renal agenesis Neuro: Lack of coordination, cerebral atrophy, seizures (12)	Radiologic evaluation for vertebral, CNS and renal anomalies; evaluate for upper airway obstruction or defects; check for anemia	X	X	X		X		X
Angelman Syndrome (Happy Puppet Syndrome): maternal 15q11-q13 deletion	"puppet-like" gait, mental retardation, seizures, brachycephaly, inappropriate laughter	Neuro: Hypotonia, seizures, electroencephalogram (EEG) abnormalities, ataxia	Maintain patient on anticonvulsant medication during perioperative period					X		
Antley-Bixler Syndrome: autosomal recessive	Craniosynostosis, choanal stenosis/atresia, radiohumeral synostosis (3)	Structural: Choanal atresia, multiple joint contractures, narrow chest, cardiac, renal and gastrointestinal defects, femoral fractures (13,14)	Evaluation for upper airway obstruction, apnea spells, cardiac, gastrointestinal and renal defects (14)	X	X	X	X			X
Apert Syndrome: autosomal dominant; FGFR2 gene mutation at 10q25	Irregular craniosynostosis, mid face hypoplasia, syndactyly with "mitten" hand (3)	Structural: narrow palate and airway, hypertelorism and proptosis, cleft palate, heart and kidney defects, abnormal tracheocartilage (48% of patients require tracheostomy) Neuro: agenesis of corpus callosum, ventriculomegaly, increased intracranial pressure (9,10)	Careful maintenance of airway, sleep studies in preoperative evaluation to rule out sleep apnea, keep patient in prone position, monitor patient's fluid levels (9,10)	X	X	X	X	X		X
Arteriohepatic Dysplasia (Alagille Syndrome): autosomal dominant; mapped to 20p12	Growth retardation, typical facies, chronic cholestasis, hypercholesterolemia, pulmonic stenosis	Structural: Butterfly and other vertebral anomalies, cardiac defects, cleft palate, abnormal hepatic ducts	Radiologic evaluation for vertebral anomalies; evaluate cardiac, liver and renal function	X			X		X	X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Atelosteogenesis, Type I (Giant Cell Chondrodysplasia): unknown; cases sporadic	Short stature, proximal shortness of limbs, absent fibula, markedly delayed ossification of proximal phalanges and middle phalanges, early lethal condition	Structural: Abnormally and fused cervical vertebrae, abnormal ribs, narrow chest, laryngeal stenosis, cleft palate	Radiologic evaluation for vertebral and rib anomalies	X	X					
Baller-Gerold Syndrome (Craniosynostosis-Radial Aplasia Syndrome): autosomal recessive	Craniosynostosis, radial aplasia, imperforate anus, mental retardation, growth failure (3)	Structural: Malformed limbs, microstomia, micrognathia, CNS, cardiac and renal defects, cleft palate, choanal stenosis, vertebral and rib anomalies, intracranial pressure (3,10)	Radiologic evaluation for vertebral and rib anomalies, evaluation for upper airway obstruction; evaluate neurologic, renal and cardiac function; spontaneous ventilation and PEEP may increase intracranial pressure	X	X		X	X		X
Bannayan-Riley-Ruvalcaba Syndrome (Cowden Syndrome): autosomal dominant, PTEN gene mutation at 10q23	Mental deficiency, macrocephaly, polyposis of colon, hamartomas, pigmentary changes of the penis	Structural: Joint hyperextensibility, pectus, tongue polyps, lipomas Neuro: Seizures, hypotonia, myopathy Misc: Rectal bleeding, adverse reaction to postoperative epidural buprenorphine analgesia (15)	Check for history of bleeding and carnitine levels; perform preoperative neuromuscular examination; evaluate for upper airway obstruction or defects	X	X			X		
Beckwith-Wiedemann Syndrome: sporadic dosage imbalance of gene locus at 11p15.5	Macroglossia, macrosomia, omphalocele, exomphalos, neonatal hypoglycemia, ear creases (3)	Structural: Macroglossia (airway obstruction), prognathism, organomegaly, cardiac, liver and renal defects, hemihypertrophy, diaphragmatic eventration Misc: Hypoglycemia, immunodeficiency (16)	Closely monitor glucose intraoperatively and evaluate for upper airway obstruction or defects (using awake vocal cord inspection before induction) (17) and cardiac, liver and renal function	X	X		X	X	X	X
Brachmann-de Lange Syndrome (Cornelia de Lange Syndrome): unknown; most cases sporadic	Growth and mental deficiencies, synophrys, thin downturning upper lip, hirsutism, micromelia	Structural: Micrognathia, malformed mandible, cleft palate, choanal atresia, cardiac and rib defects, malformed limbs, diaphragmatic hernia Neuro: Hypertonia, seizures, apnea, aspiration	Radiologic evaluation for rib defects and diaphragmatic hernia; evaluate for upper airway obstruction or defects and cardiac function	X	X	X	X	X		
Branchio-Oculo-Facial Syndrome: autosomal dominant	Branchial defects, lacrimal duct obstruction, pseudocleft of upper lip, mental and growth deficiencies	Structural: Micrognathia, incomplete and/or complete cleft lip, renal defects Neuro: Cerebellar vermis agenesis	Evaluate for upper airway obstruction or defects and neurologic and renal function	X				X		X
Campomelic Dysplasia: mutations in SOX9, a sex determining region Y (SRY) related gene located at 17q24	Growth deficiency, large brain with gross cellular disorganization, bowed tibiae, hypoplastic scapulae, flat facies, genital anomalies, early death	Structural: Cleft palate, micrognathia, flat cervical vertebrae, kyphoscoliosis, narrow chest, rib anomalies, tracheobronchiomalacia, cardiac and renal defects Misc: Apneic spells	Radiologic evaluation for vertebral and rib defects; evaluate for upper and lower airway obstructions or defects, cardiac and renal function	X	X		X	X		X
Carpenter Syndrome: autosomal recessive	Growth and mental deficiencies, polydactyly and syndactyly of feet, acrocephaly due to craniosynostosis, cardiovascular defects, umbilical hernia, omphalocele	Structural: Hypoplastic mandible, narrow palate, cardiac defects, short neck, hydronephrosis	Evaluate for upper airway obstruction or defects and cardiac function	X			X			X
Cat-eye Syndrome (Coloboma of Iris-Anal Atresia Syndrome): 22pter→q11 present in quadruplicate	Coloboma, down-slanting palpebral fissures, anal atresia, mental deficiency, renal agenesis	Structural: Micrognathia, cardiac and renal defects, biliary atresia, cleft palate	Evaluate for upper airway obstruction or defects and cardiac function	X			X		X	X
Catel-Manzke Syndrome: unknown; majority sporadic	Growth deficiency, hyperphalangy of index finger, micrognathia, cleft palate	Structural: Cleft palate, micrognathia, cardiac, rib or vertebral defects, short neck, pectus, joint laxity, Robin sequence Neuro: Seizures	Radiologic evaluation for vertebral or rib anomalies; evaluate for upper airway obstruction or defects and cardiac function	X	X		X	X		
Cerebro-Costo-Mandibular Syndrome: probable autosomal recessive	Rib-gap defect with small thorax, severe micrognathia, mental and growth deficiencies	Structural: Severe micrognathia with glossoptosis, cleft soft palate, rib or vertebral anomalies, cardiac, CNS, renal and rib defects, tracheal rings, small thorax	Radiologic evaluation for vertebral and rib anomalies; evaluate for upper and lower airway obstruction or defects and neurologic, cardiac and renal function	X	X		X	X		X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Cerebro-Oculo-Facio-Skeletal (COFS) Syndrome: autosomal recessive	Multiple brain abnormalities, microcephaly, hirsutism, neurogenic arthrogryposis, microphtalamia, early death	Structural: Micrognathia, kyphoscoliosis, CNS and renal defects Neuro: Hypotonia, hyporeflexia or areflexia, neurodegeneration, contractures	Evaluate for upper airway obstruction and neurologic and renal function	X	X			X		X
Cervico-Oculo-Acoustic Syndrome (Wildervanck Syndrome): unknown; sporadic	Craniofacial asymmetry, short neck, low hairline, eye anomalies, hearing loss	Structural: Klippel-Feil anomaly (fusion of cervical and possibly thoracic vertebrae), torticollis, renal defects, hydrocephaly	Radiologic evaluation for vertebral anomalies; evaluate for renal function and hydrocephaly	X	X			X		X
CHARGE/VATER Associations: unknown	Ocular Coloboma, *H*eart disease, choanal *A*tresia, tracheoesophageal fistula, vertebral anomalies, *R*etarded growth and development and/or CNS anomalies, *G*enital anomalies, *E*ar anomalies and deafness (3)	Structural: Choanal atresia, vertebral anomalies, tracheoesophageal fistula, cardiac and renal defects, micrognathia, cleft lip/palate Neuro: Multiple cranial nerve abnormalities (3,13)	Radiologic evaluation for vertebral anomalies; evaluate for upper and lower airway obstruction or defects and cardiac and renal function (3,13)	X	X	X	X	X		X
Chondrodysplasia Punctata: autosomal dominant, X-linked dominant or autosomal recessive	Slow growth, mental deficiency, flat facies, proximal shortening of humeri and femora, multiple joint contractures, punctate mineralization	Structural: Vertebral and thoracic cage anomalies, tracheal stenosis, cardiac defects	Radiologic evaluation for vertebral and thoracic cage anomalies; evaluate for cardiac and pulmonary function and tracheal defects	X	X	X	X			
Coffin-Siris Syndrome: possible autosomal recessive	Growth and mental deficiencies, hypoplastic to absent fifth finger and toenails, hirsutism with sparse scalp hair, coarse facies	Structural: Lax joints, choanal atresia, short sternum, cardiac, CNS and renal defects, cleft palate Neuro: Hypotonia	Radiologic evaluation for vertebral or chest anomalies; evaluate for cardiac, neurologic and renal function and upper airway obstruction or defects	X	X		X	X		X
Cohen Syndrome: autosomal recessive	Hypotonia, obesity, prominent incisors, mental deficiency, microcephaly, ocular defects, delayed puberty	Structural: Hyperextensible joints, mild scoliosis, mild micrognathia, prominent incisors, leukopenia, cardiac defects Neuro: Hypotonia, lack of cooperation	Evaluate for upper airway obstruction or defects and cardiac function	X			X	X		
Costello Syndrome: autosomal dominant; mostly sporadic	Growth and mental deficiencies, coarse face, macrocephaly, low-set ears, short neck, papillomas in the perioral, nasal, and anal regions	Structural: Nasal papillomas, hypertrophic cardiomyopathy, short neck Misc: Cerebral atrophy; gastrointestinal reflux	Evaluate for upper airway obstruction or defects and cardiac function	X	X	X	X	X		
Cystic Fibrosis: autosomal recessive	Progressive obstructive pulmonary disease and gastrointestinal tract malabsorption frequently accompanied by paranasal sinus disease (3)	Structural: Prolonged intubation increases risk of bleeding caused by vitamin K malabsorption and increased bronchial obstructions caused by pulmonary secretions (18)	Closely monitor patient's blood loss intraoperatively; baseline pulmonary function tests (18)	X	X					
Deletion 3p Syndrome: de novo 3p deletion, deletion of 3p25→pter	Growth and mental deficiencies, flat occiput, microcephaly, epicanthal folds, polydactyly, ptosis, prominent nasal bridge, malformed ears	Structural: Micrognathia, cardiac and renal defects, cleft palate Neuro: Hypotonia	Evaluate for upper airway obstruction or defects and cardiac and renal function	X				X		X
Deletion 4p Syndrome (Wolf-Hirschorn Syndrome): de novo 4p deletion	Growth and mental deficiencies, cranial asymmetry, strabismus, microcephaly, iris deformity, strabismus, hypertelorism, hypospadias, cryptorchidism	Structural: Cleft lip/palate, micrognathia, cardiac, CNS and renal anomalies, scoliosis Neuro: Hypotonia, seizures	Evaluate for upper airway obstruction or defects and cardiac, neurologic and renal function	X			X	X		X
Deletion 4q Syndrome: de novo 4q deletion, deletion of 4q31→qter	Growth and mental deficiencies, limb anomalies, cardiac defects, genitourinary defects, gastrointestinal defects	Structural: Cleft palate, short neck, micrognathia, rib, vertebral, CNS, renal and cardiac defects Neuro: Hypotonia, seizures, apnea	Radiologic evaluation for rib and vertebral anomalies; evaluate for upper airway obstruction or defects and neurologic, renal and cardiac function	X	X	X	X	X		X
Deletion 5p Syndrome: Cri du chat Syndrome	Growth and mental deficiencies, microcephaly, epicanthal folds, asymmetric round face, cardiac and ear anomalies, cat-like cry	Structural: Cleft lip/palate, short neck, renal, cardiac and vertebral defects, scoliosis Neuro: Hypotonia, flaccid vocal cords	Radiologic evaluation for vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac and renal function	X	X		X	X		X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Deletion 9p Syndrome: de novo 9p deletion, deletion of 9p22→pter	Mental deficiency, craniostenosis, up-slanting palpebral fissures, epicanthal folds, midface hypoplasia	Structural: Small mouth, cleft palate, micrognathia, cardiac, rib, vertebral and renal anomalies, short neck, choanal stenosis, diaphragmatic hernia, scoliosis	Radiologic evaluation for rib and vertebral anomalies; evaluate for upper airway obstruction or defects and renal and cardiac function	X	X		X	X		X
Deletion 11q Syndrome: 11q deletion, deletion of 11q23→qter; ring 11 chromosome	Mental and growth deficiency, large carp-shaped mouth, low-set malformed ears, joint contractures, trigonocephaly	Structural: Cardiac, CNS and renal defects, micrognathia, short neck, joint contractures Neuro: Hypotonia	Evaluate for upper airway obstruction or defects and neurologic, renal and cardiac function	X			X	X		X
Deletion 13q Syndrome: 13q deletion, ring 13 chromosome	Microcephaly, high nasal bridge, eye defects, growth and mental deficiencies, short webbed neck, limb defects	Structural: Micrognathia, CNS, renal and cardiac defects, short neck, narrow palate, facial asymmetry	Evaluate for upper airway obstruction or defects and neurologic, renal, and cardiac function	X			X	X		X
Deletion 18p Syndrome: 18p deletion, ring 18 chromosome	Growth and mental deficiencies, ptosis, epicanthal folds, large protruding ears	Structural: Cleft palate, micrognathia, cardiac, CNS, short neck, pectus, cardiac and CNS defects Neuro: Hypotonia	Evaluate for upper airway obstruction or defects and neurologic and cardiac function	X	X		X	X		
Developmental Delay/ Mental Retardation: multifactorial/single gene or chromosomal	Delay in mental capabilities and development (3)	Behavioral: Lack of cooperation Misc: Inadequate respiration, aspiration, depressed pharyngeal reflexes and apnea (12)	Frequent suctioning to control secretions, use of endotracheal tube with inflated cuff to maintain airway and avoid pulmonary complications; consider anticholinergic agents (12)	X	X			X		
Diastrophic Dysplasia (Diastrophic Nanism Syndrome): autosomal recessive; gene encodes a novel sulfate transporter; maps to distal long arm of chromosome 5	Disproportionate short stature, joint limitations, hypertrophied auricular cartilage	Structural: Cleft palate, micrognathia, hypoplasia of cervical vertebral bodies (spinal stenosis), kyphoscoliosis (in severe cases can lead to quadriplegia during anesthesia) (19), laryngotracheal stenosis	Radiologic evaluation for vertebral anomalies (spinal stenosis); evaluate for upper and lower airway obstruction or defects	X	X					
DiGeorge Sequence (Velo-Cardio-Facial Syndrome): partial monosomy of 22q11.2	Hypoplasia to aplasia of thymus and parathyroids, cardiac defects, ear anomalies, immunodeficiency, hypocalcemia	Structural: Micrognathia, cleft palate, CNS and cardiac defects, scoliosis, laryngeal web Neuro: Seizures, hypotonia	Evaluate for upper and lower airway obstruction or defects and neurologic and cardiac function; check calcium level and lymphocyte counts	X	X		X	X		
Distichiasis-Lymphedema Syndrome: autosomal dominant	Double row of eyelashes, lymphedema, vertebral anomalies, epidural cysts, short stature	Structural: Vertebral anomalies, cardiac defects, cleft palate, micrognathia, scoliosis	Radiologic evaluation for vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac function	X	X		X			
Down's Syndrome: trisomy 21	Mental deficiency, hypotonia, flat faces, cardiac defects, slanted palpebral fissures, small ears, hyper-extensibility (3)	Structural: Atlantoaxial instability, short neck, cardiac, intestinal, rib defects, hyperflexible, hypothyroidism (3) Neuro: Hypotonia, seizures	Radiologic evaluation for vertebral (atlanto-axial instability) and rib anomalies; evaluate for cardiac, intestinal and endocrine disorders (3)	X	X	X	X	X		
Dubowitz Syndrome: autosomal recessive	Growth and mental deficiencies, infantile eczema, microcephaly, ocular abnormalities	Structural: Micrognathia, submucous cleft palate, cardiac defect Neuro: Hypotonia, hyperactivity	Evaluate for upper airway obstruction or defects and cardiac function	X			X	X		
Duchenne's Muscular Dystrophy: X-linked recessive; affects males	Inability to walk, thoracolumbar scoliosis and cardiopulmonary failure due to deficiency in the protein dystrophin (3)	Misc: Extensive blood loss, dural leak, hypovolemic arrest, pneumothorax and cerebrovascular accident (20); may have spinal fusion	Use of hypotensive anesthesia may reduce blood loss and need for massive transfusion (20); evaluate for cardiac, renal and pulmonary function; avoid succinylcholine (malignant hyperthermia)	X	X			X		
Duplication 15q Syndrome: 15q21-15q23 duplication	Growth and mental deficiencies, prominent nose, broad nasal bridge, camptodactyly, cardiac defects	Structural: Micrognathia, scoliosis, vertebral anomalies, cardiac defects, pectus, short neck	Radiologic evaluation for vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac function	X	X		X			

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Duplication 3q Syndrome: 3q21→qter duplication	Mental and growth deficiencies, high arched palate, broad nasal root, craniosynostosis, hypertrichosis, cardiac and renal defects, limb anomalies	Structural: Cleft palate, micrognathia, cardiac, CNS and renal defects, short webbed neck, chest deformities, hemivertebrae Neuro: Seizures	Radiologic evaluation for hemivertebrae and chest deformities; evaluate for upper airway obstruction or defects and cardiac, CNS and renal function	X	X		X	X		X
Duplication 4p Syndrome: 4p15.2→16.1 duplication	Growth and mental deficiencies, enlarged ears, microcephaly, macroglossia, flat nasal bridge, kyphoscoliosis, genital anomalies	Structural: Small pointed mandible, cardiac, CNS, vertebral and renal defects, macroglossia, kyphoscoliosis, cleft lip, short neck Neuro: Hypertonia in infancy followed by hypotonia, seizures	Radiologic evaluation for vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac, CNS and renal function	X	X		X	X		X
Duplication 10q Syndrome: 10q24→qter duplication	Ptosis, short palpebral fissures, camptodactyly, mental deficiency, microcephaly, renal anomalies	Structural: Cleft palate, cardiac, rib, vertebral and renal defects, pectus, kyphoscoliosis	Radiologic evaluation for rib and vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac and renal function	X	X		X	X		X
Dyggve-Melchior-Clausen Syndrome: autosomal recessive	Growth and mental deficiencies, coarse facies, dislocated hips, irregularly calcified iliac crests	Structural: Flattened vertebrae, ossification defects, scoliosis, kyphosis, short neck, odontoid hypoplasia, barrel chest, short limbs	Radiologic evaluation for vertebral anomalies and ossification defects	X	X					
Ectodermal Dysplasia (Hypohydrotic Ectodermal Dysplasia Syndrome): usually X-linked recessive	Defects in sweating, alopecia, hypodontia	Structural: Absent sweat and mucous glands, absent tears Misc: Hyperthermia, asthma, rhinitis, aspiration	Evaluate for upper airway obstruction or defects and respiratory complications; temperature instability	X	X	X				
Ectrodactyly-Ectodermal Dysplasia-Clefting Syndrome (EEC Syndrome): autosomal dominant; variable expression	Ectrodactyly, ectodermal dysplasia, cleft lip/palate, microdontia	Structural: Cleft lip/palate, renal and CNS defects, choanal atresia	Evaluate for upper airway obstruction or defects and CNS and renal function	X	X			X		X
Ehlers-Danlos Syndrome (several types): autosomal dominant, autosomal recessive; X-linked recessive	Hyperextensibility of joints and skin and poor wound healing with thin scar (3)	Structural: Unpredictable hypertensive and spinal responses to tracheal intubation and extubation (21,22) Misc: Arterial rupture during general anesthesia, failure to achieve haemostasis, vascular rupture, sympathetic block and bleeding diathesis (21,22)	Avoid increases in arterial pressure by the use of β-blockers slow controlled induction, intubation, and extubation (21,22); evaluate cardiovascular system prior to sedation/anesthesia	X	X		X			
Epilepsy: multifactorial	Convulsive seizures, chronic focal seizures, reduced mental activity (3)	Seizure activity (23)	Extraoperative electrocorticography and video monitoring to localize focus of seizure and the sensorimotor region, may avoid general anesthesia (23)					X		
Escobar Syndrome (Multiple Pterygium Syndrome): autosomal recessive	Multiple pterygia, syndactyly, small stature, camptodactyly	Structural: Difficulty opening mouth, micrognathia, cleft palate, cardiac defect, fusion of abnormal vertebrae, neck pterygium, rib anomalies, joint dislocations, scoliosis, kyphosis, apnea	Radiologic evaluation for rib, vertebral and joint anomalies; evaluation for upper airway obstruction or defects and cardiac function	X	X		X			
Esophageal Atresia: can be a component of trisomy 18, VATER association, isolated malformation	Esophageal atresia and/or tracheoesophageal fistula (3)	Structural: Pulmonary defect, anastomotic leak, refistula, hyperbilirubinemia, sclerema and intracranial hemorrhage or lesion (24)	Primary anastomosis within a few hours after birth, single-layer end-to-end anastomosis via transpleural route; preoperative advice—do not mobilize lower segment or use gastrostomy on patients with distal fistula (24)	X	X	X				
Femoral Hypoplasia-Unusual Facies Syndrome: unknown; majority sporadic	Asymmetrical femoral hypoplasia, short nose, polycystic kidneys, cleft palate	Structural: Cleft palate, micrognathia, missing vertebrae and/or hemivertebrae, sacralization of lumbar vertebrae, scoliosis, limited joint movement, renal, rib and cardiac defects	Radiologic evaluation for rib and vertebral anomalies; evaluate for upper airway obstruction or defects and renal and cardiac function	X	X		X			X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Fetal Aminopterin/ Methotrexate Syndrome: prenatal aminopterin and/or methotrexate exposure	Prenatal onset growth deficiency, broad nasal bridge, cranial dysplasia, low set ears	Structural: Micrognathia, underdeveloped facial bones, cleft palate, rib and cardiac defects	Radiologic evaluation of facial bones and rib defects; evaluate for upper airway obstruction or defects and cardiac function	X	X		X			
Fetal Hydantoin Syndrome (Fetal Dilantin Syndrome): prenatal phenytoin (Dilantin) exposure or one of its metabolites	Growth and mental deficiencies, rib anomalies, hernias, nail hypoplasia	Structural: Cleft lip/palate, short neck, rib, CNS, cardiac, renal and gastrointestinal defects	Radiologic evaluation for rib defects; evaluate for upper airway obstruction or defects and cardiac, neurologic, renal and gastrointestinal function	X	X	X	X	X		X
Fetal Trimethadione Syndrome (Tridione Syndrome): prenatal trimethadione and paramethadione exposure	Growth and mental deficiencies, speech disorders, ambiguous genitalia	Structural: Cleft lip/palate, micrognathia, cardiac and renal defects, scoliosis	Evaluate for upper airway obstruction or defects and cardiac and renal function	X			X			X
Fetal Valproate Syndrome: prenatal valproic acid exposure	High forehead, midface hypoplasia, cardiac defects, meningomyelocele	Structural: Cleft lip, cardiac defects, small mouth, neural tube defect, bifid ribs, small chest	Radiologic evaluation for rib defects; evaluate for upper airway obstruction or defects and cardiac and pulmonary function	X	X		X	X		
Fibrochondrogenesis: probable autosomal recessive	Short stature, rhizomelic shortening of limbs, camptodactyly, omphalocele, early death	Structural: Cleft palate, flattened and hypoplastic vertebrae, sagittal midline cleft, short neck	Radiologic evaluation of vertebral anomalies; evaluate for upper airway obstruction or defects	X	X					
Fibrodysplasia Ossificans Progressiva Syndrome: autosomal dominant	Short hallux, fibrous dysplasia, progressive ossification in muscles, joints and subcutaneous tissues	Structural: Progressive cervical vertebral spine fusion, scoliosis, cardiac conduction abnormalities; ossification causes restrictive pulmonary disease and difficulties with tracheal intubation, jaw ankylosis following soft tissue trauma and/or local dental anesthetics (25)	Radiologic evaluation for vertebral anomalies (cervical spine instability) and tissue ossification; evaluate for upper and lower airway obstruction or defects; monitor for cardiac conduction problems and pulmonary function	X	X		X			
Fragile X Syndrome: X-linked gene at Xq27.3	Mental deficiency, large prominent ears, macroorchidism, hyperextensible joints, high arched palate, mitral valve prolapse (12,26)	Structural: High arched palate, prognathism, pectus, scoliosis, torticollis, mitral valve prolapse (12,26) Neuro/Behavioral: Lack of cooperation, autism, hypotonia (12,26) Misc: Cardiac arrhythmias (possibly tachycardia) (26)	Carefully monitor cardiac status and consider sedation to manage uncooperativeness; evaluate for upper airway obstruction or defects	X			X	X		
Freeman-Sheldon Syndrome: autosomal dominant	"Whistling" facies, deep-set eyes, H-shaped cutaneous dimpling on chin, ulnar deviation of hands, contractures	Structural: Small mouth with whistling appearance, high palate, kyphoscoliosis Misc: Muscle rigidity following halothane anesthesia; risk for aspiration, malignant hyperthermia and seizures	Evaluate for upper airway obstruction or defects	X	X	X		X		
Frontonasal Dysplasia Sequence (Median Cleft Face Syndrome): unknown; generally sporadic	Defect in midfacial development (notched broad nasal tip or completely divided nostrils), median cleft lip, hypertelorism	Structural: Cleft lip, varying defects in structure of the nose, CNS and cardiac defects	Evaluate for upper airway obstruction or defects and neurologic and cardiac function	X			X	X		
Frontometaphyseal Dysplasia: X-linked	Prominent supraorbital ridges, coarse facies, joint limitations, progressive hearing loss, muscle atrophy; splayed metaphyses	Structural: Small mandible, cervical vertebral anomalies, high palate, chest wall deformities, scoliosis, cardiac defects, subglottic stenosis, obstructive uropathy	Radiologic evaluation for vertebral anomalies and chest deformities; evaluate for upper and lower airway obstruction or defects and cardiac function	X	X		X	X		X
Fryns Syndrome: autosomal recessive	Diaphragmatic defects, coarse facies, genital tract anomalies, brain malformation, early death	Structural: Cleft lip/palate, micrognathia, abnormal lung lobations; diaphragmatic defects, genital tract, renal, gastrointestinal, cardiac abnormalities	Radiologic evaluation for diaphragmatic defects and gastrointestinal anomalies; evaluate for upper and lower airway obstruction defects, pulmonary function, genital tract and cardiac function	X	X	X	X	X		X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Goldenhar Syndrome/ Oculoauriculovertebral Dysplasia (Hemifacial Microsomia): unknown; usually sporadic	First and second branchial arch defects, oculoauriculo-vertebral dysplasia, hemifacial microsomia and cardiac defects (3)	Structural: Mandibular hypoplasia, craniovertebral anomalies, cleft lip/palate, cardiac and pulmonary complications, renal, CNS defects, laryngeal anomaly, lung hypoplasia (27)	Radiologic evaluation for mandibular deformity and craniovertebral anomalies; evaluate for upper and lower airway obstruction or defects, pulmonary function, laryngeal, renal, cardiac and neurologic function; omit premedication and use anticholinergics in small doses; keep patient spontaneously breathing before intubation; use a nasopharyngeal technique to maintain open airway to avoid intubation problems; IV induction agents such as ketamine or thiopentone is preferable to gaseous induction (27)	X	X		X	X		X
Gorlin Syndrome (Nevoid Basal Cell Carcinoma Syndrome): autosomal dominant; gene at 9q23.1-q31	Basal cell carcinomas, rib anomalies, epidermal cysts, punctate dyskeratotic pits on palms and soles	Structural: Thoracic or cervical vertebral anomalies, prognathism, jaw cysts, scoliosis, ectopic calcifications, CNS and renal defects, cleft lip/palate, pectus	Radiologic evaluation for ribs and vertebral anomalies and ectopic calcifications of bones and CNS structures; evaluate for upper airway obstruction or defects and neurologic and renal function	X	X			X		X
Hajdu-Cheney Syndrome (Cheney Syndrome, Acroosteolysis Syndrome, ArthroDento-Osteo Dysplasia): autosomal dominant; usually sporadic	Small stature, wormian bones, failure of suture ossification, hydrocephalus, resorption of bones	Structural: Small mandible, biconcave vertebrae, cervical instability, lax joints; bone resorption, impaction of cerebellum into foramen magnum, early loss of teeth, osteopenia with fractures, short neck, small mouth	Radiologic evaluation for vertebral anomalies, fractures, osteolysis and basilar compression; evaluate for upper and lower airway obstruction or defects and hydrocephalus	X	X			X		
Hallermann-Streiff Syndrome (Oculomandibulo-dyscephaly with Hypotrichosis Syndrome): unknown; sporadic	Proportionate short stature, microphthalmia, wormian bones, small pinched nose, dental anomalies, skin atrophy	Structural: Anterior displacement of the temporomandibular joint, micrognathia, high arched palate, neonatal teeth, thin ribs, tracheomalacia, scoliosis Neuro: Mental deficiency, seizures, obstructive sleep apnea, difficult intubation	Radiologic evaluation for facial bones and rib anomalies; evaluate for upper and lower airway obstruction and defects	X	X			X		
Hay-Wells Syndrome of Ectodermal Dysplasia (Ankyloblepharon-Ectodermal Dysplasia-Clefting Syndrome): autosomal dominant	Ankyloblepharon, ectodermal dysplasia, cleft lip/palate, partial deficiency of sweat glands, hypodontia	Structural: Cleft lip/palate; deficiency of sweat glands, deafness, cardiac defects	Evaluate for upper airway obstruction or defects and temperature instability	X			X			
Hecht Syndrome (Trismus Pseudocamptodactyly Syndrome): autosomal dominant	Shortened muscle group, trismus tendon and ligament anomalies	Structural: Limited opening of the mouth, difficult intubation	Evaluate for upper airway obstruction or defects	X						
Hydrolethalus Syndrome: autosomal recessive	Hydrocephalus, micrognathia, polydactyly, genital anomalies, early death	Structural: Cleft in the base of the skull, micrognathia, cleft lip/palate, cardiac and neurologic defects, defective lung lobation, stenotic trachea and bronchi, abnormal tongue	Evaluate for upper and lower airway obstruction or defects, cardiac, neurologic and pulmonary function	X	X		X	X		
Hypomelanosis of Ito (Incontinentia Pigmentosa Achromians): heterogeneous	Mental deficiency, short stature, seizures, macrocephaly, coarse facies, diffuse alopecia, digital anomalies, pigmentary changes	Structural: Cleft lip/palate, kyphoscoliosis	Evaluate for upper airway obstruction or defects	X				X		
Hypophosphatasia (Perinatal Lethal Hypophosphatasia): autosomal recessive; gene mapped to 1p36.1-p34	Short limb dwarfism, generalized lack of ossification, poorly mineralized cranium, hypoplastic fragile bones	Structural: Vertebral abnormalities, fragile bones	Radiologic evaluation for vertebral anomalies, poor ossification	X	X					

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Jarcho-Levin Syndrome (Spondylothoracic Dysplasia): autosomal recessive	Short trunk dwarfism, prominent occiput, crab-like rib cage, protuberant abdomen	Structural: Multiple rib and vertebral defects, short neck, kyphoscoliosis, cleft palate, hydronephrosis, CNS defects	Radiologic evaluation for ribs and vertebral anomalies; evaluate for upper airway obstruction or defects and neurologic function	X	X			X		
Jeune Thoracic Dystrophy (Asphyxiating Thoracic Dystrophy): autosomal recessive	Small thorax, short limbs, hypoplastic iliac wings, early death	Structural: Lung hypoplasia, short ribs, thoracic defects, renal cystic tubular dysplasia, biliary dysgenesis and fibrosis, situs inversus, pulmonary hypertension (28)	Radiologic evaluation for ribs and chest anomalies (situs inversus); evaluate for liver, cardiovascular, renal and pulmonary function	X	X		X		X	X
Johanson-Blizzard Syndrome: autosomal recessive	Growth and mental deficiencies, hypoplastic alae nasi, pancreatic insufficiency, hypothyroidism	Structural: Hypoplastic to aplastic alae nasi, nasolacrimal duct cutaneous fistulae, rectoureteral fistula, cardiac defects, situs inversus Neuro: Hypotonia, deafness	Radiologic evaluation for fistulas and situs inversus	X	X		X			
Kabuki Make-Up Syndrome: sporadic	Growth and mental deficiency, long palpebral fissures, epicanthal folds, tooth abnormalities	Structural: Cleft palate, scoliosis, cardiac and urogenital defects, joint hyperextensibility, sagittal cleft of vertebral body, pectus, diaphragmatic eventration Neuro: Hypotonia, seizures	Radiologic evaluation for vertebral defects; evaluate for upper airway obstruction or defects and cardiac function	X	X		X	X		
Klippel-Feil Sequence: sporadic	Short neck, low hairline, cervical vertebral fusion	Structural: Rib and vertebral anomalies, cardiac and renal defects, cleft palate, scoliosis, deafness, torticollis, unstable short neck	Radiologic evaluation for rib and vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac and renal function	X	X		X			X
Langer-Giedion Syndrome (Tricho-Rhino-Phalangeal syndrome, Type II; TRP II): deletion of 8q24.11-q24.13	Multiple exostoses, mild growth and mental deficiencies, hearing loss, delayed speech, microcephaly, redundant skin, bulbous nose	Structural: Recessed mandible, vertebral segmentation defects, scoliosis, lax joints, multiple exostoses, thin ribs, cardiac defects Neuro: Seizures	Radiologic evaluation for vertebral and rib anomalies; evaluate for upper airway obstruction or defects and cardiac function	X	X		X	X		
Langer Mesomelic Dysplasia: autosomal dominant	Mesomelic dwarfism, rudimentary fibula, micrognathia	Structural: Small mandible	Evaluate for upper airway obstruction or defects	X	X					
Larsen Syndrome: autosomal dominant	Multiple joint dislocations, flat facies, spina bifida, scoliosis, tracheomalacia, short fingernails	Structural: Cleft palate, hypoplastic cervical vertebrae, wedged vertebrae, anomalies of the thoracic, lumbar and sacral spine, multiple dislocations, hearing loss, cardiac defect, tracheo and bronchiomalacia or stenosis, mobile arytenoid cartilage (maintain adequate airway)	Radiologic evaluation for vertebral anomalies; evaluate for upper and lower airway obstruction or defects and cardiac and pulmonary function	X	X		X			
Lenz-Majewski Hyperostosis Syndrome: unknown; sporadic	Failure to thrive, mental deficiency, dense/thick bone, hypotrophic skin, symphalangism, early death	Structural: Choanal stenosis or atresia, nasolacrimal duct stenosis, thick ribs (thoracic immobility), micrognathia, contractures Neuro: Cerebral atrophy	Radiologic evaluation for rib anomalies; evaluate for upper airway obstruction or defects and neurologic and pulmonary function	X	X			X		
Marden-Walker Syndrome: autosomal recessive	Joint contractures, growth and mental deficiencies, immobile facies, decreased muscle mass, blepharophimosis	Structural: Cleft palate, micrognathia, small mouth, multiple joint contractures, scoliosis, pectus, CNS defects, hypoplastic lung Neuro: Hypotonia, seizures	Radiologic evaluation for vertebral anomalies and joint contractures; evaluate for upper airway obstruction or defects and neurologic, renal, cardiac and pulmonary function	X	X		X	X		X
Marfan Syndrome: autosomal dominant	Tall stature, arachnodactyly with hyperextensibility, lens subluxation, aortic dilatation	Structural: Hypertensive cardiovascular response to intubation and surgery, aortic incompetence caused by uncontrolled hypertension (increased pulsatile shear stress on the aortic wall—use β-blockers) (22,29,30), mitral valve prolapse, diaphragmatic hernia, pneumothorax, cleft palate, scoliosis, hyperextensibility	Evaluate for upper airway obstruction or defects and cardiovascular and pulmonary function	X	X		X			

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Marshall-Smith Syndrome: unknown, mostly sporadic	Accelerated growth and maturation, underweight, motor and mental deficiencies, shallow orbits, broad middle phalanges	Structural: Small mandibular ramus, choanal atresia, obstructing tongue, spinal stenosis (craniocervical instability), rudimentary epiglottis, laryngomalacia, pulmonary hypertension, short sternum Neuro: Hypotonia, deafness, cerebral atrophy	Radiologic evaluation for accelerated bone age; evaluate for upper and lower airway obstruction or defects and neurologic and pulmonary function; muscle relaxants should be avoided before intubation (3)	X	X			X		
Maternal PKU Effects: excess phenylalanine in utero	Mental and growth deficiencies, increased muscle tone, pigeon-toed gait, microcephaly	Structural: Mandible hypoplasia, cardiac defects	Evaluate for upper airway obstruction defects and cardiac function	X			X	X		
Meckel-Gruber Syndrome (Dysencephalia Splanchnocystica): autosomal recessive; mapped to 17q21-q24	Encephalocele, polydactyly, growth deficiency, cystic dysplasia of kidneys, genital anomalies, early death	Structural: Cleft lip/palate, micrognathia, CNS, cardiac and renal defects, short neck, bile duct anomalies, lobulated tongue, cleft of epiglottis, lung hypoplasia, intestinal malrotation	Radiologic evaluation of skull defects; evaluate for upper and lower airway obstruction or defects and cardiac, renal and pulmonary function	X	X		X	X	X	X
Melnick-Needles Syndrome: X-linked dominant	Prominent eyes, bowing of long bones, small facies, short upper arms and distal phalanges, ribbon-like bones	Structural: Small mandible, small chest, rib and vertebral defects, mitral valve prolapse, kyphoscoliosis, hydronephrosis, cleft palate, pulmonary hypertension Neuro: Hypotonia	Radiologic evaluation for rib and vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac, renal and pulmonary function	X	X		X	X		X
Menkes Syndrome: X-linked recessive, mapped to Xq13	Progressive cerebral deterioration with seizures, twisted and fractured hair, copper deficiency, death usually by 3 yr (4)	Structural: Wormian bones, metaphysis widening, gastric polyps associated with bleeding, tortuous vessels, fragile bones Neuro: Hypertonia, seizures	Observe for intracranial hemorrhage and seizures (31); radiologic evaluation for bone fractures	X	X	X		X		
Metaphyseal Dysplasia, Jansen Type (Metaphyseal Dysostosis, Jansen Type): autosomal dominant	Severe short stature, wide irregular metaphyses, flexion deformities of joints, hypercalcemia, small thorax	Structural: Micrognathia, delayed ossification, small chest, flexion deformities of major joints, deafness	Radiologic evaluation for ossification problems and joint defects; evaluate for upper airway obstruction or defects and pulmonary function	X	X					
Miller Syndrome (Postaxial Acrofacial Dysostosis Syndrome): autosomal recessive	Eye lid colobomas, malar hypoplasia, hypoplastic ears, limb deficiency, especially postaxial	Structural: Cleft lip/palate, micrognathia, choanal atresia, pectus, rib, vertebral, cardiac, renal and intestinal defects, absence of hemidiaphragm	Radiologic evaluation for rib or vertebral anomalies and absence of hemidiaphragm; evaluate for upper airway obstruction or defects and cardiac, renal and intestinal problems	X	X	X	X			X
Miller-Dieker Syndrome (Lissencephaly Syndrome): 17p13.3 deletion; LIS-1 gene	Incomplete development of the brain, failure to thrive, microcephaly, mental deficiency, early death	Structural: Micrognathia, cleft palate Neuro: Hypotonia, seizures, feeding difficulties	Evaluate for upper airway obstruction and cardiac and renal function	X		X	X	X		X
Moebius Sequence: sporadic	Sixth and seventh nerve palsy, limb reduction defects, syndactyly	Structural: Micrognathia, vertebral anomalies Neuro: Feeding difficulties, aspiration	Radiologic evaluation for vertebral anomalies; use of antisialogogue premedications recommended	X	X	X		X		
Mohr Syndrome (OFD Syndrome, Type II): autosomal recessive	Cleft tongue, conductive deafness, polydactyly, partial reduplication of hallux and first metatarsal	Structural: Cleft lip/palate, mandible hypoplasia, cleft of tongue, pectus, scoliosis, hydrocephaly	Evaluate for upper airway obstruction or defects	X				X		
Mucopolysaccharidoses: Hunter, Hurler, Hurler-Scheie, Scheie, Morquio, Maroteaux Lamy and Sanfilippo: Hunter: X-linked recessive. The remaining syndromes: autosomal recessive	Mucopolysaccharide storage in tissues and organs, coarse features, growth deficiencies, urinary excretion of Dermatan Sulfate, Heparan Sulfate and Chondroitan Sulfate (3)	Structural: Narrowing of nasopharynx, obstruction of airway, deposition of mucopolysaccharides in coronary arteries and heart valves (32) and cardiac instability (33) Metabolic: Postoperative hypoglycemia upon treatment with propranolol (33) Misc: Patients may have excessive oral secretions (34–36)	Use inhalational induction, anticholinergic preoperatively (use of atropine to control excessive secretion complications), monitor patient with ECG watch for postoperative pallor, sweating and tachycardia to avoid metabolic complications (33–36)	X	X	X	X	X	X	X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Multiple Neuroma Syndrome (Multiple Endocrine Neoplasia, Type 2b): autosomal dominant; mapped to 10q11.2; RET proto-oncogene	Tall stature, multiple neuromata of tongue and lips, ganglioneuromatosis, medullary thyroid carcinoma, pheochromocytoma	Structural: Joint laxity, kyphosis, scoliosis, lordosis, mucosal neuromas Neuro: Hypotonia	Evaluate for upper airway obstruction and tumor surveillance (laboratory values and endocrinology work-up to rule out pheochromocytoma)	X				X		
Multiple Pterygium Syndrome (Escobar Syndrome): autosomal recessive	Growth deficiency, multiple pterygia anomalies, syndactyly, camptodactyly	Structural: Cleft palate, micrognathia, small mouth, tongue adhesions, scoliosis, small chest, vertebral and rib anomalies with limited neck extension, diaphragmatic hernia, cardiac defects, apnea, malignant hyperthermia (37)	Radiologic evaluation for rib and vertebral anomalies and diaphragmatic hernia; evaluate for upper airway obstruction or defects and cardiac and pulmonary function	X	X		X			
Multiple Synostosis Syndrome (Symphalangism Syndrome): autosomal dominant	Progressive symphalangism, hypoplasia of alae nasi, deafness	Structural: Hypoplastic nasal septum, fusion of the nasal bone and the frontal process of the maxilla, vertebral anomalies, pectus	Radiologic evaluation for vertebral anomalies and facial bones; evaluate for upper airway obstruction or defects	X	X					
MURCS Association: unknown; sporadic	Small stature, Müllerian duct anomalies, renal and cervicothoracic vertebral defects	Structural: Vertebral and rib anomalies, renal defects, limb defects, cleft lip/palate, micrognathia	Radiologic evaluation for rib or vertebral anomalies; evaluate for upper airway obstruction or defects and renal function	X	X					X
Nager Syndrome (Nager Acrofacial Dysostosis Syndrome): sporadic	Malar hypoplasia, radial limb hypoplasia, ear defects	Structural: Cleft palate, severe micrognathia, microstomia, radioulnar synostosis, larynx or epiglottis hypoplasia, vertebral anomalies, hydrocephaly, feeding difficulties	Radiologic evaluation for vertebral anomalies and synostosis; evaluate for upper and lower airway obstruction or defects	X	X			X		
Neu-Laxova Syndrome: autosomal recessive	Microcephaly/ lissencephaly, canine facies with exophthalmos, syndactyly with subcutaneous edema, early death	Structural: Micrognathia, CNS, renal and cardiac defects, flattened nose, short neck, cleft lip/palate	Evaluate for upper airway obstruction or defects and renal and cardiac function	X			X	X		X
Neurofibromatosis (von Recklinghausen disease): autosomal dominant	Multiple neurofibromas and café-au-lait spots with or without bone lesions (3)	Structural: phaeochromocytoma, laryngeal involvement and obstruction to the outflow of right ventricle (38) Metabolic: Exaggerated responses to muscle relaxants with prolonged response to tubocurarine, suxamethonium combined with tacrine, and suxamethonium and pancuronium (38) Misc: Multiple organ involvement, severe kyphoscoliosis, mental retardation, lung cysts, renal artery dysplasia with hypertension, bone cysts, pulsating exophthalmos, sarcomatous changes, spinal nerve compression, laryngeal stenosis (39)	Careful preoperative assessment before general anesthesia or regional block, monitor neuromuscular function throughout surgery, patient may be sensitive or resistant to succinylcholine; evaluate for upper airway obstruction or defects (38,39)	X	X		X	X		
Noonan Syndrome: autosomal dominant	Short stature, webbing of the neck, pectus excavatum, deafness, cryptorchidism and pulmonic stenosis (3)	Structural: Pulmonic stenosis, micrognathia, pectus, vertebral anomalies, cardiac defects, lymphedema, cervical ribs, chylothorax (40)	Spinal analgesia with narcotic may provide cardiovascular stability and renally excreted drugs may be affected (40); at risk for malignant hyperthermia and bleeding diathesis	X	X		X	X		
Oculo-Auriculo-Vertebral Spectrum (First and Second Branchial Arch Syndrome, Hemifacial Microsomia, Goldenhar Syndrome): unknown; usually sporadic	Hypoplasia of malar, maxillary, and/or mandibular region; microtia, variable deafness, vertebral and oral anomalies	Structural: Mandibular hypoplasia, vertebral anomalies, facial asymmetry, cleft lip/palate, CNS, cardiac and renal defects, laryngeal anomaly, lung hypoplasia	Radiologic evaluation for vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac, renal and pulmonary function	X	X		X	X		X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Opitz Syndrome (Opitz-Frias Syndrome; G Syndrome): autosomal dominant, 22q11.2 deletion also reported	Hypertelorism, hypospadias, swallowing difficulties, recurrent aspiration and intermittent pulmonary difficulty (3)	Structural: Cleft lip/palate, micrognathia, cleft tongue, CNS, laryngoesophageal, cardiac and renal defects, lung hypoplasia Misc: General anesthesia or anticholinesterase reversal of neuromuscular block may aggravate muscular weakness or induce myotonic episodes. Rigidity may be evident in the absence of succinylcholine administration. May have recurrent pulmonary aspiration; feeding difficulties, stridor (41)	Avoid use of halothane with succinylcholine, monitor patient to avoid recurrent pulmonary aspiration (41); evaluate for upper and lower airway obstruction or defects and cardiac, renal and pulmonary function	X	X	X	X	X		X
Oral-Facial-Digital Syndrome (OFD Syndrome, Type I): X-linked dominant; may be lethal in males	Oral frenula and clefts, digital asymmetry, hypoplasia of alae nasi	Structural: Cleft lip/palate, oral clefts, hypoplastic mandible lobulated tongue, CNS defects and cystic kidneys, choanal atresia	Evaluate for upper airway obstruction or defects and renal function	X	X					X
Oromandibular-Limb Hypogenesis Spectrum (Hypoglossia-Hypodactyly Syndrome, Aglossia-Adactyly Syndrome, Facial-Limb Disruptive Spectrum): unknown; usually sporadic	Limb deficiency, hypoglossia, micrognathia, tongue anomalies, brain defects	Structural: Small mouth, micrognathia, oral clefts, CNS defects Neuro: Feeding difficulties, hyperthermia episodes	Radiologic evaluation for limb defects; evaluate for upper airway obstruction or defects and neurologic impairment	X	X			X		
Osteogenesis Imperfecta Syndrome, Type I (Autosomal Dominant Osteogenesis Imperfecta): autosomal dominant; mutation of type I collagen	Growth deficiency, dental anomalies, fragile bones, blue sclerae, easy bruising, hearing loss, hyperextensibility	Structural: Hyperextensible joints, fragile bones, scoliosis, wormian cranial bones, mitral valve prolapse	Careful placement of patient so as not to damage the spine or cranium or break fragile bones; radiologic evaluation of skeleton for fractures; evaluate for cardiac function	X	X		X			
Osteogenesis Imperfecta Syndrome, Type II (Osteogenesis Imperfecta Congenita, Vrolik Disease): autosomal dominant; mutation of type I collagen	Growth deficiency, short, broad, long bones, multiple fractures, blue sclerae, early death	Structural: Fragile bones, flattened vertebrae, soft calvarium Neuro: Hypotonia, hydrocephaly	Careful placement of patient so as not to damage the spine or cranium or break any bones; radiologic evaluation of skeleton for fractures	X	X					
Oto-Palato-Digital Syndrome, Type I (Taybi Syndrome): X-linked	Deafness, mild mental deficiency, small stature, broad distal digits with short nails, cleft palate	Structural: Cleft palate, facial bone hypoplasia; pectus, cervical vertebral anomalies, limited elbow extension, hearing impairment	Radiologic evaluation of major joints and cervical spine; evaluate for upper airway obstruction	X	X					
Oto-Palato-Digital Syndrome, Type II: X-linked	Growth and mental deficiencies, fixed overlapping fingers, hypertelorism, polydactyly, hearing loss	Structural: Small mouth and mandible, cleft palate, flattened vertebrae, pectus, thin ribs and adrenal hypoplasia	Radiologic evaluation of facial bones and for vertebral anomalies; evaluate for upper airway obstruction or defects	X	X					
Pallister-Hall Syndrome: autosomal dominant	Hypothalamic hamartoblastoma, hypopituitarism, imperforate anus, postaxial polydactyly	Structural: Cleft lip/palate, micrognathia, dysplastic tracheal cartilage, laryngeal, epiglottis, or lung defects, cardiac, CNS, renal vertebral and rib defects, adrenal, pituitary, pancreas and thyroid hypoplasia	Radiologic evaluation for vertebral and rib anomalies; evaluate for upper and lower airway obstruction or defects and cardiac, renal, pulmonary and endocrine function	X	X		X	X		X
Pena-Shokeir Phenotype (Fetal Akinesia/Hypokinesia Sequence): autosomal recessive	Neurogenic arthrogryposis, short neck, polyhydramnios, pulmonary hypoplasia, hypertension, early death	Structural: Micrognathia, high arched palate, small mouth, multiple contractures, cleft palate, cardiac and CNS defects	Radiologic evaluation for multiple joint contractures; evaluate for upper airway obstruction or defects and cardiac, neurologic and pulmonary function	X	X		X	X		
Peters'-Plus Syndrome: autosomal recessive	Peters anomaly, short limb dwarfism, mental retardation, prominent forehead	Structural: Micrognathia, cleft lip/palate, joint hypermobility, cardiac, renal, vertebral and CNS defects, pectus Neuro: Seizures, spasticity, feeding difficulties	Radiologic evaluation for vertebral or joint anomalies; evaluate for upper airway obstruction or defects and cardiac, renal and neurologic function	X	X	X		X		X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Phenylketonuria (PKU): autosomal recessive	Mental deficiency, microcephaly, cardiac defects, seizures (3)	Misc: Eczema, pyloric stenosis, possible seizure activity and sensitivity to narcotics and CNS depressants, and cardiac defects (7)	Maintain patient on anticonvulsant medication during perioperative period; evaluate for cardiac function and pyloric stenosis		X			X		
Pierre Robin Sequence: heterogeneous; may be syndromic (e.g., Stickler)	Micrognathia, glossoptosis, cleft soft palate, primary defect: early mandibular hypoplasia (3)	Structural: Cleft palate, micrognathia, small mandible, glossoptosis (42)	Treatment course may include prone positioning, nasal pharyngeal airway, lip-tongue adhesion or tracheostomy (42); evaluate for degree of upper airway obstruction or defects; use inhalation induction with spontaneous ventilation	X						
Polycystic Kidney Disease: autosomal dominant	Cysts in kidneys and possibly liver, pancreas, spleen, lungs, bladder, thyroid (43)	Misc: Lung cysts leading to pneumothorax and hypertension and possible cerebral aneurysm (43)	Use renally excreted drugs and closely monitor patients for risks associated with hypertension (43)		X			X	X	X
Popliteal Pterygium Syndrome (Facio-Genito-Popliteal Syndrome): autosomal dominant	Popliteal web, lower lip pits, cleft palate, genital anomalies	Structural: Cleft palate/lip, intraoral fibrous band connecting maxillary and mandibular alveolar ridges, popliteal web, rib and vertebral defects	Radiologic evaluation for rib and vertebral anomalies; evaluate for upper airway obstruction or defects	X	X					
Prader-Willi Syndrome: paternal-derived deletion of 15q11-q13	Marked obesity, short stature, hypogonadism, mental deficiency, infantile hypotonia, small hands and feet (3)	Structural: Truncal obesity with tapered limbs, diabetes mellitus, scoliosis Neuro: Hypotonia Misc: Cardiovascular problems (arrhythmias, conduction abnormalities, PVCs, hypertension) (4), respiratory problems (restrictive abnormality, dry mouth from viscous saliva), CNS problems (sleep disturbance or apnea, convulsions, thermoregulation disturbance) (44,45)	Suggested anesthesia approach: control diabetes mellitus with insulin infusion, use ECG and noninvasive blood pressure monitor, intraoperative mechanical ventilation, avoid use of atropine, monitor body temperature, exhaled carbon dioxide and postoperative apnea (44,45)	X	X		X	X		
Progeria Syndrome (Hutchinson-Gilford Syndrome): unknown; usually sporadic	Alopecia, premature aging, subcutaneous fat atrophy, skeletal hypoplasia and dysplasia, dental anomalies	Structural: Micrognathia, stiff joints, facial hypoplasia, thin ribs, small thoracic cage, delayed ossification, ovoid vertebral bodies, fractures, atherosclerosis, narrow glottis opening (46)	Radiologic evaluation for rib, vertebral and joint anomalies (fractures); evaluate for upper airway obstruction or defects and cardiac and pulmonary function	X	X		X			
Proteus Syndrome: unknown; sporadic	Overgrowth, thickening of skin, subcutaneous tumors, hemihypertrophy	Structural: Cleft palate, dysplastic vertebrae (spinal stenosis), coarse ribs, thoracic hemangiomata, pectus, hemihypertrophy, scoliosis, muscle atrophy, emphysema, cardiac and renal defects Neuro: Seizures, mental deficiency	Radiologic evaluation for rib and vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac, renal and pulmonary function	X	X		X	X		X
Pseudoachondroplasia (Pseudoachondroplastic Spondyloepiphyseal Dysplasia): autosomal dominant	Growth deficiencies, small irregular epiphyses and metaphyses, flattened/beaked vertebrae, normal craniofacial appearance	Structural: Vertebral flattening or beaking and rib anomalies, hypermobility of major joints, kyphosis, scoliosis, odontoid hypoplasia	Radiologic evaluation for rib and vertebral anomalies; evaluate for rib and vertebral anomalies and odontoid hypoplasia		X					
Rapp-Hodgkin Ectodermal Dysplasia Syndrome (Hypohidrotic Ectodermal Dysplasia): autosomal dominant	Hypohidrosis, dysplastic nails, hypodontia, hypospadias, oral clefts	Structural: Small mouth, cleft lip/palate, cleft uvula, velopharyngeal incompetence, dry vocal cords	Evaluate for upper airway obstruction or defects	X						
Restrictive Dermopathy: autosomal recessive	Enlarged fontanels, small pinched nose, polyhydramnios, multiple joint contractures, defective skin, early death	Structural: Small mouth, cleft palate, choanal atresia, renal, rib and cardiac defects, ankylosis of temporomandibular and other joints, micrognathia, pulmonary hypoplasia, defective skin	Radiologic evaluation for rib defects and joint anomalies; evaluate for upper airway obstruction or defects and cardiac, renal and pulmonary function	X	X		X			X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Retinoic Acid Embryopathy (Accutane Embryopathy): Isotretinoin (Accutane) exposure	CNS and cardiac defects, mild facial asymmetry, microtia	Structural: Micrognathia, cardiac defects, facial asymmetry, cleft palate Neuro: CNS defects, hydrocephaly, hearing loss	Evaluate for upper airway obstruction or defects and cardiac and neurologic function	X			X	X		
Roberts-SC Phocomelia (Pseudothalidomide Syndrome; Hypomelia-Hypotrichosis-Facial Hemangioma Syndrome): autosomal recessive	Hypomelia, midfacial defect, severe growth and mental deficiencies, midfacial capillary hemangioma, early death	Structural: Cleft lip/palate, micrognathia, hypomelia, flexion contractures, short neck, cardiac and renal defects, thrombocytopenia Neuro: Seizures, mental deficiency	Radiologic evaluation for limb defects and joint contractures; evaluate for upper airway obstruction or defects and cardiac and renal function	X	X		X	X		X
Robinow Syndrome: autosomal recessive or dominant	Flat facial profile, short forearms, short stature, hypertelorism, hypoplastic genitals	Structural: Cleft palate, micrognathia, macroglossia, hyperplastic alveolar ridges, scoliosis, pectus, hemivertebrae, rib, renal and cardiac defects Neuro: Seizures, mental deficiency	Radiologic evaluation for vertebral and rib anomalies; evaluate for upper airway obstruction or defects and renal and cardiac function (47)	X	X		X	X		X
Rubinstein-Taybi Syndrome: cAMP-regulated enhancer-binding protein (CBP) gene defect at 16p13.3	Broad thumbs and toes, slanted palpebral fissures, hypoplastic maxilla, growth and mental deficiencies	Structural: Small mouth, scoliosis, micrognathia, cardiac defects Neuro: Hypotonia, seizures Misc: Unusual reaction to anesthesia (respiratory distress and cardiac arrhythmias)	Evaluate for upper airway obstruction or defects and cardiac function	X	X		X	X		
Russell-Silver Syndrome: unknown; majority sporadic	Short stature, skeletal asymmetry, café-au-lait spots, clinodactyly	Structural: Hypoplastic mandible, renal and cardiac defects, intestine malrotation Misc: risks for malignancies, hypoglycemia, growth hormone deficiency, adrenal insufficiency, excessive sweating (48)	Radiologic evaluation of mandible; evaluate for upper airway obstruction or defects and cardiac, renal and endocrine function; check for thermal instability (48)	X		X		X		X
Schinzel-Giedion Syndrome: autosomal recessive	Growth and mental deficiencies, coarse facies, high protruding forehead, shortening of forearms and legs, renal and genital anomalies	Structural: Choanal stenosis, mid face hypoplasia, macroglossia, wormian bones, short neck, rib, cardiac and renal anomalies Neuro: Seizures	Radiologic evaluation for rib anomalies; evaluate for upper airway obstruction or defects and cardiac and renal function	X	X		X	X		X
Schwartz-Jampel Syndrome (Chondrodystrophica Myotonia): autosomal recessive	Myotonia, small stature, joint limitations, low hairline, blepharophimosis	Structural: Small mandible, joint limitations, vertical shortness of vertebrae, small mouth, pectus Misc: Myotonia, muscle wasting, feeding and respiratory problems, difficult intubation and malignant hyperthermia (3)	Radiologic evaluation for vertebral anomalies and joint contractures; evaluate for upper airway obstruction or defects and myotonia	X	X	X		X		
Shprintzen Syndrome (Velo-Cardio-Facial Syndrome): deletion of 22q11.21-q11.23	Mild mental impairment, short stature, conductive hearing loss, cleft palate, velopharyngeal incompetence	Structural: Cleft palate, retruded mandible, cardiac defects, scoliosis, holoprosencephaly, hypothyroidism, absent thymus, hypocalcemia, hypotonia, abnormal position of internal carotid arteries (visible pulsations in posterior pharyngeal wall) (3)	MRI of pharynx and fiberoptic nasopharyngoscopy for anatomical defects; evaluate for upper airway obstruction or defects and cardiac and thyroid function; check electrolyte levels	X	X		X	X		X
Sickle Cell Disease: autosomal recessive	Hemolytic anemia and painful crises, increased blood viscosity, red blood cells in sickle shape (49)	Misc: Hypoxia, dehydration, cold, infection and acidosis may lead to sickling of red blood cells (49)	Avoid use of tourniquets, use alkalation with bicarbonate and hyperventilation to avoid acidosis and a preoperative blood transfusion to decrease levels of hemoglobin S depending on how extensive surgery may be (49)		X					
Seckel Syndrome: autosomal recessive	Severe growth and mental deficiencies, prominent nose, microcephaly, low-set malformed ears	Structural: Micrognathia, inability to extend knees, dislocation of hips and elbows, 11 pairs of ribs, facial asymmetry, scoliosis, cleft palate, hypoplastic anemia Neuro: Seizures	Radiologic evaluation for rib and joint anomalies; evaluate for upper airway obstruction or defects and anemia	X	X			X		

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Short Rib-Polydactyly Syndrome, Type II (Majewski Type): autosomal recessive	Short stature, disproportionately short limbs, polysyndactyly of hands and feet, ambiguous genitalia, early death	Structural: Midline cleft lip, cleft palate, hypoplasia of epiglottis and larynx, narrow thorax, short ribs, renal cysts, lobulated tongue, CNS defects, pulmonary hypoplasia	Radiologic evaluation for chest and rib anomalies; evaluate for upper airway obstruction or defects and renal and pulmonary function	X	X			X		X
Simpson-Golabi-Behmel Syndrome: X-linked recessive; mutations in GPC3 gene at Xq26	Prenatal onset of overgrowth, coarse facies, macrocephaly, postaxial polydactyly of hands	Structural: Cleft lip/palate, vertebral segmentation defects, macroglossia, cardiac defects, pectus, cervical ribs, scoliosis, sternal cleft, gastrointestinal, renal and CNS anomalies, polysplenia, diaphragmatic hernia	Radiologic evaluation for ribs, sternal, gastrointestinal and vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac and renal function	X	X	X	X	X		X
Smith-Lemli-Opitz Syndrome: autosomal recessive; defect in cholesterol biosynthesis	Mental deficiency, anteverted nares, ptosis, microcephaly, 2–3 toe syndactyly, hypospadias, cryptorchidism	Structural: Cleft palate, micrognathia, genital (microurethra), renal, CNS and cardiac defects, abnormal pulmonary lobes, thymus hypoplasia Misc: Hepatic dysfunction, may have anesthesia induced rigidity (50)	Evaluate for upper airway obstruction or defects and cardiac, renal, liver and genital function	X	X		X	X	X	
Spondyloepiphyseal Dysplasia Congenita: autosomal dominant; COL2A1 gene mutations	Short trunk, flat facies, barrel chest with pectus carinatum, delayed mineralization of epiphyses, myopia	Structural: Cleft palate, flattened vertebrae with narrow intervertebral disk spaces, short neck, odontoid hypoplasia, limited joint mobility, kyphoscoliosis	Radiologic evaluation for vertebral and joint anomalies including odontoid hypoplasia; evaluate for upper airway obstruction or defects	X	X					
Spondyloepiphyseal Dysplasia Tarda (X-Linked Spondyloepiphyseal Dysplasia): X-linked recessive	Short stature, flattened vertebrae, small iliac wings, short neck	Structural: Flattened vertebrae, hump-shaped mound of bone in central and posterior portions of vertebral end plates, kyphosis, mild scoliosis	Radiologic evaluation for vertebral anomalies		X					
Stickler Syndrome (Hereditary Arthroophthalmopathy): autosomal dominant; COL2A1 mutations at 12q13.11-q13.2	Flat facies, myopia, deafness, spondyloepiphyseal dysplasia	Structural: Mandibular hypoplasia, cleft palate, Robin sequence, mitral valve prolapse, spondyloepiphyseal dysplasia, hyperextensible joints, scoliosis, pectus, arthritis	Radiologic evaluation for vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac status	X	X		X			
Sturge-Weber Syndrome: unknown; sporadic	Angiomatous malformation of the skin, convulsions, hemiplegia, hemicerebral-atrophy mental retardation, seizures and ocular anomalies (3)	Structural: Associated anomalies and angiomas of the mouth and upper airway, difficult intubation, uncontrolled vascular hemorrhage resulting from perforation of vascular lesions; coarctation of aorta (51) Neuro: Seizures, mental deficiency	Avoid trauma to the hemangiomata and increases in intraocular and intracranial pressure by use of succinylcholine or acetazolamide, use soft, nonstylleted, well lubricated endotracheal tubes for tracheal intubation and careful tracheobronchial suction (51); check cardiac status	X	X		X	X		
Thanatophoric Dysplasia: autosomal dominant; mutations of FGFR3 gene	Short limbs, flat vertebrae, large cranium with low nasal bridge, brain anomalies, early death	Structural: Brain stem hypoplasia and anomalies, short and flattened vertebrae with relatively wide intervertebral disk space, clover leaf skull, cardiac and renal defects, small chest (respiratory insufficiency)	Radiologic evaluation for skull and vertebral anomalies; evaluate for cardiac and renal function and brain anomalies	X	X		X	X		X
Treacher Collins Syndrome (Mandibulofacial Dysostosis, Franceschetti-Klein Syndrome): autosomal dominant; mapped to 5q32-33.1	Malar hypoplasia, down-slanting palpebral fissures, lower eyelid defect, ear anomalies (deafness)	Structural: Mandibular hypoplasia, cleft palate, choanal atresia, cardiac defects	Evaluate for upper airway obstruction or defects and cardiac function	X			X			
Triploidy: triploidy 69 chromosomes	Large placenta with hydatidiform changes, growth deficiency, brain, renal, cardiac abnormalities, syndactyly of 3 and 4 fingers, early death	Structural: Micrognathia, cardiac, brain, renal and liver defects, skeletal asymmetry, macroglossia, adrenal, pancreas, gallbladder and colon anomalies	Evaluate for cardiac, brain, renal, liver and endocrine function	X	X		X	X	X	X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Trisomy 8: trisomy 8, usually mosaic	Mental deficiency, thick lips, micrognathia, deep-set eyes, short webbed neck, prominent ears, camptodactyly, absent patella	Structural: Cleft or high arched palate, micrognathia, ureterorenal, vertebral and cardiac defects, major joint contractures, abnormal sternum, short neck, deafness, anemia, factor VII deficiency	Radiologic evaluation for joint, vertebral and sternal anomalies and evaluate ureterorenal, cardiac or hematologic status and upper airway obstruction or defects	X	X		X	X		X
Trisomy 9 Mosaic: mosaic trisomy 9	Mental deficiency, deeply set slanted eyes, prominent nasal bridge, low set malformed ears, cardiac defects, joint contractures	Structural: Micrognathia, cleft lip/palate, joint contractures, kyphoscoliosis, narrow chest, cardiac, CNS, liver, vertebral, rib and renal defects, diaphragmatic hernia, GE reflux	Radiologic evaluation for vertebral, rib, joint and diaphragm anomalies; evaluate for upper airway obstruction or defects and cardiac, liver and renal function and GE reflux	X	X	X	X	X	X	X
Trisomy 13: trisomy 13	Defects of eye, nose, lip and forebrain, polydactyly, scalp lesions, cardiac and renal defects, early death	Structural: Cleft lip/palate, cardiac, renal, rib, CNS, colon anomalies, micrognathia, diaphragmatic defect (respiratory distress) Misc: Seizures, hypotonia, cerebellar hypoplasia	Radiologic evaluation for rib or vertebral anomalies; evaluate for upper airway obstruction or defects and cardiac, renal, neurologic and pulmonary function	X	X		X	X		X
Trisomy 18: trisomy 18	Growth deficiency, prominent occiput, small mouth, clenched hands, short sternum, overlapping fingers with low arch dermal ridge pattern, hypertonia, early death	Structural: Small mouth, micrognathia, cleft lip/palate, skeletal muscle hypoplasia, short sternum, cardiac, lung, renal, CNS, gastrointestinal, rib and vertebral defects	Radiologic evaluation for rib, vertebral and gastrointestinal anomalies; evaluate for upper airway obstruction or defects and cardiac, neurologic, lung and renal function	X	X	X	X	X		X
Tuberous Sclerosis (Adenoma Sebaceum): autosomal dominant	Hamartomatous skin nodules, seizures, phakomata and bone lesions (3)	Structural: Blockage of blood flow to and from heart contributing to congestive heart failure, severe and progressive dypsnea, spontaneous pneumothorax, haemoptysis and respiratory failure, hamartomatous brain lesions, renal angiomyolipomas, endocrine abnormalities and lesions of oropharynx and larynx leading to difficult intubation (52)	Closely monitor all body systems and airway management (52); evaluate by ultrasound for hamartomatous lesions that can occur in any organ	X	X	X	X	X	X	X
Turner Syndrome (XO Syndrome): 45,X karyotype	Short female, broad chest, widely spaced nipples, webbed neck, ovarian dysgenesis, congenital lymphedema	Structural: Small mandible, cardiac defects (usually coarctation of aorta), lymphedema, short webbed neck, renal defect (usually horseshoe kidney), rib and vertebral anomalies Misc: Hypothyroidism, hypertension, diabetes mellitus	Radiologic evaluation for rib and vertebral anomalies and evaluate for cardiac, renal and endocrine status	X	X		X			X
Van der Woude Syndrome (Lip Pit-Cleft Lip Syndrome): autosomal dominant; gene at 1q32	Lower lip pits, cleft lip with or without cleft palate, hypodontia	Structural: Cleft lip/palate	Evaluate for upper airway defects	X						
VATER Association: unknown; sporadic	*V*ertebral anomalies, *A*nal atresia, *T*racheo*E*sophageal fistula, *R*adial dysplasia, renal anomaly, cardiac defects	Structural: Vertebral and rib anomalies, cardiac and renal defects, tracheoesophageal fistula, laryngeal stenosis, limb deficiency	Radiologic evaluation for rib and vertebral anomalies; evaluate for lower airway obstruction or defects and cardiac and renal function	X	X		X			X
WAGR Syndrome (Aniridia-Wilms Tumor Association): 11p13 deletion	Aniridia, Wilms tumor, mental and growth deficiencies, congenital cataracts, hypospadias, cryptorchidism	Structural: Micrognathia, kyphoscoliosis, cystic kidneys, cardiac defects, blindness	Evaluate for upper airway obstruction or defects and cardiac and renal function	X			X	X		X

Table 1. (*Continued*)

Disease/Etiology (see References 3 and 4)	Brief Description	Potential Sedation and Anesthesia Complications	Recommendations for Presedation Evaluation (see References 5–10)	Checklist Items						
				Difficult airway	Altered respiratory mechanics	Gastric reflux	Cardio-vascular disorder	Neuro-muscular problems	Liver disease	Renal disorder
Watson Syndrome: autosomal dominant	Mental retardation and pulmonary valvular stenosis, café-au-lait spots and short stature (3)	Structural: Limitations of right and left ventricular output possibly leading to acute cardiac decompensation and right-sided cardiac failure (53)	Maintain an adequate preload, a normal heart rate, and avoid decreases in afterload and myocardial contractility by use of a nitrous oxide-relaxant during general anesthesia, additionally haemodynamic monitoring and antibiotic prophylaxis to prevent bacterial endocarditis (53)				X	X		
Werdnig-Hoffmann Disease: autosomal recessive	Spinal muscular atrophy characterized by selective anterior horn cell degeneration causing skeletal deformities, kyphoscoliosis and contractures (3)	Misc: Recurrent urinary tract infections, dyspnea worsening of pulmonary function and spinal complications (54)	Spinal/epidural anesthesia may be contraindicated because of spine deformity (54)	X				X		
Williams Syndrome: deletion of elastin gene at 7q11.23	Growth and mental deficiency, prominent lips, hoarse voice, cardiovascular anomalies (usually supravalvular aortic stenosis) (3)	Structural: Difficult intubation and hypotonia leading to masseter spasm (55), scoliosis, renal and bladder defects, pectus, hypercalcemia	Warm anesthetic agents prior to surgery and avoid use of halothane with suxamethonium (55); evaluate for upper airway obstruction or defects and cardiac and renal function; check electrolytes	X			X	X		X
Xeroderma Pigmentosa Syndrome: autosomal recessive defect in DNA repair	Sensitivity to sunlight, atrophic and pigmentary skin changes, actinic skin tumors, progressive neurologic problems	Structural: Atrophic skin of mouth leading to difficulty opening mouth Misc: Ataxia, spasticity, impaired hearing	Evaluate for oral lesions and skin tumors and neurologic function	X				X		
XXXY and XXXXY Syndromes	Hypogenitalism, mental deficiency, limited elbow pronation, low dermal ridge count on fingertips	Structural: Joint laxity, prognathism, cleft lip/palate, short neck, joint limitation, obesity, CNS defects, pectus	Evaluate for upper airway obstruction or defects	X				X		
Yunis-Varon Syndrome: autosomal recessive	Severe growth and mental deficiency, microcephaly, agenesis/hypoplasia of thumbs and great toes, absent clavicles, early death	Structural: Micrognathia, glossoptosis, absent clavicles, abnormal sternum, CNS malformations, cardiac defects	Evaluate for upper airway obstruction or defects and cardiac and neurologic function	X	X		X	X		

Neuro = neurological, CNS = central nervous system, PEEP = positive end-expiratory pressure, Misc = miscellaneous, ECG = electrocardiogram, cAMP = cyclic adenosine monophosphate, GE = gastroesophageal.

as possible. Special behavior assessments may be required before sedation or anesthesia administration to meet or gain the trust of the patient and family and to alleviate problems. Exaggerated anxiety may lead to further tactile defensiveness, hyperactivity, attention deficits, psychomotor disturbances, and uncooperativeness. Desensitization and allaying anxiety are important key points to remember before successful sedation or anesthesia administration in patients with special needs. This is particularly important for patients with genetic diseases with neurologic involvement [approximately 60% of the reported 10,000 genetic conditions have central or peripheral nervous system abnormalities (4)]. In addition, hearing impairment and blindness are recognized features of several genetic diseases that raise additional problems for the health care provider.

Genetic disorders pose a significant challenge to health care providers. The recognition of genetic conditions is increasing in the United States, with many patients not previously encountered requiring surgical procedures and intervention with anesthesia. This is a result of changing medical practice, growing awareness and recognition of genetic diseases, modern medical advances, and increased longevity of patients with many genetic conditions. With increased prevalence (and incidence) of genetic diseases and with better recognition comes the need for comprehensive efforts of health care providers to meet the growing special needs of each patient. Acknowledging unique anesthesia considerations is an essential part of providing adequate health care for patients with genetic diseases and can serve as a means of avoiding morbidity and mortality.

We thank Karen Henrion for expert preparation of the manuscript. We thank William Daniels, DO, pediatric anesthesiologist, for his critical reading of the manuscript and helpful suggestions.

References

1. Baird P, Anderson T, Newcombe H, Lowry R. Genetic disorders in children and young adults: a population study. Am J Hum Genet 1988;42:677–93.
2. Woodward A, Alves S, Butler MG. Genetic conditions among patients receiving genetic services in middle Tennessee. So Med J 1993;86:42–5.
3. Jones, K. Smith's recognizable patterns of human malformation. 5th ed. Philadelphia: WB Saunders, 1997.
4. Online Mendelian Inheritance in Man, OMIM™. Center for Medical Genetics, Johns Hopkins University (Baltimore, MD) and National Center for Biotechnology Information, National Library of Med (Bethesda, MD). Available at http://www.ncbi.nlm.nih.gov/omim. Accessed April 14, 1999.
5. Montogama E, Davis, P. Smith's anesthesia for infants and children. 6th ed. St. Louis: Mosby-Year Book, 1996:953–61.
6. Nargozian C. Anesthetic management. Clin Plas Surg 1991;18: 227–30.
7. Katz J, Steward, D. Anesthesia and uncommon pediatric diseases. 2nd ed. Philadelphia: WB Saunders, 1993:467–8.
8. Bevan J. Congenital syndromes in pediatric anesthesia: what is important to know. Can J Anaesth 1998;45:R3–9.
9. Sculerati N, Gottlieb M, Zimbler M, et al. Airway management in children with major craniofacial anomalies. Laryngoscope 1998;108:1806–12.
10. Vaughan C. Anesthetic management of children with craniofacial anomalies. CRNA 1997;8:123–34.
11. Kalla G, Fening E, Obiaya M. Anaesthetic management of achondroplasia. Br J Anaesth 1986;58:117–9.
12. Stiles C. Anesthesia for the mentally retarded patient. Ortho Clin North Am 1981;12:45–56.
13. Vas L, Naregal P, Karmarkar S. Maxillary hypoplasia with unsuspected choanal atresia. Ped Anaesth 1997;7:465–7.
14. LeBard S, Thiemann L. Antley-Bixler syndrome: a case report and discussion. Ped Anaesth 1998;8:89–91.
15. Shiraishi N, Nakamura T, Saito H, et al. Anesthetic management of a patient with Cowden syndrome. Masui 1995:282–5.
16. Kim Y, Shibutani T, Hirota Y, et al. Anesthetic considerations of two sisters with Beckwith-Wiedemann syndrome. Anesth Prog 1996;43:24–8.
17. Suan C, Ojeda R, Garcia-Perla J, Perez-Torres M. Anaesthesia and the Beckwith Wiedemann syndrome. Paediatr Anaesth 1996;6:231–3.
18. Schulte D, Kasperbauer J. Safety of paranasal sinus surgery in patients with cystic fibrosis. Laryngoscope 1998;108:1813–5.
19. Poussa M, Merikanto J, Ryoppy S, et al. The spine in diastrophic dysplasia. Spine 1991;16:881–7.
20. Fox H, Thomas C, Thompson A. Spinal instrumentation for Duchenne's muscular dystrophy: experience of hypotensive anaesthesia to minimize blood loss. J Paediatr Ortho 1997;17:750–753.
21. Brighouse D, Guard B. Anaesthesia for caesarian section in a patient with Ehlers-Danlos syndrome type IV. Br J Anaesth 1992;69:517–9.
22. Woolley M, Morgan S, Hays D. Heritable disorders of connective tissue surgical and anesthetic problems. J Pediatr Surg 1967;2:325–31.
23. Goldring S. Pediatric epilepsy surgery. Epliepsia 1987;28:82–102.
24. Louhhimo I, Lindahl H. Esophageal atresia, primary results of 500 consecutively treated patients. J Pediatr Surg 1983;18:217–29.
25. Nussbaum BL, Ohara I, Kaplan FS. Fibrodysplasia ossificans progressiva: report of a case with guidelines for pediatric dental and anesthetic management. ASDC J Dent Child 1996;63:448–50.
26. Casamassimo P, Mcllvaine W, Hagerman R, Shellhart W. General anesthesia and fragile X syndrome: report of a case. Anesth Prog 1985;32:104–6.
27. Madan R, Trikha A, Venkataraman RK, et al. Goldenhar's syndrome: an analysis of anaesthetic management. Anaesth 1990;45:49–52.
28. Borland L. Anesthesia for children with Jeune's syndrome (asphyxiating thoracic dystrophy). Anaesth 1987;66:86–8.
29. Tritapepe L, Voci P, Pinto G, et al. Anaesthesia for caesarian section in a Marfan patient with recurrent aortic dissention. Can J Anaesth 1996;43:1153–5.
30. Wells D, Podolakin W. Anaesthesia and Marfan's syndrome: case report. Can J Anaesth 1987;34:311–4.
31. Tobias J. Anaesthetic considerations in the child with Menkes' syndrome. Can J Anaesth 1992;39:712–5.
32. Busoni P, Fognani, G,. Failure of the laryngeal mask to secure the airway in a patient with Hunter's syndrome. Ped Anaesth 1999;9:153–5.
33. Baines D, Keneally J. Anaesthetic implications of the mucopolysaccharideoses: a fifteen year experience in a children's hospital. Anaesth Intensive Care 1983;11:198–202.
34. Hopkins R, Watson J, Jones J, Walker M. Two cases of Hunter's syndrome: the anaesthetic and operative difficulties in oral surgery. Br J Oral Surg 1973;10:286–99.
35. Moores C, Rogers JG, McKenzie M, Brown TCK. Anaesthesia for children with mucopolysaccharidoses. Anaesth Intensive Care 1996;24:459–63.
36. Walker R, Darowski M, Morris P, Wraith J. Anaesthesia and mucopolysaccharidoses. Anaesthesia 1994;49:1078–84.
37. Kuzma PJ, Calkins MD, Kline MD, et al. The anesthetic management of patients with multiple pterygium syndrome. Anesth Analg 1996;83:430–2.
38. Naguib M, Al-Rajeh S, Abdulatif M, Abatin W. The response of a patient with Von Recklinghausen's disease to succinylcholine and atracurium. MEJ Anesth 1988;9:429–34.
39. Fisher M. Anaesthetic difficulties in neurofibromatosis. Anaesthesia 1975;30:648–50.
40. Ransom D, Leicht C. Continuous spinal analgesia with Sufentanil for labor and delivery in a parturient with severe pulmonary stenosis. Anesth Analg 1995;80:418–21.
41. Bolsin S, Gilbe C. Opitz-Frias syndrome. Anaesthesia 1985;40: 1189–93.
42. Jones S, Derrick G. Difficult intubation in an infant with Pierre Robin syndrome and concomitant tongue tie. Pediatr Anaesth 1998;8:510–1.
43. Silverstein K, Adams M, Fonseca R. Evaluation and management of the renal failure and dialysis patient. Oral Maxillofac Surg Clin North Am 1998;10:417–27.
44. Dearlove O, Dobson A, Super, M. Anaesthesia and Prader-Willi syndrome. Pediatr Anaesth 1998;8:267–71.
45. Makenzie JW. Anaesthesia and the Prader-Willi syndrome. J Roy Soc Med 1991;84:239.
46. Chapin JW, Kahre J. Progeria and anesthesia. Anesth Analg 1979;58:424–5.
47. Macdonald I, Dearlove OR. Anaesthesia and Robinow syndrome [letter]. Anaesthesia 1995;50:1097.
48. Dinner M, Goldin E, Ward R, et al. Russell-Silver syndrome: anesthetic implications. Anesth Analg 1994;78:1197–9.
49. Vipond AJ, Caldioctt, LD,. Major vascular surgery in a patient with sickle cell disease. Anesth 1998;53:1204–6.
50. Peterson W, Crouch E. Anesthesia-induced rigidity, unrelated to succinylcholine, associated with Smith-Lemli-Opitz syndrome and malignant hyperthermia. Anesth Analg 1995;80:606–8.
51. Batra RK, Veena G, Madan R, Trikha A. Anesthesia and the Sturge-Weber syndrome. Can J Anaesth 1994;41:133–6.
52. Lee J, Imrie M, Taylor V. Anaesthesia and tuberous sclerosis. Br J Anaesth 1994;73:421–5.
53. Conway J, Posner M. Anaesthesia for caesarian section in a patient with Watson's syndrome. Can J Anaesth 1998;41:1113–6.
54. Carter G, Bonekat H, Milio L. Successful pregnancies in the presence of spinal muscular atrophy: two case reports. Arch Phys Med Rehabil 1994;75:229–31.
55. Patel J, Harrison M. Williams syndrome: masseter spasm during anesthesia. Anaesthesia 1991;46:115–6.