The Difficult Pediatric Airway

Nothing valuable can be lost by taking time.

-Abraham Lincoln

As noted previously, there exist developmental anatomic and physiologic differences between infants and children and adults which can make even the "normal" pediatric airway a management challenge. A review of the pediatric closed claims cases (n=111) stated that the most common causes of injury were a result of inadequate ventilation (n=31, 28%) and esophageal intubation (n=6, 5.4%). Of the 31 children who were inadequately ventilated, 30 proceeded to have a cardiac arrest. There were 25 deaths, and an additional 5 severely brain damaged survivors. The authors concluded that inadequate ventilation was a more common problem in children than in adults (Geiduschek JM et al. *Anesthesiology* 71:A1174, 1989). It is no wonder, then, that anesthesiologists may feel uncomfortable doing pediatric cases, especially those involving small infants. Add to the situation an acquired or congenital problem involving the airway and the anxiety of the anesthesiologist and the risk to the patient increase dramatically. "Safe" management guidelines for the difficult airway are delineated in the excellent ASA practice guidelines (*Anesthesiology* 78:1993).. Of particular note in the pediatric population, unlike adults, classifications have not been devised to help the anesthesiologist reliably determine which pediatric patients may be particularly difficult to ventilate by mask and, especially, to visualize the larynx on direct laryngoscopy. In this outline, I will attempt to classify some of the anatomic variables (both congenital and acquired) which predict difficulty in airway management, and outline strategies (based on ASA guidelines) which have been found to be particularly useful in children.

Preoperative Assessment: Identification

(I) History

A history of feeding problems or respiratory problems, such as snoring, noisy breathing, change of voice, recurrent croup, or sleep apnea should alert the anesthesiologist to a potentially less than normal airway. The parents can often describe the position in which the child can most comfortably eat or breathe. Importantly, prior surgical procedures may have been asociated with airway difficulties; the nature of these difficulties and their resolution is crucial, and may be obtained from parents and/or old records.

Age is usually your ally; that is, growth will *generally* improve the airway. From birth to the age of two years all the laryngeal structures move caudad. This allows for more cervical vertebral motion, allowing for easier alignment of the axes for visualization. Additionally, the angle of the glottis becomes perpendicular to the trachea, again allowing for easier visualization. Growth of the mandible (especially in micrognathic infants, such as those with Pierre Robin anomalad), allows for more complete displacement of the tongue during

laryngoscopy. However, certain changes that occur with age may be detrimental towards success in airway management. For example, the appearance of teeth may alter the axis of visualization in children with mandibular hypoplasia enough to make visualization impossible, while prior records document successful visualization. Another example of age making problems worse might include progressive cervical spine immobility in children with Klippel-Fiel or Goldenhar's syndrome.

(II) Physical Examination

A preoperative systematic examination of the various systems is optimal, but may need to be postponed if the child is in severe respiratory distress. In that case, further examination or moving of the patient might be deferred until immediate resuscitation is available. Assessments must be made as to severity of respiratory distress, presence of hypoxemia (pulse oximetry, cyanosis), and inspiratory or expiratory stridor.

Physical examination of the airway should begin at the nares and proceed down the airway. Choanal stenosis can occur as an isolated finding and be life threatening in the newborn; it can also be associated with craniofacial anomalies, such as Apert/Crouzon's syndromes. Mouth breathing is obligatory, and relaxation of pharyngeal structures will lead to obstruction as the tongue relaxes against the posterior pharynx.

Laryngeal obstruction might be associated with webs, cleft,or papillomas, infection, trauma or foreign body, as well as tracheomalacia. The differential diagnosis of subglottic obstruction includes subglottic stenosis, hemangioma, papillomatosis, infection, trauma or foreign body.

As noted previously, laryngoscopy is essentially the displacement of tongue and soft tissue into the *potential* displacement area, usually best accomplished after the "sniffing" position is achieved to promote alignment of the three axes of visualization. (See Routine Airway Management: Fig. 4) Therefore, our physical examination should assess mouth opening, size of the tongue or presence of other soft tissue mass, such as cystic hygroma (too great a mass to displace), mandibular size (not enough potential displacement area), and neck mobility. Please refer to appendix A for congenital and acquired causes of difficult airway grouped according to these physical characteristics. Remember that the presence of a congenital lesion should alert one to the possibility of other associated anomalies; for example, an external ear deformity is often associated with mid-face hypoplasia syndromes as well as cardiac anomalies.

Appendix A: Congenital and Acquired Causes of Difficult Airway

Difficult Airway: Micrognathia

Pierre-Robin syndrome	Apert's syndrome
Treacher-Collins syndrome	Crouzon's syndrome
Cornelia deLange syndrome	achondroplasia
Mobius syndrome	Smith-Lemli-Opitz
Goldenhar's syndrome	Carpenter's syndrome
Turner's syndrome	Freeman-Sheldon syndrome
Orofacialdigital syndrome	Patau syndrome

Difficult Airway: Macroglossia

Trisomy 21	mucopolysaccharidosis
Beckwith's syndrome	hemangioma
glycogen storage disease	cystic hygroma
congenital hypothyroidism	teratoma
gangliosidosis	trauma

Difficult Airway: Cervical Spine

fracture/subluxation	torticollis
Klippel-Feil malformation	Goldenhar's syndrome
neck burn contracture	rheumatoid arthritis
Trisomy 21	Arthrogryposis multiplex
Morquio's mucopolysaccharidosis	

(III) Laboratory and Radiologic Evaluation

In selected cases, respiratory function tests might help to differentiate extrathoracic from intrathoracic obstruction. ABG's might be indicated as an aid in assessment of severity of distress or as a baseline. Further investigations such as plain film x-rays, xerograms, CT scan or MRI are of potential utility in selected cases for diagnosis of the lesion, site of obstruction, and bony or soft tissue abnormalities.

Anesthetic Management of the Difficult Airway

The ASA **Practice Guidelines for Management of the Difficult Airway** (*Anesthesiology* 1993) can be accessed through a link on this website. Successful management of the difficult airway implies recognition, adequate preparation, and, finally, familiarity with at least several of the special techniques which may be used to intubate the trachea of patients with a difficult airway.

(I) DEVELOPMENT OF AN ANESTHETIC PLAN

Considerations include the condition of the patient (in extremis? in distress? occult airway problems?), surgical requirements (ett mandatory?), available intubating instruments, skill of anesthesiologist, backup personnel and escape route. Although anesthetic plans for intubation **must** be individualized by the patient, the situation, and expertise of the practitioner, a strong recommendation is made to have the patient breathing spontaneously until intubation is accomplished. If difficulty with mask ventilation is anticipated with loss of protective reflexes, anesthesia before endotracheal intubation is contraindicated.

As a component of informed consent, the parents must be counseled regarding the added risk in securing a difficult airway. The possibility of emergent tracheotomy/tracheostomy needs to be clarified to the parents and the surgeon. Presentation of a rational anesthetic plan may help to allay the fears of the family.

(II) PATIENT PREPARATION

NPO status must be assured prior to elective surgery. Premedicants are generally best administered under direct supervision. Sedatives may diminish genioglossus tone and worsen obstruction, if present. Atropine (0.02 mg/kg) or glycopyrrolate (0.05 mg/kg) may be administered orally 1 hour prior to anesthesia for antisialogogue effects. H_2 blockers and/or metoclopramide may be given to those patients felt to be at risk for gastric aspiration. Even in those children in which an inhalation induction of general anesthesia is planned, topicalization of the mouth and pharynx with local anesthetic is very useful; this would theoretically allow an oral airway or LMA to be inserted earlier in the course of

anesthetic induction without eliciting laryngospasm. Care must be taken in the small child not to inadvertently overdose them if a spray is used.
In the infant, 4% lidocaine jelly may be suckled from a fingertip. If nasal intubation is planned a vasoconstrictor should be applied topically.
Finally, although most children will strenuously resist it, an IV is generally recommended *prior* to induction, so as to have it in place if problems do occur.

In older children or adolescents, awake intubation with sedation may be the technique of choice. Judicious use of sedatives such as midazolam, droperidol and fentanyl may provide a cooperative, amnestic patient. Topicalization of the airway with glossopharyngeal and superior laryngeal nerve blocks may be done as in adult patients. EMLA cream has recently been advocated as an excellent airway analgesic (ASA meeting, 1997).

(III) ANESTHETIC TECHNIQUES

Theoretically, the initial consideration is whether a surgical airway should be secured while the patient is awake (elective tracheostomy). This may be the best option in those patient with severe airway obstruction and other options have either failed, or are considered too risky. Newborns in whom awake tracheostomy should be considered are those with Robin sequence, subglottic hemangioma or stenosis, and laryngomalacia. This procedure is not necessarily easy in a small, moving child with difficult anatomy.

Awake laryngoscopy might be indicated in moribund patients in need of cardiopulmonary resuscitation. An oxygenating laryngoscope may be used, if available. Although generally viewed as "safe" in neonates, recent concerns have arisen regarding the risks of intracranial hemorrhage in preterm infants who undergo awake intubation.

Generally, inhalation induction is the technique is choice. It is familiar to pediatric anesthesiologists, preserves spontaneous ventilation, and can be carried out with an FiO_2 of 1.0 to increase the margin of safety from hypoxemia. Anesthetic induction time may be prolonged due to airway obstruction and/or omission of nitrous oxide. Airway obstruction can generally be resolved by opening the mouth, thrusting the jaw forward and extending the neck ("triple airway maneuver"), as well as application of 10-15 cm H_2O of CPAP. Ventilation can then be gradually assisted and controlled. Once controlled mask ventilation has been demonstrated, neuromuscular blockade may be an option, depending on planned technique of intubation.

(IV) INTUBATION TECHNIQUES

Several techniques will be mentioned below. Details can be found in the difficult airway literature.

•blind nasal intubation: After vasoconstrictors have been applied, endotracheal tube gently passed through the nares and guided by auscultation for breath

sounds at proximal end of the tube. If ett gets caught at laryngeal inlet, flexion of head and neck and/or rotation of the ett may allow it to pass.

•blind oral intubation: Occasionally, on laryngoscopy, only the epiglottis is visible and a styletted ett can be passed underneath and into the trachea. In a spontaneously breathing patient, placement may be guided by listening to breath sounds. A rubber bougie may be utilized as a guide for the ett. In any case, blind intubation attempts can result in laryngeal trauma, and no more than two attempts should be made.

•fiberoptic intubation: This may be accomplished either awake or after inhalation induction with bronchoscope introduced via a special adapter valve connected to the breathing circuit. Ultra-thin fiberoptic bronchoscopes are available with E.D. 2.2 mm which can accommodate a 3.0 ett. More commonly, a "pediatric" bronchoscope is utilized (can accommodate 4.5 ett) and a wire is passed through the suction port to facilitate anterograde intubation with a smaller tube. Although the most versatile technique for securing the difficult airway, it is also the technique requiring the most skill and preparation. It can be particularly frustrating using the oral approach due to the lack of plastic airway guides for pediatric patients; thus, the tongue may fall back and defeat the endoscopist. An assistant may pull the tongue forward using forceps or a laryngoscope. The LMA may be a useful adjunct in fiberoptic bronchoscopy

•lighted stylet: A stylet which incorporates a light at the end is used to transilluminate the larynx as an indication of successful placement of the ett. This can be especially difficult in young children due to the paucity of soft tissue in the neck. It may be useful in small children to intentionally advance the stylet into the esophagus to aid in differentiation. Karr and Benumoff combined capnography with an illuminated stylet to enhance recognition of the trachea (*Amer J Anes* 25:87; 1988).

•translaryngeal guided retrograde wire: A relatively old technique, and particularly useful in maxillofacial trauma and when other techniques have failed and have obscured visualization. A guide (epidural catheter, CVP catheter etc.) is passed through the cricothyroid membrane and up through the mouth or nares. An ett is then passed over the guide and into the trachea. Numerous failures are reported due to impingement on the epiglottis or the right vocal cord. A useful variation is to thread the wire through the working channel of a fiberoptic bronchoscope and advancing the ett under direct visualization.

•Bullard laryngoscope: This incorporates a fiberoptic bundle at the end of a broad hockey shaped blade. It is inserted into the vallecula and lifts the base of the tongue upward, exposing the larynx. Due to high cost and relative limitations, the Bullard scope is not available at our institution.

•tubular laryngoscope blades (anterior commisure scope): Used for many years by otorhinolaryngologists, this blade allows for a better view by preventing the soft tissue of the tongue and pharynx from obscuring the view in patient where the anterior mandibular space is inadequate.

•laryngeal mask airways: LMA's are now an integral component of our operating suite. LMA's may play several roles in the anesthetic plan for difficult airway patients; they can be utilized to help maintain the airway during inhalational anesthesia (Markakis et al:*Anesth Analg*75:822-4, 1992); they can serve as a conduit for intubation, either blind or using a fiberoptic scope; lastly, LMA's may be useful as escape in a *cannot intubate/cannot ventilate* by mask situation.

Obviously, it would be exceedingly difficult to *master* every technique mentioned above. Functionally, the airway difficulty may be classified as follows:

-ACCESS (e.g. cervical halo, small mouth opening)
-VISUALIZATION (e.g. anteror larynx, large tongue)
-TARGET (e.g. laryngeal pathology)

Try to at least familiarize yourself with *one* technique which might prove useful in each circumstance, and one escape route. Fiberoptic bronchoscopy is useful in virtually all difficult airway patients. Other techniques specific to situations listed above include: ACCESS - retrograde wire, light wand; VISUALIZATION - light wand, anterior commisurescope; TARGET - rigid bronchoscope

(V) ESCAPE ROUTE

As mentioned, LMA insertion is an excellent escape route in the *cannot intubate/cannot ventilate* situation. However, every anesthesiologist should be familiar with the technique for emergency transtracheal oxygenation, and each anesthetizing location must have the necessary equipment. Simply put, a large bore intravenous catheter is inserted through the cricothyroid membrane, and connected to some form of jet ventilation. Adequate oxygenation will be maintained over the next 30 minutes while a more formal airway is secured (tracheostomy, ett, or an awake patient with spontaneous ventilation). It is important to allow adequate exhalation time to avoid overinflation of the lungs, especially if upper airway obstruction exists.

Summary

Successful management of the difficult pediatric airway can be challenging and stressful. Anticipation is often key to success, and it is preferable to err on the side of conservatism. In the unanticipated difficult airway, anesthesia personnel must utilize the conservative, "common sense" approach advocated in the ASA guidelines. The OR staff should gain expertise on healty patients in techniques which might prove useful in the difficult airway (fiberoptic bronchoscopy, LMA insertion, lighted stylet etc.) and maintain a well organized difficult airway cart which meets ASA recommendations.