

Objectives:

- 1) Discuss the evaluation of a child with a potentially difficult airway
- 2) List pertinent physical findings in a child with a potentially difficult airway
- 3) Discuss pediatric syndromes that may be associated with a difficult airway
- 4) Discuss the management of a child with a known difficult airway
- 5) Discuss management of a child with an unexpected difficult airway.

A difficult airway is defined as any situation that presents ineffective oxygenation/ventilation of the patient by means of bag-mask ventilation, laryngoscopy, or intubation and that may lead to a surgical airway (needle cricothyrotomy or tracheostomy.) A difficult airway in a pediatric patient (anticipated or not) can be a stressful situation for all involved. Having a systematic approach to evaluation and managing the unique pediatric airway (including complete loss of the airway) will minimize trauma to the patient and practitioner when a difficult airway presents itself. Anesthesiologists are recognized experts in understanding airway anatomy/ physiology, significant airway distress and devising protocols for managing the airway and potential complications. As many protocols are designed for adult patients, the small size of pediatric patients and frequent need for sedation or general anesthesia demand that techniques used in adults may have to be modified.

A child with a compromised airway may present to any facility with emergency services, so clinicians must be able to recognize and intervene effectively to restore or stabilize the airway. Anesthesiologists must ensure that facilities have proper equipment available to manage a pediatric airway and have a protocol for responding. The wide range of pediatric sizes (premie to morbidly obese teens) makes a wide variety of sizes of equipment a necessity. The difficult airway cart in an adult facility will not look like a difficult airway cart in a pediatric facility.

One approach to the difficult airway is to divide the situation into anticipated or unanticipated difficult airway. The anticipated difficult airway then includes congenital syndromes or anatomy that may present early in life and acquired anatomy that may present at anytime. Acquired difficult airways include infectious etiologies such as epiglottitis, croup, bacterial tracheitis, peritonsillar/retropharyngeal abscesses and acutely acquired anatomy such as trauma or foreign body aspirations.

Difficult Pediatric Airway

Anticipated

- 1) Congenital lesions:
Syndromes with anatomic features such as micrognathia (see below), cervical spine anomalies, vascular rings/slings, glottic obstruction such as webs/hemangiomas, cleft palate, macroglossia

Unanticipated

No known predictors

2) Acquired Lesions

- a) Infections (epiglottitis, croup, abscesses, tracheitis, diphtheria, papillomas)
- b) Airway trauma
- c) Foreign body aspiration

Situations/syndromes in which direct visualization of the glottis may be impossible

Micrognathia (small mandibular space)

Pierre Robin syndrome/sequence

Treacher Collins syndrome

Goldenhar syndrome (may also have cervical spine anomalies)

Stickler's syndrome

Velocardiofacial syndrome

Fetal alcohol syndrome

Apert's syndrome

DiGeorge Syndrome

Isolated micrognathia (20% of cases)

Cervical Spine Anomalies (instability or limited mobility)

Klippel-Feil syndrome

Goldenhar syndrome

Arthrogryposis syndromes

Down Syndrome

Crouzon's syndrome

Macroglossia

Hunter Syndrome

Hurler Syndrome

Beckwith Weideman Syndrome

Down Syndrome

Others

Miscellaneous Anatomical Challenges

Cleft lip/palate

Cystic Hygroma

Encephaloceles

Freeman-Sheldon syndrome (limited mouth opening)

Body piercings

Trauma/Burns

Obesity

In any airway situation the algorithm first to be considered is whether the airway is **Surgical or Nonsurgical**. An airway that may be nonsurgical can be turned into a surgical airway if a patient has multiple attempts at intubation by others or has moved down the difficult airway algorithm to the point that any further inspection and manipulation of the airway may be detrimental or futile. If the patient has an airway at all in that situation (LMA, oral AW with bag-mask ventilation) then the question is whether the most experienced person in the room should attempt a final inspection and attempt at intubation or proceed with surgical airway.

If the decision is made to establish the airway nonsurgically then the question becomes **“awake or asleep?”** In general pediatric patients except the most moribund are unlikely to cooperate with any interventions awake so local anesthetics and sedation must be considered. The sedated patient may be considered not awake, yet not asleep. If the decision is made to proceed with asleep techniques the benefits of general anesthesia must be weighed against the potential risk of loss of airway reflexes, spontaneous ventilation and complete loss of the airway. Additionally the question then will be whether attempts should be made to maintain **spontaneous ventilation or proceed with relaxants/paralytics** to secure the airway.

When a child with a difficult airway presents emergently the degree of airway compromise must be determined quickly. Unless contraindicated by known congenital heart disease, supplemental oxygen should be administered while simultaneously assessing:

ABCs

General appearance – awake/moribund, agitation, anxiety, weak/absent cry, cyanosis, posture, voice

Work of breathing – retractions, stridor, chest wall movement, use of accessory muscles, depth of inspiration

Range of motion of mandible and neck

History if available – timing of respiratory distress, precipitating factors, choking, recent illnesses, prior airway experience or difficulties.

If any studies are deemed necessary (PA/Lat neck or chest) the child may need to be accompanied by airway experts should complete loss of the airway occur. The need for speed in the pediatric patient (especially infants) is due to greater O₂ consumption and less oxygen reserve. Hypoxemia occurs much more rapidly than in a similar situation in an adult patient. If the child is protecting his airway, the most efficient use of energy may be to provide oxygen while preparing all necessary equipment to establish a more definitive airway

What are anatomical and physiologic differences in the pediatric airway compared to the adult airway?

Pediatric Airway Anatomy

- Small compliant trachea
- Anterior and cephalad glottis (C3-4 at birth)
- Small nares and jaw
- Nosebreathers in first 3 months of life
- Large head, esp. occiput (natural flexion when supine)
- Abundant soft tissue (tonsils, adenoids, tongue, etc.)
- Long narrow epiglottis (may be short and angled)
- Cords slant anteriorly (posterior commissure more cephalad)
- Cricoid ring is narrowest point
- Few Type I respiratory fibers
- Horizontal ribs
- Short trachea (5.5 cm vs 12-14cm in adults)
- Larynx is cone-shaped, not a cylinder

Pediatric Airway Physiology

- Increased O₂ consumption (>= 6cc/kg/min vs 3cc/kg/min adult)
- Increased CO₂ production (6cc/kg/min)
- V_t 6cc/kg (same as adult on weight basis)
- Increased respiratory rate (35/min vs 16/min adult)
- Alveolar ventilation twice that of adults
- FRC 30cc/kg for adults and neonates
- Ventilation is diaphragm dependent
- Easy fatigue of diaphragm and intercostals
- Decreased mechanical advantage of chest wall
- O₂ dissociation curve shifted to left in neonates (p₅₀ of HgbF is 19mmHg)
- Decreased peripheral delivery of O₂ offset by higher hematocrit in newborns (~60%)

Airway Evaluation

The true incidence of difficult airway in children is not known. The Mallampati Scale is recognized as a useful measure of predicting the ease of establishing an adult airway. One of the limitations of the Mallampati score in young children is to get cooperation in mouth opening; older children are generally cooperative with the airway exam. Recognizing the differences in the premie airway and that of morbidly obese teenagers, there is no acceptable standard airway exam in children and the Mallampati exam does not correlate well to children. Koop et al found that 12 of 16 children with difficult laryngoscopy had Class 1 or 2 Mallampati exams.

Some prefer the COPUR Scale for evaluation in children (ref Lane.) This scale rates **C**hin size, interdental **O**pening, **P**revious intubation or OSA, **U**vula visualization, and estimated **R**ange of motion of neck on a 4-point scale. Scores above 10 predict difficult intubation. Failing a cooperative exam on a pediatric patient, it is helpful to view the patient in profile paying particular attention to facial anatomy (brow, eyes, ears, maxillary size, teeth, cleft lip/palate), mandibular size (micrognathia/retrognathia) and opening, cervical spine mobility, chest wall abnormalities, and preferred posture for breathing.

Tools and Tricks for the Difficult Pediatric Airway

When faced with a difficult airway, experience and familiarity of the anesthesiologist with the variety of devices available will determine the approach. If intubation is elective or optional, alternatives to endotracheal intubation should be considered. Supraglottic devices such as the LMA, the Laryngeal Tube, Combitube and Cobra Perilaryngeal Airway may be used.

Alternatives to intubation

Supraglottic devices should provide an airway with minimal manipulation. Minor airway trauma is not uncommon and airway protection is not guaranteed.

The laryngeal mask airway (**LMA –NA**) became available in the UK in 1988 when Dr. Archie Brain released his invention; it was approved for use in the US by the FDA in 1991. It is available in sizes for newborns to adults and has been used extensively in ORs and offsite locations (radiology, GI, pulmonary suites) as well as airway rescue

and as an assist to intubation. They are latex-free and are designed for single use to minimize disease transmission. Success with insertion is reported to be 97%.

Weight	LMA size	Largest ETT
<5kg	1	3.5
5-10kg	1.5	4.0
10-20kg	2	4.5
20-30kg	2.5	5.0
>30kg	3	6.0

Modifications of the classic LMA include the Flexible LMA with a longer reinforced tube, the Fast Track LMA with rigid elbow suited for position above the glottis for blind intubations (not yet available in sizes smaller than 3 and ETTs of 6.0), and the ProSeal LMA designed to facilitate positive pressure ventilation with airway protection. This special use LMA has an orifice that allows for passage of a gastric tube to the esophagus and stomach.

Unique pediatric anatomy may present difficulty with positioning LMAs; complications including edema from overinflation of the cuff, pulmonary aspiration and downfolding of the epiglottis have been reported in children.

The **Combitube and Laryngeal Tube** (King Systems Corp) is a single lumen tube with two high-volume, low-pressure cuffs, a larger oropharyngeal cuff and a smaller distal esophageal cuff that seals the upper esophagus. The distal end is closed to prevent reflux of esophageal or gastric material. Two ventilating orifices lie between the cuffs. Few studies conducted in children so far.

The **Cobra Perilaryngeal Airway**, PLA (Engineered Medical Systems) is designed to be positioned in the hypopharynx where it abuts the laryngeal inlet; the distal head sits over the glottis against the aryepiglottic folds. The low-pressure, high-volume cuff occludes the nasopharynx pushing the tongue forward to prevent air leaks. One cohort study of this device was stopped after 2 of 29 children experienced pulmonary aspiration.

Alternatives to Direct Laryngoscopy

When a definitive airway is necessary and intubation is not optional, several alternatives may be considered if direct laryngoscopy is unsuccessful or impossible. Several devices are available including lighted stylets, videolaryngoscopes, and fiberoptic intubation.

Lighted and fiberoptic stylets include Trachlights, lightwands, and Optical Stylets. These portable and lightweight techniques have a built-in light source and depend on external illumination of the neck; infant, pediatric and adult sizes are available. Contraindications to their use include airway tumors, foreign bodies and infections. An appropriate size ETT is mounted on the stylet which is inserted blindly in the midline, observing for a bright glow to indicate passage into the trachea after which the ETT is advanced off the stylet into the airway.

Fiberoptic stylets are portable lightweight with a built-in light source and fiberoptic scope and depend on visualization of the larynx. They are less expensive than fiberoptic bronchoscopes and adult and pediatric sizes are available. There is a port for Oxygen insufflation. Relative contraindications are those for fiberoptic bronchoscopy (bleeding and excessive secretions.)

Bullardscopes and Videolaryngoscopes (GlideScope, Saturn Biomedical Systems) combine the benefits of rigid laryngoscopy with the visualization of fiberoptic techniques and direct vision. They are useful for patients with restricted mouth opening and cervical motion. Adult and pediatric sizes are available; an infant GlideScope will be available in 2008.

The GlideScope blade has a 60° angle with a video camera and light source along the inferior edge. This allows an unobstructed view of the anterior epiglottis. The equipment interfaces with other video systems so that the airway anatomy may be demonstrated for teaching opportunities. This device may be used by those with limited skills at FOB as it is relatively easy to teach and learn. When the glottis is in view a stylet ETT is advanced into the trachea under vision.

Fiberoptic bronchoscopy allows intubation under vision with less trauma and distortion of the airway.

Visibility is limited by blood or secretions and consideration should be given to a preoperative antisialogogue if FOB is anticipated. FOB should be considered early when dealing with a difficult airway for the same reason. As with any of the above techniques some dexterity and proficiency is required and should be practiced in normal airways in advance of its use in difficult airways. The technique may be used for oral or nasal intubations. The anterior infant glottis may be more easily navigated from the nasal approach avoiding the acute anterior flexion into the trachea.

Neonatal scopes 2.2 mm OD are available for newborns and infants; these lack ports for suction or oxygen insufflation. Pediatric scopes 2.8-3.1 mm OD can be used for children up to 8 years of age. Older children will

accommodate 4.0-5.6 mm OD scopes. An experienced assistant is needed for monitoring the patient and aiding with jaw thrust.

Invasive or Surgical Airway Access

Needle Cricothyrotomy (Commercial kits available)

Transtracheal Jet Ventilation

Retrograde wire intubation (Commercial kits available)

Tracheostomy

In an emergency situation when all airway attempts have failed, the options are to awaken the patient (if an option) or advance to invasive techniques. Needle cricothyrotomy may provide adequate oxygenation with or without jet ventilation until a definitive airway is secured. Retrograde wire techniques may be used alongside a needle cricothyrotomy to allow intubation from above while ventilating the patient via the cannula.

When an unanticipated airway presents itself, the clinician needs to have ready access to extra equipment and additional hands to assist with the airway. If mask airway is difficult, an oral airway, 2-person mask airway, or LMA may precede an attempt at intubation. If unable to intubate the decision may be made to awaken the stable patient or attempt mask ventilation/intubation with optimal positioning and a different blade or other airway tools discussed. If the situation becomes can't intubate/can't ventilate, any technique that allows oxygenation of the patient may be used temporarily as preparation is made for an invasive airway.

Other topics for review

Epiglottitis – Still out there despite Hib

Foreign Body of the Airway – Who gave this child a peanut?

Laryngeal papillomatosis

Oh, Nice Tongue Ring!

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