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7:30  Registration begins

8:00 am  Introduction, Welcome  
David Polaner, MD, FAAP

8:15 am  Embryology and Development of the Airway  
Robert Holtzman, MD

9:00 am  Question and Answer  
Holtzman

9:05 am  Reappraisal of the Pediatric Airway Anatomy  
Scott Markowitz, MD

9:35 am  Airway Imaging  
Bruno Marciniak, MD

10:20 am  Question and Answer  
Markowitz & Marciniak

10:30 am  Break/View Exhibits

11:00 am  Cuffed Endotracheal Tubes in Children-Beneficial and Safe  
Andreas Gerber, MD

11:45 am  Real Time Respiratory Data to Guide Ventilation  
David Polaner, MD, FAAP

12:15 pm  Question and Answer  
Gerber & Polaner

12:30 pm  Lunch Room: Yale, Lobby & Terrace  
& View Exhibits

1:30 pm  Abstracts Presentations

2:00 pm  Cystic Fibrosis: Update and Recent Advances  
Scott Sagel, MD

2:40 pm  Flexible Bronchoscopy and Laryngo-tracheomalacia  
Robin Deterding, MD

3:20 pm  Laryngotracheal Reconstruction  
Peggy Kelley, MD

4:00 pm  Question and Answer  
Sagel, Deterding, and Kelley

4:15 pm  PANEL: Perioperative Management of Asthma  
Deterding, Szolnoki, Rabinovitch; Polaner-Moderator

5:15 pm  Evaluation

5:30 pm  Adjourn
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          Robert Yellon, MD
12:00 pm Questions and Answers
        Erb and Yellon
12:15 pm Lunch Room: Yale, Lobby & Terrace
        & View Exhibits
1:15 pm  **Dexmedetomidine**
          James Cain, MD
1:45 pm  **Effects of Dexmedetomidine and Propofol on Airway Anatomy**
          Mohamed Mahmoud, MD
2:30 pm  **Videostroboscopy**
          Lawrence Borland, MD and Joseph Dohar, MD
3:00 pm  Questions and Answers
          Cain, Mahmoud, Dohar, and Borland
3:15 pm  **PANEL: Airway Management Outside the OR**
          Dobyns, Lane, Givens, Agarwal-Moderator
4:15 pm  **Abstracts**
5:00 pm  Evaluation
5:15 pm  Adjourn
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8:00 am  **Introduction**  
Lawrence Borland, MD
8:10 am  **The Larynx**  
Mona Abaza, MD MS
9:00 am  **Sleep Studies and Evaluation for Surgery**  
Norman Friedman, MD
9:45 am  **Drugs and Obstructive Sleep Apnea**  
David Polaner, MD
10:30 am  **Trisomy 21 and the Airway**  
Lawrence Borland, MD
11:00 am  **Teaching and Evaluating Airway Skills**  
Geoffrey Lane, MB
11:45 am  Questions and Answers  
Abaza, Friedman, Polaner, Borland, and Lane
12:15 pm  Evaluation
12:30 pm  Lunch – informal Room: Yale, Lobby & Terrace
12:30 pm  **Airway Workshop**  
Geoffrey Lane, MB, Judit Szolnoki, MD, Rita Agarwal, MD, Jennifer Zieg, MD
2:00   Evaluations
2:15   Adjourn
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THE LARYNX

Mona M Abaza, MD, MS
University of Colorado School of Medicine, Department of Otolaryngology

Financial Disclosures

• No relevant financial relationships with any commercial interests.

What’s left?

• Talked about
  – Embryology
  – Airway reconstruction
  – Strobovideolaryngoscopy
• Requests
  – Evaluation
  – EMG
  – Injection methods
Evaluation of THE LARYNX

- Vibratory Margin measures
- Aerodynamic Measures
- Phonatory Function Measures
- Acoustic Signal Measures
- Laryngeal Muscle Measures
- Psychoacoustic Measures

Laryngeal Function

- Strobovideolaryngoscopy
- High-speed photography
- Videokymography
- Electroglosttography
- Aerodynamic measures
- Acoustic Parameters
  - Phonatory Function
  - Acoustic analysis
- Subjective measure

Strobovideolaryngoscopy

- Images retained on Retina 0.2 seconds
- Desynchronized light
- Digital systems allow the camera to capture only one frame, unlike previous videos systems
- Limitations
  - Diplophonia
  - Sever hoarseness
  - Voice Breaks
  - Vocal Tremor
**High-Speed Video**

- 2 second study requires 4.44 seconds to play back
- Uses
  - Onset and offset of oscillation
  - Evaluate tension, stiffness, mass and other parameters
  - Diplophonias
  - Vocal Tremor

**Videokymography**

- 7812.5 images per second vs 50 per second on videotape
- Uses
  - Pre and Post operative evaluation of the treatment of scar
  - Subharmonic variations
  - Multiple glottal cycle openings
  - Irregular vibrations

**Electroglottography**

- Weak high frequency current passed through the larynx from one electrode to another
- Opening and closing varies the transverse electrical voltage
- More accurate during closed phase
- Quantitative evaluation possible
Electroglottography

- Flow Glottogram
  - Estimate of glottal airflow produced during speech
  - Filter out the resonance of the vocal tract
  - More information about the open glottis

Aerodynamic Measures

- Pulmonary Function Testing
- Pneumotachograph and Hot-wire anemometer
  - Subglottic pressure (invasive measurement)
  - Supraglottic pressure
  - Glottal impedance (calculated)
  - Velocity of airflow at the glottis (calculated)
  - Other calculated measures
    - Mean flow rate (male: 100 ml/sec, female: 92 ml/sec)
    - Glottal resistance

Phonatory Function Measures

- Maximum Phonation time
  - Male: 34 seconds
  - Female: 26 seconds
- Frequency-Intensity Profile
  - Phonetogram
    - Calculated parameters
      - Glottal efficiency
      - Airflow intensity profile
Acoustic Analysis

- Objective measurements of the acoustic signal
- Defined microphone distance and phonatory task
- Defined normal parameters

Acoustic Analysis

- Fundamental frequency
- Jitter (frequency perturbation)
- Shimmer (amplitude perturbation)
- Noise to harmonic ratio
- Soft phonation index

Acoustic Analysis

- Voiced/Voiceless measures
- Tremor indexes
- High/low frequency measurements
- Voicing time
- Subharmonics
Acoustic Analysis

- Cepstral Peak
  - More reliable measures of dysphonia and breathiness
  - Computer calculated values
  - Seems to more useful in disordered voices

Signal Classification

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<tr>
<th>Type</th>
<th>Characteristics</th>
<th>Measures</th>
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<td>Periodic with no qualitative changes</td>
<td>Perturbation analysis (Jitter, Shimmer, NHR)</td>
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<tr>
<td>II</td>
<td>Qualitative changes</td>
<td>Subharmonics and modulating frequencies</td>
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<tr>
<td>III</td>
<td>No periodic structure to signal</td>
<td>Perceptual Ratings</td>
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Psychoacoustic Evaluations

- GRBAS scale (5 pt scales)
  (0-normal, 1-mild, 2-moderate, 3-extreme)
  - Grade
  - Roughness
  - Breathiness
  - Asthenic quality
  - Strain
Laryngeal Muscle Measures

- LEMG
  - Diagnostic
  - Therapeutic
  - Intra-operative

Anatomy

- Superior laryngeal nerve
  - Nodose ganglion
    - External (motor): Cricothyroid
    - Internal (sensory): Motor?
- Recurrent laryngeal
  - Left: Aortic arch
  - Right: Brachycephalic artery

Anatomy

- Interconnections of SLN and RLN in region of interarytenoid numerous
- Neuroanatomy of laryngeal pathways not well understood yet
Anatomy

• Thyroarytenoid (TA)
  – Adducts, lowers, shortens and thickens vocal fold
  – Vocalis (medial belly)
    • Slow twitch fibers
    • Phonation
  – Muscularis (lateral portion)
    • Fast twitch fibers
    • Adduction

Anatomy

• Cricothyroid (CT)
  – Lowers, stretches, elongates and thins the vocal fold
  – Longitudal tension (pitch)
  – Largest intrinsic laryngeal muscle
    • Oblique Portion
    • Vertical Portion

Anatomy

• Interarytenoid (IA)
  – Adducts cartilaginous portion of vocal fold, closing posterior gap
    • Transverse fibers (Lateral margin to contralateral lateral margin)
    • Obliques fibers (Base to contralateral apex)
  • Lateral Cricoarytenoid (LCA)
    – Adducts, lowers, elongates and thins the vocal fold
    – Allows edge to have a more angular or sharp contour
Anatomy

- Posterior Cricoarytenoid (PCA)
  - Abducts, elevates, elongates and thins vocal folds
  - Rounds vibratory edge

- Type I
  - Highly resistant to fatigue
  - Contract slowly

- Type II A
  - Rapidly contracting
  - Fatigue resistant

- Type II B
  - Rapidly contracting
  - Fatigue easily

Anatomy

- Laryngeal muscles
  - Higher proportion of Type II A fibers
    - TA and LCA
  - Multiple innervations for motor endplates
    - CT: 20-30 muscle fibers per unit
      - Similar to intraocular and facial expression muscles
      - Gastronomous 1700:1
    - TA: 70-80% of muscle fibers have two or more endplates
Indications

- Hypomobility of the vocal fold
- Dystonias

Electrode Types

- Monopolar
  - Solid needle, fully insulated except for the tip
  - Recording area circular
  - Potentials larger, longer and with more phases
- Bipolar
- Concentric
- Hooked wire
- Single fiber

Electrode Types

- Concentric
  - Hollow needle with a silver, steel or platinum wire through it
  - Insulated except tip
  - Directional recording characteristics
### Electrode Types

- **Bipolar**
  - Hollow needle with two platinum wires, both insulated except for the tip
  - Outer shaft grounded
  - Restricted recording range
  - Shorter and lower voltage potentials recorded compared to concentric

- **Hooked wire**
  - Hooked, uninsulated tip
  - Stabilizes once released from inserting needle
  - Cannot be repositioned

- **Single Fiber**
  - Electrode along shaft with shaft acting as reference electrode
  - Single fiber comparisons in neuropathic disorders (MG, ALS)
    - **Jitter**: difference between two time-locked firing potentials of the same motor unit
      - Increased in impulse blocking in MG
    - **Fiber Density**: number of muscle fibers by unit
      - Increased in myopathies and early reinnervation
Methods

- TA
  - Transcricoid
  - Transoral
  - Used for botox
- PCA
  - Transcervical need to rotate larynx
  - Transoral
- LCA
  - Transcervical most common
  - Transoral more challenging

Interpretation

- Considered subjective by many
- Qualitative analysis of signals has proven challenging

Interpretation

- Insertional Activity
  - Normal: Burst of activity not longer than several hundred milliseconds
  - Increased: Unstable muscle membranes in early nerve and muscle injuries
  - Decreased: Fibrosis or scar changes in late nerve or muscle injury
**Interpretation**

- Spontaneous Activity
  - Normal: None at rest
  - Presence indicates degeneration and/or ongoing injury
  - Begins 2-3 weeks after denervation
  - Poor prognosis

**Interpretation**

- Waveform
  - Shape, amplitude and duration of motor unit potentials
  - Normal
    - Biphasic (upward positive, downward negative)
    - Reflects changes in the electrical activity of the muscle membrane
    - Amplitude 200-500 microvolts
      - Number and strength of muscle fibers
    - Duration 5-6 milliseconds
      - Velocity of neural input (influenced by insulation of the nerve)

**Interpretation**

- Waveform
  - No abnormal units: Active denervation
  - Nascent Units: Recent nerve injury
    - Small amplitudes, long durations and polyphasic shapes
      - Tiny, minimally insulated nerves with weak muscle fibers
Interpretation

- **Waveform**
  - Giant polyphasic
    - Not all fibers regenerate, more branching of those that do
    - Greater than normal amplitudes and durations
  - Polyphasic with normal duration
    - Nerve uninjured but muscle damaged
    - Amplitude smaller (reflects decreased mass and force of contraction)

Interpretation

- **Recruitment**
  - Serial activation of motor units during increased voluntary muscle contraction
  - Seen as increase in number and density of motor unit potentials

So it doesn’t work, now what?

- Injection
- Thyroplasty
**Injection Laryngoplasty**

- 1911: Injection techniques first described by Brunning
- 1915: First investigations of framework surgery by Payr
- 1970’s: Isshiki’s systemic design for thyroplasty
- 1986: Kaufman popularizes thyroplasty in US

**Injection Techniques**

- Indications
  - Mobile vocal folds
  - Atrophy, Bowing
  - Paresis of SLN or RLN
  - Paralyzed vocal folds
    - Less than one year or 6 months with EMG indication of regeneration, earlier if temporary materials used
    - Small (1-2mm) gap with or without framework surgery

**Injection Materials**

- Teflon (polytetrafluoroethylene)
  - Very good initial success but has unacceptable rate of granuloma formation
  - Dedo argues that granulomas only happen in poorly placed or excessive teflon
Injection Materials

- Collagen
  - Autologous Collagen
    - 9 x 6 inch segment of skin needed to harvest
    - Several month delay
    - Low density collagen good biomechanical match to SLP and TA
  - Bovine Collagen
    - Technically requires skin testing
    - Best survival in superficial layer, but may cause stiffness
    - Reabsorption has been variable but considered a permanent material

- Micronized Dermis (Cymetra ~8-12+ weeks)
  - Preparation arduous, good temporary substance

- Autologous Fat
  - Long-term studies have proved efficacy
  - Biomechanical properties are similar to vocal folds
  - No standard for preparation
  - Reabsorption at one month variable (30-50%), but what’s left is stable at 3 to 5 years
  - Most feel difficult to consistently correct greater than 2mm gap
### Injection Materials

- **Gelfoam (~4-6 weeks)**
  - Preparation, large needle, OR only
- **Hyaluronic Acid (Restylane~4-6 months)**
  - Limited experience in TVF, longer acting, off-label use
- **Carboxymethylcellulose/glycerin/water (Radiesse Voice Gel~ 6-10 weeks)**
  - Off the shelf, easy to prepare
  - Good duration for trial or temporary injection
- **Calcium Hydroxylapatite (Radiesse Voice ~ avg. 18 months)**
  - Very poor visco-elastic match to vibratory edge

### Injection Techniques

- **Endoscopic**
  - Micro suspension laryngoscopy
  - Trans-oral or trans-cervical fiberoptically guided
  - Flexible scope with injection port

### In Kids???

- 13 patients, 27 injections
- Gel Foam, Radiesse Voice, Radiesse Voice gel
- 89% subjective improvement
- 1 patient with objective stridor for 2 days
- No long term follow up
  - Cohen et al, 2011
Conclusion

- Many techniques to evaluate the LARYNX
- Many limitations to our knowledge
- Not many pediatric studies in this area
Financial Disclosures

- No relevant financial relationships with any commercial interests.

Objectives

- To define the indications for obtaining a sleep study.
- To demonstrate the components measured during the study and the methodology used.
- To illustrate how one interprets the results.
- To describe the systemic effects of OSA and its implications for the perioperative period.
Sleep-Related Breathing Disorders

- Primary Snoring (10-12%)
- Upper Airway Resistance Syndrome
- Obstructive Hypoventilation
- OSA (1-3%)

Increasing Severity

All children should be screened for snoring. Complex high-risk patients should be referred to a sleep specialist for evaluation.

Diagnostic PSG is useful to distinguish OSA from primary snoring.

T&A is first line therapy for most children.

Critical Closing Pressure

- P crit = the critical luminal pressure where the airway collapses
- flow
- apneas
- hypopneas
- normals

Critical closing pressure cannot be evaluated electively.

AMERICAN ACADEMY OF PEDIATRICS
Section on Pediatric Pulmonology, Subcommittee on Obstructive Sleep Apnea Syndrome
Clinical Practice Guideline: Diagnosis and Management of Childhood Obstructive Sleep Apnea Syndrome

- All
- High-risk failure cannot
- Diagnostic PSG
- First line
The Reality

- In a 2005 survey of the members of the American Society of Pediatric Otolaryngology, only 10% of children who underwent an adenotonsillectomy had a pre-operative PSG. Typically, the PSG was being requested by the pediatric otolaryngologist when the diagnosis was questionable.

You’re OUT !!!!!

Outpatient Tonsillectomy for SDB

- Retrospective study
- 134 patients mean age 6 +/- 2.6 years
- Indication for surgery was SDB 115
- Presumptive diagnosis

- Results
  - Eleven or 8% admitted from day surgery unit
  - Majority of respiratory issues
  - Mean age was 4 years
  - 92% discharged home mean duration of stay 144 minutes
  - 4 of discharged patients readmitted but none for respiratory problems

✓ CONCLUSION:
- Post-operative monitoring will identify those patients who require admission for respiratory insufficiency prior to discharge
My recommendations:

- Sleep studies Pre-Op ordered when:
  - Young children (<2 years of age)
  - Questionable history & physical exam
  - Syndromic children
  - Severe co-morbidities

Rosen, Pediatrics 1994

Objectives

- To define the indications for obtaining a sleep study.
- To demonstrate the components measured during the study and the methodology used.
- To illustrate how one interprets the results.
- To describe the systemic effects of OSA and its implications for the perioperative period
What does a pediatric PSG evaluate?

- **EEG**
- **EOG**
- **EMG**
- **HR / RR**
- **Snore Microphone**
- **Airflow & Effort**
- **Gas Exchange (O₂ & CO₂)**
- **Position**

**Pediatric Sleep Study**

- Pediatric Trained Respiratory Therapist
  - May be the best tool
- End-Tidal CO₂
  - Partial Obstructive Hypoventilation
- Video Monitoring
  - Pitiful Index
- Have redundancies
- Pediatric Interpretation

Friedman, Norm, MD, DABSM
Sleep Studies and Evaluation for Surgery

ISPA 6
Is a respiratory event present?

Yes: If you use a nasal pressure sensor!

End Tidal CO₂ waveform
Flow Limitation

Objectives

- To define the indications for obtaining a sleep study.
- To demonstrate the components measured during the study and the methodology used.
- To illustrate how one interprets the results.
- To describe the systemic effects of OSA and its implications for the perioperative period

Terminology: Indices

- Obstructive Apnea / Hypopnea Index
- Central Apnea Index
- Apnea/ Hypopnea Index
- Respiratory Disturbance Index
- Arousal Index
- Respiratory Event Related Arousal (RERA) Index
- Pitiful Index
<table>
<thead>
<tr>
<th>Index</th>
<th>Full name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAI</td>
<td>Central apnea index</td>
<td>Only central respiratory events</td>
</tr>
<tr>
<td>AHI</td>
<td>Apnea/Hypopnea index</td>
<td>All respiratory events except for RERAs</td>
</tr>
<tr>
<td>RDI</td>
<td>Respiratory disturbance index</td>
<td>All respiratory events including RERAs</td>
</tr>
<tr>
<td>OAHI</td>
<td>Obstructive apnea/Hypopnea index</td>
<td>Includes OA, OH and mixed apneas</td>
</tr>
<tr>
<td>RERA-I</td>
<td>Respiratory event related arousal index</td>
<td>Only includes RERAs</td>
</tr>
</tbody>
</table>

**Does she have OSA?**

**FLOW**

Paradoxical
Normal Respirations

Paradoxical Respirations

What is a significant Obstructive apnea/hypopnea index?

Pediatric Severity Scale

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>0</th>
<th>1-4.9</th>
<th>5.0-9.9</th>
<th>≥ 10.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>OAHI</td>
<td>0-9</td>
<td>1.0-4.9</td>
<td>5.0-9.9</td>
<td>≥ 10.0</td>
</tr>
<tr>
<td>RERA</td>
<td>0-9</td>
<td>1.0-4.9</td>
<td>5.0-9.9</td>
<td>≥ 10.0</td>
</tr>
<tr>
<td>Total Arousal Index</td>
<td>0-9.9</td>
<td>10.0-14.9</td>
<td>5.0-9.9</td>
<td>≥ 20.0</td>
</tr>
<tr>
<td>Sat Nadir</td>
<td>≥ 90%</td>
<td>85% to 89%</td>
<td>80% to 84%</td>
<td>≥ 79%</td>
</tr>
</tbody>
</table>

Montgomery-Downs HE Sleep. 2004 Feb 1;27(1):87-94.
Adult Severity Scale

- Mild AHI 5-15
- Moderate AHI 15-30
- Severe AHI > 30

Pitfalls

- Different Laboratory
- Rebound REM sleep
- Nasal Pressure sensor
- Increase supine sleep
- RDI rather than OAHI
- Develop a close relationship with your sleep lab

Does Pre-op Sleep Studies help the clinician?
Objectives

- To define the indications for obtaining a sleep study.
- To demonstrate the components measured during the study and the methodology used.
- To illustrate how one interprets the results.
- To describe the systemic effects of OSA and its implications for the perioperative period.

Pathophysiology

- Owens RL Curr Opin in Pulm Medicine 2007
- Obstructive Sleep Apnea is a heterogeneous disease with multiple root causes OR Structurally vulnerable airway interacting with unstable ventilation with reduced/absent dilator muscle activation while asleep.
- BT Woodson

Balancing Act

- Airway predisposed to collapse
- Neuromuscular compensation

Friedman, Norm, MD, DABSM Sleep Studies and Evaluation for Surgery
Anesthesia and OSA

- 4 anesthetic implications:
  - Systemic effects of apneic cycle
  - Impact of anesthetic drugs
  - Dynamics of negative pressure pulmonary edema
  - Hypoxic response

Apneic Arousal Cycle

Morbidity of SDB

**Physiologic**
- Sleepiness
- Cardiovascular
  - Pulmonary HTN
  - Left Vent. Hypertrophy
- Poor growth
- Depressed mood
- Healthcare utilization

**Behavioral**
- Restlessness
- Shyness
- Aggressive
- Hyperactivity
- Impulsivity
- Poor planning
- Inattentive
- Poor school performance
Anesthetic Drugs

- Decrease pharyngeal tone
- Promote pharyngeal collapse
- Attenuates ventilatory and arousal responses to hypoxia, hypercarbia, and obstruction
- Dose-dependent attenuation of respiratory activity of upper airway muscles, intercostal muscles, and diaphragm
- Worsen OSA as a result

Pathophysiology

- Anatomy
- Pathology
- Viscoelastic mechanics
- Flow mechanics: Starling Resistor
- Neuromuscular compensation
- Arousal
- Ventilatory control

Pathophysiology: Anatomy

- Skeletal
  - Obvious craniofacial dysmorphology
  - Longer pharynx post-pubertal males
- Pharyngeal soft tissues
  - Larger tonsils but not parapharyngeal fat pad
- Lumen
  - Dynamic narrowing a) UAR or b) compliance
- Craniofacial development
  - Soft tissues grow more rapidly than skeleton b/w 3 to 5 years
- Obesity
  - For adults PP fat pad and smaller lung volumes
Obstruction Sites

- Nose
- Nasopharynx
- Soft Palate
- Tonsils
- Post. Pharyngeal wall
- Base of Tongue
- Hypopharynx
- Larynx
- Lower Airway

Children with OSA have narrower pharyngeal airway

Considerations for the Obese Patient

- Nafiu et al, “Obesity and risk of peri-operative complications in children presenting for adenotonsillectomy”
- Database review of 2170 children s/p T+A over 3 year period
- Classified children into normal weight (1714), overweight/obese (456) according to BMI criteria
- Did not look specifically at OSA

Nafiu et al, OJPORL 2009

- Overweight and obese children were more likely to have:
  - Post-induction desaturation to <90% (40% vs 31%)
  - Multiple attempts at laryngoscopy (27% vs 12%)
  - Difficult mask ventilation
  - Post-induction and PACU upper airway obstruction
  - More likely to be admitted after surgery
  - BMI showed positive correlation with length of stay
  - BMI and presence of co-morbidities were independent predictors of LOS

Shows that obesity/overweight BMI is an important preoperative risk factor separate from OSA

Should obese/overweight children now be planned for post-operative admission?

Nafiu et al, OJPORL 2009
Pathophysiology: Viscoelastic

- As the intraluminal pressure becomes more negative at some point the airway will buckle
- The buckle point is the critical closing pressure

Mechanical Factors

- Static
  - Surface adhesive forces
  - Neck & Jaw posture
  - Tracheal Tug
  - Gravity
- Dynamic
  - Upstream resistance

Critical Closing Pressure (Pcrit)

- Index of viscoelastic and neuromuscular properties
- The lower your P crit the less collapsible your airway
- Children with OSA have a higher Pcrit or more collapsible airway.
- Hypercapnia increases airflow by lowering the P crit presumably by augmenting airway neuromotor activity in normal children
- No effect of hypercapnia on airway compliance for children with OSA. Hypercapnia does not help compensate for airway collapse
Pathophysiology: Neuromuscular Compensation

- Phasic activation of upper airway muscles with inspiration
  - Increase in airway lumen
  - Increase in airway stiffness
- Dilator muscles
  - Genioglossus (GG), Hyoglossus and Styloglossus
- OSA children have higher awake GG activity

Neuromuscular Compensation: Negative Pressure reflex

- Compensatory reflex
- Upper airway collapse results in reduction in minute ventilation and an increase in resp. effort
- The large negative luminal pressure activates mucosal mechanoreceptors that trigger the pharyngeal dilator muscles.

Pathophysiology: Arousal

- Arousal → opens airway and normalizes gas exchange
- Principle stimuli
  - Respiratory effort
  - Hypoxemia
- Hypoxemia is poor stimulus
- Arousal threshold varies by sleep stage
  - High arousal threshold may stabilize breathing by allowing time for recruitment of mechano or chemoreceptors to activate the pharyngeal dilator muscles
- Children with OSA require a greater stimulus for arousal to occur
Pathophysiology: Ventilatory Control

- CO2 level is the principle determinant of central respiratory drive
- If CO2 concentration is too low, have apnea until CO2 rises
- If apnea threshold for non REM sleep is too close to CO2 level for awake breathing → unstable
- If have exaggerated response to rise in CO2 → hyperventilation → vicious cycle
- Arousal from sleep augments muscular tone (Good) but also chemoR increases response (Bad), Overall effect: disrupt sleep
- For child, may have neuromuscular activation w/o arousal
- High arousal threshold is protective
- Upon falling asleep CO2 rises (protective)

<table>
<thead>
<tr>
<th>High End Tidal CO2</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apnea Threshold</td>
<td></td>
</tr>
</tbody>
</table>

ES Katz Proc Am Thoracic 2008
Do not forget the nose

Nasal Obstruction & OSA

- Reduce nasal afferent reflexes that help to maintain muscular tone of the upper airway
- Promote mouth opening, which destabilizes the lower pharyngeal airway
  - Posterior mandible rotation
  - Inferior displacement of the hyoid
- Reduce humidification
  - Increase mucus viscosity
  - Increase surface tension forces
- Increase upstream airway resistance
  - Due to Starling resistor predisposing to downstream airway collapse.
Drugs and Obstructive Sleep Apnea (OSA)

David M. Polaner, MD, FAAP
Professor of Anesthesiology and Pediatrics
University of Colorado School of Medicine and The Children’s Hospital Colorado

Many drugs affect airway patency and ventilation, yet are often needed in the perioperative period. Children with OSA are particularly vulnerable to the adverse effects of these agents, and may respond differently than children without OSA, yet new information on the underlying reasons for these differences is not commonly appreciated.

Airway patency: Although we worry greatly about how our patients will maintain their airways during induction of anesthesia, in the PACU and while receiving opioid analgesics, there is evidence that upper airway collapsibility in many children with OSA is increased even in the absence of drugs or anesthetics compared to children with normal sleep studies.(1) In an animal model, intermittent hypoxia was shown to reduce upper airway stability.(2) This means that under conditions of anesthesia, airway obstruction can be expected to be worse than in children without OSA, and that when sedating drugs like opioids are administered, postop obstruction during sleep may be likely to persist for at least a short time even after the anatomic reason for obstruction (that is, the tonsils and adenoids) is no longer present.

Premedication: The use of premedication (usually midazolam or another benzodiazepine) is somewhat controversial. Concerns regarding both preoperative respiratory depression or airway obstruction and prolonged postoperative sedation are often cited, but although this makes intuitive sense, there is no high-level evidence to support the practice or to refute it. Aside from anecdotal case reports there is a small (65 children) retrospective study that did not reveal any adverse events, but the quality of these data is poor.(3) Without better evidence, caution is recommended in the use of premedication, although anxiolytic doses of short acting agents like midazolam can be used with appropriate pre- and postoperative monitoring and observation. It should be noted that lower than usually administered doses of midazolam (0.25mg/kg vs 0.5mg/kg) have been found to be equally effective if a bit longer time is allowed to elapse after administration.(4)

Inhalation anesthetics: Children with OSA have much higher closing pressures during inhalation anesthesia with halothane compared to matched controls.(5) They also have diminished tidal volumes and minute ventilation compared with controls at 1 vol% ET halothane concentrations, with concomitant increased ETCO2 levels. Problems with this study include not controlling for equi-MAC levels at different ages of subjects and the inclusion of some subjects with Trisomy 21 in the OSA group, which may worsen the airway issues above that caused by OSA alone. The effects, however, can be profound: in this study the addition of only 0.5mcg/kg of fentanyl resulted in apnea in nearly 50% of the OSA patients. Halothane (although no longer available in the US) has been shown to cause less airway collapse than sevoflurane during induction at equi-MAC concentrations.(6) Sevoflurane has also been shown to cause more profound central respiratory depression than halothane at 1.4 MAC.(7) The increase in airway collapse caused by isoflurane (and presumably other volatile agents as well) appears to occur primarily at the level of the soft palate.(8)

Opioids: There have always been concerns regarding the use of opioids for patients prone to airway obstruction, and problems following tonsillectomy in these patients have been widely reported. Patients with adenotonsillar hypertrophy who undergo tonsillectomy are known to have the potential for postoperative airway complications even though the source of obstruction has been removed. This has long been ascribed to the blunted ventilator response to hypoxia and hypercarbia that takes weeks to resolve after relief of the obstruction. An abnormal ventilatory response to hypercarbia has been demonstrated in children with OSA, and certainly is a large part of why these patients have respiratory control issues.(9) However, this alone does not completely explain the problems that these patients may have in the immediate postoperative period, especially the first 24 hours after surgery, nor does residual anesthesia fully explain it.
A series of recent studies in animals and children show that chronic intermittent hypoxia, such as seen in children with more severe OSA, results in up-regulation of central opioid receptors and thus increased sensitivity to opioids. Thus intermittent hypoxia appears to exert an independent adverse effect on postoperative ventilation from that of hypercarbia, and by an altogether different mechanism.

Studies in piglets showed that intermittent hypoxia increased opioid binding in several brainstem regions, and that since opioid receptor affinity was unchanged, the increase was most likely due to up-regulation of the mu receptor population. Similarly, in a rat pup model of intermittent hypoxia (FiO2=0.12 during sleep, ambient air when awake for 2 weeks) respiratory sensitivity to fentanyl was seen.(10) In a group of children with OSA who underwent preoperative polysomography the nadir of the SpO2 during sleep was correlated with lower opioid requirements in the PACU.(11) That is, the lower the preop sleep SpO2, the less opioid needed to achieve equal levels of analgesia. Most notable were the patients with the lowest SpO2 (low 70’s or below), who needed NO opioid at all, and were comfortable with acetaminophen alone. A follow-up to this study stratified children with OSA undergoing adenotonsillectomy into a group with SpO2 > 85% and one <85%.(12) The dose of morphine in PACU needed to achieve equipotent analgesia in the more hypoxic group was about one half that of the less hypoxic group.

Implications and conclusions:

- Abnormal airway patency may be present in children with OSA, thus airway obstruction may not be immediately relieved by adenotonsillectomy.
- Children with OSA have diminished ventilatory responses to hypercarbia. This may be worsened with opioids and may take time to “reset” in moderate and severe OSA.
- The increased sensitivity to opioids is also likely exacerbated by up-regulation of μ opioid receptors in the CNS, and thus these patients are more sensitive to opioids.
- Because of increased opioid receptors, OSA patients with more severe preoperative hypoxia during sleep need less opioid to achieve equal levels of analgesia.
- Giving “normal” opioid doses to these patients probably represents a relative overdose.

References:


11. Brown KA, Laferriere A, Moss IR. Recurrent hypoxemia in young children with obstructive sleep apnea is associated with reduced opioid requirement for analgesia. Anesthesiology 2004;100:806-10; discussion 5A.

Trisomy-21
Anesthetic Considerations

Lawrence M. Borland, M.D
Associate Professor
University of Pittsburgh

In memory
of
William I Cohen M.D.
Director
Down Syndrome Center of Western PA
Children’s Hospital of Pittsburgh
Financial Disclosures

- No relevant financial relationships with any commercial interests.

Trisomy-21

**Incidence** is 1 in 755 live births - 1/150 conceptions

**Cause**

- Non-disjunction of paired chromosomes during formation of egg (95%) or sperm (5%)
- Only association: advancing parental age

**Genotypes**

- Trisomy 21 95%
- Mosaic 3-4%
- Translocation 2%
Clinical Features

- Hypotonia
- Mental retardation
- Short stature
- Prematurity
- Lower birth weight
- Brachycephaly
- Macroglossia
Clinical Features

- Small mandible & maxilla
- Excess nuchal skin
- Epicanthal folds
- Flat, depressed nasal bridge
- Atlantoaxial instability
- Velvety, loose adhering mottled skin in infancy; coarse skin in adolescence

Clinical Features

- Palpebral fissures slant upwards
- Brushfield spots
- Single palmar crease
- Posteriorly rotated ears
- Upturned nose
- Flattened occiput
- Short, broad hands
- Clinodactyly of the fifth finger
- Gap between first and second toes

More…. 

- Congenital heart disease 50%
- Endocardial cushion defects
- ASD & VSD
- Gastrointestinal Malformation 5%
- Duodenal atresia or stenosis
- Esophageal atresia
- Anal atresia
- Megacolon (Hirschprung’s)
More….

- Myopia
- Congenital Cataracts
- Joint Instability
  - Increased risk of atlantoaxial (C1-C2) subluxation
- Oncology
  - 10-30x risk of leukemia
  - Thyroid (hypo 15%, hyper)

Basis for ENT Issues

- Mid-facial hypoplasia
  - All “air-spaces” are smaller than sex-age matched controls

Head and Neck Disorders

- Hearing loss from Chronic Otitis Media
- Significant adenotonsilar hypertropy
  - OSA
- Macroglossia
- Subglottic stenosis
Causes of OSA

- Decreased anterior-posterior diameter of the nasopharynx
- Anomalous skull base
- Macroglossia
- Tonsillar hypertrophy
- Decreased tone with inhalational anesthesia

Upper Airway Obstruction under GA

- Relaxation of the soft tissues
- Large tongue
- Large tonsils
- Short neck

Subglottic Stenosis

- Smaller airways than other children
- Subglottic area
- Trachea narrowing
- Post-intubation stridor /croup are more common in patients with DS
Atlantoaxial Instability (AAI) and Subluxation (AAS)

- Confusion still exists for preoperative evaluation
- AAP report from 1994 recommends
  - Cervical neck x-rays at
  - Age of 5 and 6 when
  - Participating in sports
  - Or if neurologic symptoms exist

Cervical Neck X-rays

- Lateral neck x-rays
  - Neutral
  - Flexion
  - Extension

Normal Atlas-Odontoid process Distance

- Up to 4.5 mm is normal
- Activities should be restricted if greater than this amount
- Follow-up at regular intervals
Feeding Problems

- Hypotonia
- Poor suck/swallow incoordination
- Aspiration of thin liquids
- GERD

Trisomy-21
The CHiP Experience

930 anesthetic encounters in 488 patients (out of 74,021) with DS undergoing non-cardiac procedures were analyzed.

Borland, LM, et.al

Trisomy-21
The CHiP Experience

Most frequent ARC’s
- Bradycardia (severe) (3.66% vs. 0.36%)
- Natural airway obstruction (1.83% vs. 0.81%)
- Post-intubation croup (1.83% vs. 0.91%)
- Bronchospasm (0.43% vs 0.23%) ns
- Difficult intubation (0.54% vs. 0.32%) ns

Borland, LM, et.al
Bradycardia with Inhalational Agents

- Most notable with Halothane
- Can occur with all three agents, even Sevoflurane, however incidence is less
- Careful attention to precordial heart tones
- Avoid high concentrations of anesthetic agent
- IV access early

SBE Prophylaxis

- Guidelines available by AAP for specific heart lesions and surgical procedures
- Anesthesia for Infants and Children edited by Motoyama and Davis appendix B
Teaching and Evaluating Airway Skills

Geoffrey Lane MB, FRCA
Professor, University of Colorado Denver

Financial Disclosures

• I have no relevant financial relations with any commercial interests

Geoffrey Lane MB, FRCA

Anesthesia - procedures

• Airway: mask, DL, SGAs, Videolaryngoscopy, Fiberoptic
• Vascular: central venous, arterial
• Pain: neuraxial blocks, ultrasound guided blocks,
SAM meeting, Boston, 9/2008

“Every resident should do at least 100 fiberoptic intubations before graduation”

Dr Andranik Ovassapian, (1936-2010)

- Doing 100 cases may demonstrate experience, but does not prove proficiency or expertise
- With good teaching, proficiency may be accomplished more economically
- What’s needed is an objective method to evaluate skills
Why evaluate procedure skills?

(it's easier to test knowledge and reasoning)

- To guide and improve educational process
- To test ability and skills; for graduation, certification, licensure etc.
- These 2 goals may require different standards and measurements!

Pressures on training programs

- Shorter working hours = less time available
- OR efficiency discourages teaching
- More skills to learn, less time for each
- Public, and hence authorities, seek reassurance regarding skills and competence
Evaluation systems

- Check lists: simple, may be incorrect
- Observation: bias, can use criteria
- Cusum: esoteric statistics
- GRS: more reliable, comprehensive
- Simulation: complexity, cost vary

Learning procedural skills

- Student: innate skills, dexterity
- Teacher: skills, experience
- Equipment: resolution, mechanical aspects
- Models: mannequins, vs patients
- Repetition: the 'learning curve,' experience
- Feedback: Observer, Video
1970s – early enthusiasts!

USE OF THE FIBER OPTIC BRONCHOSCOPE FOR NASOTRACHEAL INTUBATION: CASE REPORT

and D.S. Mueller, M.B., F.F.A.R.C.S.


1980s – 1990s

• Halogen sources, analogue systems
• FO workshops: ASA, IARS, “Crash”
• View-splitting devices
• Analogue camera systems

2000 - 2011

• Widespread use of fiberoptic intubation
• Improving technology, digital pictures
• Glidescope introduced 2001, upgrade 2008
• Videolaryngoscopy closer to DL, intuitive
• Starting to change resident training, less fiberoptic intubations?
TCH fiberoptic intubation evaluation

- Patients – usually elective dental cases
- Fellows have some prior training
- Firewire cable connects digital output from signal processor to laptop
- Input and edited by “iMovie”
- Can produce QuickTime movie, on CD
- Other video sources may need AD converter or SD memory card

Fiberoptic Nasal Intubation

Fiberoptic intubation score

a) Completes or fails task
b) Navigation skills
c) Time – from teeth to carina
Video record – for measuring time, and reviewing a & b, and essential feedback
Has it helped?

- Individuals have shown significant progress
- Clinical changes restrict access
- ACGME requires better evaluations, increasing value of this system
Thank you!
CASE
A two and half year old girl (adopted <4 months from China) was scheduled for laryngoscopy and bronchoscopy under anesthesia. She presents with noisy respiration. No history of cyanosis, difficulty breathing or apneic episodes. On examination, she has a tracheostomy scar. She had the tracheostomy while in ICU for a ‘chemical pneumonia’. She was not very cooperative in the clinic but the surgeon thought she may have had palatal surgery. But mom was not informed of any surgeries. Child seemed to have no obvious respiratory problem on examination.

Anesthesia
Inhalational induction in the sitting position was carried out with nitrous oxide, oxygen and sevoflurane. Pulse oximetry was attached prior to induction. Once deep to tolerate an oral airway, the patient was laid supine. But the patient obstructed as soon as she was supine and it was impossible to insert an oral airway. The saturations dropped to the 80’s, nitrous was switched off and help was sought. Air exchange was possible with jaw thrust and an open mouth. Intramuscular suxamethonium (?laryngospasm) was avoided. Intravenous line was obtained. Anesthesia deepened and a laryngoscopy was done by the surgeon and the view was as below (Laryngoscopic views).

Decision was taken to wake the child up and observe in PICU till tracheostomy was done after discussing with the parents. Saturations in PICU dropped to 70’s when the child was asleep. Tracheostomy was done under inhalational anesthesia. Airway was maintained with mask, jaw thrust and an open mouth.
View closer to base of tongue
ABSTRACT SUBMISSION FORM

Please use no more than **600 words** total (starting with title)

**TITLE:** Perils of ENT Anesthesia: Urgent Bilateral Myringotomy and Tubes in a Pediatric Patient with a Difficult Airway

**AUTHORS:** (First, Last name, Title) Mark Aittaniemi, MD and Neal Campbell, MD

**Affiliation:** The Children’s Hospital of Pittsburgh of UPMC

**Abstract**

*Background:* We present the anesthetic management of a 7 year-old boy with a difficult airway who presented acutely for bilateral myringotomy and tubes in light of his need to obtain hyperbaric oxygen therapy secondary to graft-versus-host disease and pneumatosis intestinalis. The patient was status post bone marrow transplant for aplastic anemia one year prior and recent diagnosis of graft-versus-host disease involving the skin, eyes, and alimentary tract. He presented acutely to the bone marrow transplant clinic with complaints of marked abdominal distention and increasing weight gain of up to 30 pounds over a 2-3 week period. An abdominal radiograph revealed pneumatosis intestinalis. Other past medical history included new onset nephrotic range proteinuria, hypothyroidism, adrenal insufficiency, and steroid-induced hyperglycemia and hypertension. Physical exam was remarkable for a distended abdomen with ascites, pitting edema in all extremities, a Mallampatti class 4 airway, a large tongue, and a short thyromental distance with limited neck extension due to a Cushingoid buffalo hump of the posterior neck.

*Method:* The anesthetic plan consisted of general anesthesia with an awake/sedated fiberoptic intubation. The patient’s upper airway was anesthetized with 4% lidocaine via nebulizer, then 2% lidocaine jelly on a tongue depressor. Using the preexisting broviac catheter, glycopyrrolate was given intravenously as an antisyialogogue, then midazolam, fentanyl, and dexmedetomidine were titrated to effect to achieve light sedation. An Ovassapian airway was placed in the patient’s mouth followed by a pediatric fiberoptic scope in the hypopharynx. The vocal cords were visualized and anesthetized with 1% lidocaine solution prior to intubation. The endotracheal tube was then placed in the trachea under direct visualization with minimal coughing or discomfort. End-tidal CO2 was confirmed, an induction dose of propofol was administered intravenously, and the endotracheal tube was secured. The surgical procedure was safely performed and the patient was extubated at the end without complications.
Results:

**Conclusion:** This case demonstrates the potential for severe anesthetic complications during a routine surgical procedure. Our anesthetic concerns included: difficult mask ventilation; difficult intubation; an edematous airway; decreased functional residual capacity from abdominal ascites leading to rapid hypoxia; profound hypotension upon induction of anesthesia secondary to adrenal insufficiency as well as hypovolemia from nephrotic syndrome; and risk of aspiration secondary to abnormal gastric motility. By implementing careful and thoughtful anesthetic planning for a medically complicated patient, one can ensure that this routine surgical case remains routine.

Nare–Carina Distance in Infants and Toddlers

Agnes Hunyady MD.
Christer Jonmarker MD. PhD.

Introduction

Objectives

• Description of normal nare-carina distance to provide aid for nasotracheal intubation depth
• Evaluation of Morgan’s formula modified for nasal intubation: cm mark at nostril = 1.2x(height in cm/10+5)

Financial Disclosures

• No relevant financial relationships with any commercial interests.
Introduction

Background

Anesthesiology 2008

Methods

• Approved by IRB, consent waived
• Convenience sample n=100
• Inclusion criteria:
  – Ages 0-18
  – Nasally intubated
  – Remained intubated following cardiac surgery
• Excluded:
  – Reoperation (previous surgery within study period)
  – Head not in the neutral position at the time of CXR

Methods

• CXR with head in neutral position
• Cm mark on ETT at nostril noted
• OD_{m}, ET-C_{m} measured
• Correction for parallax error:
  OD_{real}/OD_{m} = ETC_{real}/ET-C_{m}
• NC = cm mark at nare + ET-C
Methods
Statistical analysis

• Best fit regression equations for NC versus height, age, weight
• Stepwise multiple regression analysis for gender and syndrome

Preliminary results
Patient characteristics

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<table>
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<tr>
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</tr>
<tr>
<td>Gender (boys/girls)</td>
<td>13/9</td>
</tr>
<tr>
<td>Age (months)</td>
<td>10.87</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>6.68</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>64.5</td>
</tr>
<tr>
<td>Syndrome (Down/DiGeorge/Kabuki)</td>
<td>5/1/1</td>
</tr>
</tbody>
</table>

Preliminary results

![Graphs showing the relationship between Nare-Carina Distance and Height, Age, and Weight.](image)
Preliminary results

\[ R^2 = 0.9059 \]

\begin{align*}
\text{nare-carina} & \quad \text{Down syndrome} \\
\text{Linear (1.2x(height in cm/10+5))} & \quad \text{Linear (nare-carina)}
\end{align*}

Discussion

• Preliminary findings suggest good correlation of nare-carina distance with height
• The modified Morgan formula might be useful in predicting correct intubation depth in infants and toddlers

Discussion

Limitations

• N
  – Data collection ongoing
  – Alternative methodologies are being explored to extend study population
• Methodological issues
  – parallax
• Factors effecting nare-carina distance
  – Neck position
  – Intraabdominal pressure
Meta-Analysis of Complications and Mortality related to pediatric tracheotomy

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The Netherlands

Financial Disclosures

- No relevant financial relationships with any commercial interests.

The problem

- 1997: 4861 tracheotomies (Lewis 2003)
- Complication rate:
  90% (Citta-Pietrolungo 1983) - 5.6% (Alladi 2004)
- Mortality rate overall:
  59.0% (Ilce 2002) - 7.4% (Simma 1994)
- Mortality rate tracheotomy related:
  5.9% (Ilce 2002) - 0.0%
Literatur research

Pubmed:
- Age groups: child, preschool, neonates, premature
- Tracheotomy: complication, mortality

Results:
- 577 article
- 46 case-series or reviews
- 29 with sufficient data
Overall aspects

- Number of patients: 9775
- Tracheotomy related mortality: 62 / 2488 (2.5%)
- Intraoperative complications: 102 / 1389 (7.3%)
- Early complications: 162 / 1365 (11.9%)
- Late complications: 1286 / 4135 (31.1%)
- Overall mortality: 910 / 9500 (9.6%)

Conclusion

- Pediatric tracheotomy has intrinsic risks of morbidity and mortality.
- Some factors are related to the number of patients treated in the institution!
- Realistic evaluation of the situation and realistic counseling of parents are needed!
Induction of Anesthesia and Airway Management in an Infant with a Large Sublingual Thyroglossal Duct Cyst

John K. Schroeder, M.D.
Dawn M. Sweeney, M.D.
University of Rochester Medical Center
Rochester, New York

Financial Disclosures

- No relevant financial relationships with any commercial interests.

The Patient

49 day-old male with a progressively enlarging tongue
Previously healthy and born full-term
Now with difficulty feeding and weight loss over a 3 week period
No respiratory compromise, yet
The Patient

- Tense sublingual mass
- 2.4 X 2.0 cm cystic structure on CT
- Significant displacement of the tongue
- Otolaryngologist wishes to excise it in the OR

Anesthetic Concerns

- Risk of airway obstruction and/or difficult ventilation during induction
- Likely difficult intubation
- Challenge: how to adequately anesthetize the infant, while maintaining a patent airway and facilitating surgical exposure of the cyst

Anesthetic Plan

- Apply topical anesthesia (2% lidocaine) to posterior tongue and oropharynx
- Place a laryngeal mask airway (LMA) in the awake infant
- Proceed with inhalational induction, once adequate position of LMA achieved (auscultation and capnography)
The Result

Infant tolerated LMA placement well
Uneventful induction and smooth maintenance of anesthesia
Cystic structure successfully marsupialized by the surgeon
Uneventful recovery
Pathology specimen consistent with thyroglossal duct cyst

Thyroglossal Duct Cysts

Common form of neck mass in pediatric patients
Midline cyst formed from the embryologic remnants of the thyroglossal tract
Often asymptomatic for years
Symptoms can appear when they become infected or inflamed
Rare to affect airway to this extent

LMA Use for Large Thyroglossal Duct Cyst

Authors unable to intubate a 21 month-old female with a large thyroglossal duct cyst
LMA used as a conduit to assist fiberoptic intubation

Insertion of the LMA in an Awake Patient?
Pierre Robin Syndrome

Other Craniofacial Disorders

Conclusion
The LMA can serve as a means to safely manage the airway for induction in children with the potential for airway obstruction, difficult ventilation and/or difficult intubation.
New concepts in Pediatric Asthma and Peri-operative Assessment

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Director, Aero-digestive Program

University of Colorado School of Medicine
and The Children's Hospital Colorado
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Financial Disclosures

- No relevant financial relationships with any commercial interests.

Objectives

At the end of the talk the participants will:
1. Define Asthma as a heterogeneous disorder
2. Recognize high asthma risk
3. Describe optimal pre-operative therapy for high risk asthma

Asthma exacerbation definitions

- **Severe asthma exacerbations**: events that require urgent action on the part of the patient and physician to prevent a serious outcome, such as hospitalization or death from asthma.
  (glucocorticoids, increase B2 – red zone, admit)
- **Moderate asthma exacerbations**: events that are troublesome to the patient, and that prompt a need for a change in treatment, but that are not severe. These events are clinically identified by being outside the patient's usual range of day-to-day asthma variation.
  (increase B2 – yellow zone)

Time course improvement in asthma variables after ICS

Anesthesia implications

**Asthma control is different at any given time and may help determine higher risk**

Reddel, Am J Respir Crit Care Med, 2009
New concepts in asthma

- Wheezing in young children is common
- Asthma is not one phenotype but many!
- Different asthma phenotypes have different clinical features, lung function and molecular phenotypes to that may create increase risks

Wheezing in children is common

Wheezing in the first 6 years of life - 49%!

TCH treats over 30% of the Asthma in the State of Colorado

Focus on Severe Asthma

Children with Severe Asthma:
- Extreme morbidity
- Account for 30-50% of all pediatric health care costs
- Continue with on-going symptoms and airway inflammation DESPITE treatment with high dose ICS or other controllers
- Difficult to treat - you care about this group!

Severe Asthma: NIH/NHLBI SARP Consider asking about these!

- Major Criteria -- at least 1
  - Treatment with high dose ICS
  - Treatment continuous oral corticosteroids (50%)
- Minor (must have 2/7)
  - Treatment with additional controller medications
  - Daily short-acting bronchodilators (5/7 days)
  - Persistent obstruction, baseline FEV1 < 80% pred
  - One or more urgent care visits for asthma
  - Three or more oral corticosteroid bursts in year
  - History of prompt deterioration with decrease steroids
  - A near fatal asthma event requiring intubation

Severe Asthma Clusters - 4

- Cluster 1: Late-onset symptomatic asthma with normal lung function
- Cluster 2: Early-onset atopic asthma with normal lung function
- Cluster 3: Early-onset atopic asthma with mild airflow limitation
- Cluster 4: Early-onset atopic asthma with advanced airflow limitation
Severe Asthma Clusters

- Variables most distinguishing for severe asthma:
  - Asthma duration
  - Number of asthma controller medications
  - Baseline lung function

  Consider asking about these!

Anesthesia implications

- All asthma is not the same
- New history questions to consider as you evaluate patients for high risk:
- There are subsets of patients that don’t respond to steroid therapy appropriately

Treatment

- Any high risk patient should ideally have prednisone burst before surgery and after if symptomatic
- Active exacerbation and temporal relationship to that exacerbation should be considered.
- Steroids may not relieve symptoms in severe asthma – may still need significant B2 support.
Pediatric Airway Management in the ED

Financial Disclosures

• No relevant financial relationships with any commercial interests.
The decision to intubate
(Tub-e or not tub-e: that is the question)

1. Failure of airway maintenance?
2. Failure of oxygenation or ventilation?
3. Anticipated clinical course?

Key questions

• 1. Is this a “crash” airway?
  - Action: Intubate immediately
• 2. Is this a difficult airway?
  - Action: Call for assistance
  - Consider alternative approaches
• 3. If neither 1 or 2, and requires airway → RSI

Difficult airway considerations

• Difficult bag-mask ventilation (MOANS)
• Difficult laryngoscopy/intubation (LEMON)
• Difficult extraglottic device (RODS)
• Difficult cricothyrotomy (SHORT)
Difficult bag-mask ventilation (MOANS)

- Mask seal integrity
- Obesity/Obstruction
- Age (relatively elastic tissue)
- No teeth (facial collapse)
- Stiff lungs/Sleep apnea

Difficult laryngoscopy & intubation (LEMON)

- Look externally (small mandible, large tongue, large teeth, short neck)
- Evaluate 3-3-2 rule
- Mallampati score
- Obstruction/Obesity
- Neck mobility

Difficult extraglottic device (RODS)

- Restricted mouth opening
- Obstruction
- Disrupted or Distorted Airway
- Stiff lungs or cervical spine
Difficult cricothyrotomy (SHORT)

- Surgery (or other airway disruption)
- Hematoma (incl infection or abscess)
- Obesity (or other access problem—short neck, subQ emphysema, etc.)
- Radiation distortion/scarring
- Tumor (access, bleeding)

Rapid Sequence Intubation (RSI)

- Presumes full stomach, aspiration risk
- Preoxygenation to permit safe period of apnea in which to give drugs and intubate trachea without intervening positive-pressure ventilation

Rapid Sequence Intubation: The seven P’s

- Preparation
- Preoxygenation
- Pretreatment
- Paralysis AFTER induction
- Protection and positioning
- Placement with proof
- Postintubation management
Rapid Sequence
Intubation: Pretreatment

- Lidocaine
- Opioid (fentanyl)
- Atropine
- Defasciculation

Rapid Sequence
Intubation: Induction

- Midazolam
- Propofol
- Etomidate
- Ketamine

Rapid Sequence
Intubation: Paralysis

- Succinylcholine (Anectine)
- Rocuronium
FIBEROPTIC AIRWAY MANAGEMENT

Geoffrey Lane, MB, FRCA
The Childrens Hospital
Denver
TOPICS

1. **Selection and care of equipment**
   - Choice of fiberoptic endoscope
   - Video systems
   - Avoiding damage
   - Cleaning and sterilization

2. **Navigation skills**
   - Introduction
   - Rotation
   - Flexion (control lever)
   - Anatomic deflection and direction

3. **Decisions**
   - Awake vs. asleep
   - Oral vs. nasal
   - Nasal: tube first or scope first?

4. **Problem solving**
   - The tongue is in the way!
   - The larynx is hidden because the epiglottis is stuck to the back of the pharynx!
   - Laryngeal impaction and the S bend!
   - The scope is always misting up!
   - The view seems all wrong (upside down?)

5. **Advanced applications**
   - Pediatric intubations
   - Single lung ventilation – double lumen tubes and blockers.
   - Intubation through the LMA.
   - Intra-operative diagnosis of ventilation problems
   - The extreme airway

(Revised January 2011)
Section 1: Selection and care of equipment

Choice of fiberoptic endoscope.

With the publication of the ASA difficult airway guidelines, all hospitals should have appropriate fiberoptic scopes. With the availability of disposable Pentax scopes, fiberoptic intubation may be available in smaller ambulatory facilities. The choice of fiberoptic scopes is becoming complex, and should be designed to fit in with other difficult airway equipment including video laryngoscopy.

Desirable features include:
- Insertion tube length 50 – 60 cm
- Appropriate diameter - for ETT’s likely to be used (including double lumen tubes)
- Flexible tip (cannot maneuver much without it)
- Suction channel – useful but not essential - for local anesthetics, guide wires etc.
- Ease of cleaning and sterilization
- Compatibility with light sources and signal processing equipment.
- Digital bronchoscopes have much better resolution, and should be less easily damaged
- Durability, Durability Durability!!!
- Price

The scopes that are designed for intubation are usually cheaper (approximately $1000) than corresponding diagnostic bronchoscopes, and have a thickened sheath covering the insertion tube to protect them from abuse by anesthesiologists (other than you, of course!) They lack some of the electronic photography exposure features of diagnostic scopes, but can still be used with a video camera, and are generally the best choice for anesthesiologists.

Fiberoptic scopes designed and marketed for anesthesia/intubation present a compromise regarding size or diameter. As the diameter is reduced, the bronchoscope can be introduced through smaller endotracheal tubes and thus extended to pediatric use, and for examining placement of double lumen tubes. The disadvantage with smaller scopes is that when passed through large adult sized endotracheal tubes, there is a greater tendency for the tube to become caught on the laryngeal inlet. This can be very frustrating, but there are several methods to avoid or manage this problem (see page 10.)

Ultra thin pediatric scopes are available and can be used inside 3.0 mm tubes. They are soft, flimsy and more difficult to use. Though valuable for pediatric use, they are not suitable for routine intubations with endotracheal tubes larger than 4.5 mm. Ultra thin scopes may be required when examining the placement of small double lumen tubes and blockers.
Price is obviously a major consideration, but repairs are so expensive that durability is even more important. Heavy use in an academic teaching center with inevitable damage to the scopes may warrant investment in a maintenance/repair contract.

Olympus has digital bronchoscopes which use a video chip mounted on the distal end of the bronchoscope, the image is then transmitted electronically instead of using glass fibers to transmit an analogue picture. This improves the resolution dramatically, and the scopes should be less prone to damage because the image is transmitted electrically rather than by fragile glass fibers.

Storz has new scopes with good optical resolution. They have an integral camera head mounted on the scope, the video output produces an excellent large image compared with older systems. The Storz video systems can also be used with their videolaryngoscopes.

**Video Systems**

The purchase of a camera and video equipment significantly enhances a fiberoptic intubation system. (When did you last see your friendly orthopod doing an arthroscopy without an expensive video tower?)

When learning or teaching, technical maneuvers can be observed on the screen and corrected easily, whereas the novice using the eyepiece can only be guided by clinical evidence of success or failure. The video system is also valuable in difficult airways, when an assistant is needed to retract the tongue and soft tissues, or to help thread a guide wire through the scope. When the assistant can see the results of his efforts on the screen, the assistance is more effective.

The output from the digital processor can also be exported to a Mac computer using a firewire cable, and edited in iMovie. We are using this to improve instruction by replaying the video, and can also generate a simple evaluation score to track progress, and guide further instruction.

Video use also has psychological advantages by involving the OR team. When the surgeons and OR nurses can share your fiberoptic exploits on the screen, they are much more likely to offer support and encouragement than when your endeavors are seen only as an irritating delay before they can have their fun!

**Avoiding damage**

Success in fiberoptic intubation requires continued access to a satisfactory fiberoptic system. There are several easy but expensive ways to damage the scope and render it unusable. We teach our staff and residents this mnemonic:
“Please **Don’t Damage This Thin Scope!**”

**Petroleum** based lubricants such as Vaseline and lacrilube can penetrate the cover of the scope and cause separation of the fibers; use aqueous lubricants such as KY jelly or silicone.

**Drawer** Don't leave the scope in the drawer of the endoscopy cart while connected to the light source; shutting the drawer will crush the glass fibers.

**Door** Don't leave the scope plugged into the light source when removing the endoscopy cart from the room - the light cable can easily be smashed on the door frame!

**Teeth** A good bite can crush the scope - if the patient is awake, protect the scope with a bite block or airway.

**Tube** Advancing the tube down over the scope while bending the tip may damage the vulnerable, flexible tip section - always remove pressure from the control lever and keep the tip straight while advancing the tube.

**S- Bend** The scope can be forced into an S-bend when the tube tries to continue passing down the esophagus while the scope remains in the trachea. If you encounter resistance when advancing the scope through the larynx, **DO NOT FORCE IT!** Try rotating the tube 90 or 180 degrees, or use an introducer.(see page 9)

**Cleaning and sterilization**

There are several reports of disease transmission attributable to faulty preparation of endoscopes, including episodes of hepatitis, tuberculosis and more recently, pseudomonas. Ease of cleaning and sterilization is therefore essential.

Most modern scopes may be immersed in cleaning fluids or be subjected to gas sterilization. The use of automated sterilization machines such as the Steris system has simplified processing, but the use of Steris has recently been challenged by withdrawal of FDA support after some changes that were not approved. We now use a more complicated endoscope processing system.
**Section 2: Navigation Skills**

**Introduction**

The simplest approach to intubation with a fiberscope is to point the scope so that the target (larynx) is in view, and then try to advance the scope towards the target or through it. This "point and shoot" approach works in many adult patients, and is the method most people use initially. The skillful operator develops more advanced navigation skills with experience, intuition and manual dexterity. These skills will be demonstrated in the workshops, but understanding the basic principles can enable the student to advance more quickly.

Though the distal tip of the bronchoscope can be manipulated by the control lever, most of the insertion tube is deflected passively by the airway tissues. Learning how to pass the bronchoscope skillfully through the mouth or nose to the larynx requires recognition of how to use this deflection by the anatomic structures to one’s advantage.

There are three different types of maneuvers that can be used to control the scope; the expert is able to advance and navigate the scope smoothly through the airway by combining these controls effortlessly – just like a teenager operating a video game!

**1) Rotation**

The bronchoscope can be rotated around its long axis by turning both hands together. The effects on the image are different when using observed through the eyepiece of an analogue bronchoscope compared with use a camera or a digital system.

The image transmission pathway in the insertion tube of an analogue bronchoscope is constructed of bundles of parallel glass fibers. The 12 o’clock position is marked by an indent or black triangle to assist in orientation. Rotating the scope through 90 degrees will cause the 12 o’clock marker to rotate correspondingly, but so long as the observer is viewing the target through the eyepiece, the target will not change position. (The image will be carried through different fibers, but the spatial relations between target and observer are the same.)

When using a digital bronchoscope, or when a camera is placed on the eyepiece, the image displayed on the screen will rotate as the insertion tube is rotated.

When using rotation to control the scope, it is easier for novices to keep the scope relatively straight by keeping both hands as far apart as possible, otherwise a big loop may develop, and the tip may flex in unexpected directions.
(2) Flexion (control lever)

The distal tip section of the scope bends up or down with light pressure on the control lever. The flexible (or bending) part of the scope is short, and flexing it does not necessarily control the remainder of the insertion tube. It is also the most fragile part of the scope, since it has to be covered with a thin, flexible covering, and can be damaged by excessive force and by sliding the endotracheal tube down and into the flexed tip.

Since intubation scopes are only flexible in one plane, it may be necessary to combine flexion and rotation when navigating difficult or ‘tortuous’ airways.

(3) Anatomic deflection and direction

The greater part of the length of the insertion tube is not controlled directly by the control lever, but responds indirectly to pressure against anatomic features as the scope is advanced. The operator can aim the scope as it enters the mouth or nose, and by directing it against structures (e.g. the palate), can encourage the scope to assume an optimum trajectory. This type of control is demonstrated more easily than it can be described, but should be mastered if the operator is to exploit the full potentials of fiberoptic intubation.

The chances of success improve when the endoscopist has good manual control of the scope and can keep the scope in the mid-line all the way to the trachea. Recognition of the mid-line landmarks facilitates navigation, for oral intubation they include:

**Posterior:**
- Raphe (fine white line) in palate, that leads to the -
- Uvula

**Anterior**
- Furrow, or groove, down mid-line of tongue, leading to the -
- Epiglottis

Failure to understand these navigation principles is the reason for the scope passing into the esophagus, even though the operator may have visualized the larynx clearly. The problem occurs during oral intubation when the scope is introduced directly backwards (see below, A) and the tip is flexed acutely upwards to see the cords. As the scope is pushed down the airway, the tip may still lie behind the arytenoids so that the scope enters the esophagus rather than the larynx (B.) This problem is more likely to occur in small patients; adults tend to be more forgiving because the larger distances involved allow the scope to bend more towards the intended direction.
Section 3: Decisions

Awake vs. Asleep

The difficult adult airway is usually managed safely and more easily in the awake patient, using good topical anesthesia, with judicious sedation.

Children do not always cooperate well under topical anesthesia, and sedation for difficult pediatric airways can quickly lead to obstruction and hypoxia. I generally recommend an inhalation anesthetic for children between 12 months and 10 years, but the ability to maintain an adequate airway using a chin thrust maneuver is essential, and relaxants should be avoided.

There are many ways to achieve good topical anesthesia. I prefer to use viscous lidocaine first, and will then inject lidocaine through the suction channel of the scope into the larynx. Inhaling a nebulized solution of lidocaine is also effective if administered until the airway is anesthetized. It is easy to exceed therapeutic doses of local anesthetics and cause toxicity especially in smaller patients; the safe dose should be estimated before use.

Oral vs. Nasal

Nasal intubation is technically easier than oral intubation because the intranasal structures support the scope and facilitate a smooth advance. The convexity of the cervical spine helps to direct the scope forwards and away from the posterior pharyngeal wall towards the laryngeal inlet.
There are situations where oral intubation may be preferred for surgical access, e.g. for cleft palate surgery. There is also a risk of bleeding with nasal intubation despite the use of vasoconstrictors, and is of sufficient concern in the most precarious airways that oral intubation may be the first choice.

Oral intubation requires more dexterity and skill in keeping the scope towards the mid-line, and in small patients it may even be necessary to press the scope against the palate to achieve enough curvature to enter the larynx.

**Nasal: tube first or scope first?**

Passing the endotracheal tube through the nose before advancing the scope may appear easier than threading the scope through the nose first, but can cause severe bleeding and jeopardize the intubation. The tube is stiff enough to penetrate the posterior wall of the pharynx, causing a false passage, or it may perform a partial adenoidectomy.

With a little practice, the scope can be directed through the nose without tearing the mucosa and adenoids, and it will make the turn at the back of the nose more easily.

**Section 4: Problem Solving**

**The tongue is in the way!**

The tongue often presents a major visual obstruction when intubating difficult airways, especially when the patient is unconscious.

Maneuvers to pull it forwards include use of a chin thrust, pulling the tongue out of the mouth with a dry sponge, and mechanical devices. Of these, I find that a narrow, malleable surgical retractor can be shaped and used successfully in some of the most difficult pediatric airways. Using a regular laryngoscope to lift the tongue forwards is seldom helpful as the tip of the blade usually covers the glottis; a videolaryngoscope may be more helpful.

**The larynx is hidden, because the epiglottis is touching the back of the pharynx!**

This is what difficult airways are all about! In the awake patient, a deep breath will often lift the tip of the epiglottis off the posterior wall of the pharynx enough to allow the scope to be advanced.
The anesthetized patient is more of a challenge. A chin thrust by an assistant is often sufficient, but in extreme airways, it may be necessary to pull the tongue forwards using a dry sponge, or by using a malleable ribbon retractor bent to an appropriate shape.

**Laryngeal impaction and the S-Bend – or- ‘the tube won’t go down the larynx!’**

Very frustrating! This happens when the ETT is much wider than the scope, and the tip of the ETT impacts on the ary-epiglottic folds or on the arytenoids. Once this has occurred, the situation can often be resolved by (1) pulling the ETT back over the scope a short distance and then (2) rotating it 90 or 180 degrees. The tube is then advanced again, this time with the tip of the ETT above the scope so that enters the glottis between the anterior commissure and the scope without impacting the ary-epiglottic folds. The problem may be anticipated and avoided by several strategies:

1. Selecting a fiberscope whose diameter is as close to that of the endotracheal tube as possible will usually prevent the problem.

2. The new endotracheal tubes manufactured by Parker Medical Systems have a special tip that bends inwards to reduce trauma to the mucosa as the tube is advanced. The tip will remain in touch with a fiberscope passing through the laryngeal inlet and should avoid the “S-bend problem.”

3. An introducer can be placed between the fiberscope and the endotracheal tube just as we use a dilator or introducer between the guide wire and catheter/sheath during central venous cannulation. Suitable devices include a straight chest tube, a small uncuffed endotracheal tube, or an Aintree Intubation Catheter (Cook Catheters.) The chest tube and Aintree have the advantage of being longer; an uncuffed endotracheal tube is so short that the larger ETT may have to be shortened by 4 to 6 cms.

The appropriate sizes when using an Olympus LF2 scope are:

<table>
<thead>
<tr>
<th>Outer ETT (mm, ID)</th>
<th>Introducer:</th>
<th>Introducer:</th>
<th>(length)</th>
<th>(ext diam)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A: Chest Tube</td>
<td>B: Uncuffed ETT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5 mm</td>
<td>-</td>
<td>5.0 mm</td>
<td>24.5 cm</td>
<td>6.9 mm</td>
</tr>
<tr>
<td>8.0 mm</td>
<td>-</td>
<td>5.5 mm</td>
<td>27.5 cm</td>
<td>7.5 mm</td>
</tr>
<tr>
<td>8.5 mm</td>
<td>24 FG</td>
<td>6.0 mm</td>
<td>28.5 cm</td>
<td>8.2 mm</td>
</tr>
<tr>
<td>9.0 mm</td>
<td>24 FG</td>
<td>6.0 mm</td>
<td>28.5 cm</td>
<td>8.2 mm</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>28 FG</td>
<td>6.5 mm</td>
<td>29 cm</td>
<td>8.9 mm</td>
</tr>
</tbody>
</table>
The scope is always misting up!

This problem is usually caused by allowing the tip of the scope to touch the mucosa. Careful navigation, keeping to the lumen of the airway, will eliminate this problem, but if it does occur, clean the end with an alcohol wipe. When using a video camera, a 'white out' is a warning that you are almost touching the mucosa - retreat and find the lumen before advancing!

Section 5: Advanced Applications

Pediatric intubations

1. **Guide wire method**: a regular intubation scope can be used to intubate infants (when an ultra thin scope is not available,) by threading a long (125 cms) guide wire through the suction channel into the trachea. Suitable J wires can be ordered (or “appropriated” from the cath. lab in an emergency), a 0.032” to 0.036” diameter wire is usually appropriate. The scope is then withdrawn over the wire, and an appropriate ETT advanced, using a small suction catheter inside the ETT to facilitate the advance.

2. **Ultra thin fiberscopes**: Pediatric fiberscopes such as the Olympus LFP, with a 2.8 mm diameter that fits inside 3.0 mm ETT’s have extended routine fiberoptic intubation abilities to neonates. These scopes are much softer and are more difficult to control, but can be life saving.

Single lung ventilation - double lumen tubes and blockers

Fiberoptic scopes may be used to place and verify correct positioning of double lumen tubes. Confusion regarding which lumen to use is simplified if you remember that the scope may be used for two distinct purposes.

First, the scope can be inserted through the *distal, bronchial* lumen to direct the tube from the lower trachea into the selected mainstem bronchus.

Second, it can be used to confirm and adjust the position of the bronchial cuff, to ensure that the endobronchial cuff is just inside the bronchus, and that when inflated, the cuff does not extend beyond the carina to obstruct the trachea. The practical sequence is therefore:

1. Place the tube into the trachea by conventional direct laryngoscopy.
2. Advance the tube into the main stem bronchus, either directly - by simply pushing and turning it in the traditional manner, or endoscopically - by inserting the scope through the bronchial lumen and then into the selected main bronchus.

3. The position of the bronchial cuff in relation to the carina is inspected by inserting the scope through the tracheal lumen. The scope should emerge just above the carina, and the bronchial cuff should be entirely within the bronchus - to avoid obstruction of the trachea. Correct inflation of the cuff can be observed directly to avoid hyperinflation.

Bronchial blockers can be used to provide single lung ventilation, especially in smaller patients. Cook® have the Arndt Endobronchial blocker sets in a range of pediatric and adult sizes. These are designed for placement using a fiberoptic scope, using a nylon guide loop that slips over the scope for insertion and positioning.

**Intubation via the LMA**

A fiberoptic can be placed through an LMA (or other supraglottic airway) to facilitate intubation in patients who cannot be intubated directly for anatomical or neurologic reasons.

The Fastrach LMA can serve as a conduit for intubation without using a fiberoptic scope, but is not available for small children.

When using a fiberoptic scope through the LMA, the ETT can be passed over the scope and into the trachea, but the ETT is usually too short to allow the LMA to be removed. If this is necessary, then a second smaller ETT can be wedged inside the proximal end of the first ETT until the LMA is removed. Alternatively, a long guide wire can be placed through the suction channel of the fiberoptic scope. The LMA is then withdrawn, and an appropriate size ETT is then advanced over the wire, using a suction catheter inside the ETT to support the wire and facilitate passage through the glottis.

**Intra-operative diagnosis of ventilation problems.**

The fiberoptic scope can be an asset in the diagnosis and management of a variety of intra-operative ventilation problems, for example:

1. The surgeon claims the left lung is not moving as you come off by-pass. You can try pulling the tube back - but risk extubating the patient. Passing the scope down the tube allows you to confirm the position (or improve it) and turns your attention to shifting the mucous plug obstructing the left bronchus.
2. Difficult ventilation in the neurosurgical patient in the sphinx or prone position: the tube may be kinked, blocked or positioned incorrectly - use of the scope may facilitate resolution of the problem.
3. Reintubation. The scope may be used to reintubate either electively, or sometimes in emergency situations (e.g. the infant accidentally extubated coming off by-pass, when direct laryngoscopy interferes with the aortic cannula)

**Suggested Reading**

2. Ovassapian, A: Fiberoptic Endoscopy and the Difficult Airway (2nd Edn); 1996, Lippincott Williams & Wilkins.