Microlaryngoscopy & Laser Surgery

Concerns for underlying disease and laser surgery itself especially burns / fires

ANESTHETIC CONSIDERATIONS:

- Potential difficult airway / altered anatomy w/ risk of obstruction & collapse on induction
- Shared airway with need to communicate with surgical team
- Aspiration risk
- Possible jet ventilation and risks:
  - Barotrauma → pneumothorax, pneumomediastinum, gastric insufflation
- Laser risks
  - Potential for burns, fire – preventative measures and management
  - Potential for corneal / retinal damage
  - Aerosolization of viral / bacterial particles
- Potential for hemodynamic instability and myocardial ischemia
- Risk of postoperative respiratory distress secondary to trauma, edema

ANESTHETIC GOALS:

- Ensure adequate oxygenation and ventilation, minimize airway reflexes and promote crisp emergence with return of protective airway reflexes and ventilation
- Optimal surgical conditions
- Prevent barotraumas and laser related complications
- Maintain hemodynamics

HISTORY

- Diagnosis?
  - Etiology
  - Subglottic, glottic or supraglottic lesion?
  - Acute or chronic? Syndrome?
  - Treatments thus far? Previous ORs – difficult airway?
- Determine extent of airway obstruction
  - Hoarseness or dysphonia
  - Stridor
  - Dyspnea and provoking factors (e.g. position, exercise)
  - Results of prior laryngoscopies and surgeries etc
  - Careful airway examination
- Establish any contraindications to jet ventilation
  - Airway obstruction → inability to expire
  - Bullous lung disease
  - ?Children
- Coexisting diseases:
  - Incidence of myocardial ischemia / infarction with microlaryngoscopy is 1.5-4% therefore careful cardiac history
  - Exercise tolerance (functional capacity)

PHYSICAL

- **HEENT** - Thorough airway evaluation, looking especially for appreciable swelling, airway deformity
- **CVS** – Standard cardiac exam including auscultation, JVP, peripheral pulses
- **RESP** - Respiratory evaluation focusing on respiratory effort / distress, looking for overall appearance, use of accessory muscles, positional influences on respiratory effort, upper or lower airway sounds

INVESTIGATIONS

- **Labs**
  - CBC, other labs as dictated by workup
  - ABG if concerned about respiratory insufficiency
- **Imaging**
  - CXR, CT – need to know level of the lesion, degree of airway obstruction, impingement of any other structures
  - ECG in adults at risk
- **Special**
  - PFTs / Spirometry: Fixed obstruction, variable intra or extrathoracic obstruction?
  - Review consults from ENT, previous bronchoscopies

OPTIMIZATION

- Avoid routine premedications if upper airway obstruction
- Preoperative fasting and aspiration prophylaxis
- Glycopyrrolate to minimize airway secretions
- Communication with surgeon
  - Surgical plan
  - Ideal airway management (including ventilation strategy: ETT, intermittent apnea, supra or sub-glottic jet ventilation)
  - Use of laser (and which one?)
  - Expected length of procedure and expected degree of edema postoperatively / expected postoperatively disposition
- Ensure pre-operative cardiac status optimized given high incidence of myocardial ischemia

ANESTHETIC OPTIONS

- Most patients will require GA with TIVA although depending on mass location and size, local / regional techniques with mild sedation may be an alternative

- Method of "securing" airway based on degree & site of airway obstruction and any other signs of difficulty to intubate or ventilate
- Potential awake intubation (either FOI or direct), consider awake tracheostomy
- Maintain spontaneous ventilation until sure you can ventilate or intubate
- **Open airway techniques**:
    - Advantages of these techniques are lack of flammable materials in airway and unobstructed surgical view
    - Disadvantages: unprotected airway with attendant risk of aspiration of gastric contents, surgical debris, and laser plume; hypoventilation and difficulty monitoring adequacy of ventilation
        - Inhalational agents not ideal b/c would need ↑ concentrations to overcome atmospheric dilution, unreliable depth of anesthesia, unable to scavenge gases, exhaled gases are blown into surgeon's face
        - **TIVA** preferred with these open airway techniques
    - **Spontaneous ventilation** with insufflation of O_2 through side-port on suspension laryngoscope or separate introduction of catheter (this reintroduces flammability risk)
        - Additional disadvantages include mobile surgical field
    - **Apneic technique** – alternating periods of ventilation with mask / LMA / ETT or bronchoscope with periods of apnea to allow surgical resection
        - Can insufflate O_2 in presence of laser if no flammable materials are in airway
    - **Supraglottic low frequency jet ventilation** is most common jet ventilation technique for microlaryngoscopy:
        - Sanders injector delivers high flow, high pO_2 jet & entrained air directly into airway lumen
        - Start with low pressures (30-50psi), inspiration phase 1.5s and expiration phase 6s with RR 6-7/min
        - Advantages: ability to PPV to achieve adequate ventilation without flammable objects, unobstructed view and it's a simple technique
        - **Disadvantages**: significant risk of **barotrauma** with no reliable method of measuring AWPs; requirement of compliant lungs; not motionless (can do intermittent apnea); may force blood & debris into lungs; and potential gastric distension
        - To ↓ barotrauma risk, must have good alignment of tip of jet with tracheal axis and vocal cord relaxation and must have unobstructed in- and out-flow of gas
            - Exhalation is passive; if there is a lack of free egress of jetted gas, can quickly develop barotrauma and (tension) pneumothorax
        - Must monitor chest wall movement as sign of adequate ventilation
        - Jet ventilation **contraindicated** in obstructive airway lesions, decreased pulmonary compliance (e.g. obesity), bullous lung disease, and in children
        - Subglottic low frequency jet ventilation via cuffed intratracheal catheter also described (↑ fire risk, but can protect airway, ↓ entrainment)
    - **Supra or subglottic high frequency PPV** (HFPPV) uses small Vt (<2mL/kg) and high RR (60-2400/min or 1-40Hz) resulting in ↓ mean and peak AWPs, but also get ↓ emptying time and thus gas trapping
        - HFPPV is a method of achieving PEEP to ↓ shunt without imposing large volume and pressure excursion to remove CO_2
        - CO_2 elimination does occur and is probably a result of bulk convection & molecular diffusion
        - May result in improved oxygenation & less entrainment of smoke / debris; but requires specialized equipment, difficulty monitoring ventilatory parameters including AWPs and risk of autoPEEP, resulting in hypoventilation and barotrauma
- **Intubation techniques**:
    - Advantages
        - Ability to control ventilation and oxygenation
        - Volatile anesthetics may be used without fear of contaminating the OR or unpredictable delivery of anesthetic to patient
    - Disadvantages
        - No perfect ETT exists for Laser surgery
        - ETTs obstruct the surgeon's view
    - **Conventional ETT**
        - Advantages
            - Easily available, meet standard specifications for ETTs
            - Do not reflect laser and therefore will avoid injury to non-targeted tissue
        - Disadvantages
            - Readily ignite and maintain combustion
            - If ignited, PVC tubes soften and deform
            - Burning PVC tubes release HCl which causes severe pneumonitis
            - Silicone tubes become a brittle ash that crumbles easily and can be aspirated
            - Red rubber tubes maintain their structural integrity
            - Burning red rubber ETT produce CO
    - **Conventional ETT with protection**
        - Flammable ETTs can be wrapped with metallic tape to shield them from the laser
        - Advantages: Ability to use conventional ETT
        - Disadvantages
            - Metallic tape may reflect laser beam onto non-targeted tissues
            - If not applied smoothly, tape's rough edges may cause trauma
            - The tape adds considerable thickness to the tube
            - Dislodged tape may occlude the airway
            - The tube cannot be wrapped at or below the cuff, so this area remains exposed and vulnerable to the laser
            - Sterility is difficult to maintain
            - Not all metallic tapes can protect from all types of laser
    - **Ready-to-use laser-resistant tubes**
        - Fome-Cuf: aluminum and silicone rubber spiral with silicone covering and self-inflating foam sponge cuff, intended for use with CO_2 laser only
            - Advantages: Cuff tends to maintain seal even if penetrated by laser

        - Disadvantages: Flammable external surface and cuff, cuff may be difficult to deflate if it is damaged
    - Laser Flex: stainless steel corrugated spiral with PVC Murphy eye and double cuffs, intended for CO_2 or KTP laser
        - Advantages: Metal nonflammable, kink resistant, and proximal cuff serves as shield for distal cuff
        - Disadvantages: Although matte finished, may reflect laser onto non-targeted tissue, metal may transfer heat to adjacent tissues and cuffs are flammable and need to be inflated with saline
    - Laser-Shield II: silicone rubber tube wrapped with aluminum and wrapped over with Teflon, intended for CO_2 or KTP laser
        - Advantages: Smooth, less traumatic coating than manual wrapping and pliable tube
        - Disadvantages: Dislodged tape can occlude the airway and again, cuff not wrapped, so vulnerable to laser (although is filled with saline / methylene blue); also combustion of Teflon gives toxic by-products
    - LaserShielding Tube: silicone rubber tube with ceramic particles, intended for use with CO_2 and Nd:YAG lasers
        - Advantages: Similar characteristics to conventional ETT but thicker cuff to provide better resistance to puncture
        - Disadvantage: Ignition still possible
- **Metal tracheal tubes**
    - No longer manufactured – of historic interest only
- Location of lesion, degree of obstruction, surgical plan and patient factors (e.g. obesity, restrictive lung disease, bullous disease) will determine best management

SUMMARY

- **GETA** with small tube e.g. 4.5-6.5 mm laser tube which allows PPV, prevents gastric distension, facilitates control of oxygenation and elimination of CO_2, protects the trachea and allows for variety of anesthesia regimens and indefinite time period of surgery
- **Spontaneous ventilation** with oxygen to side port
- Paralysis utilizing TIVA with either:
    - **Passive oxygenation** with catheter through the cords
    - **Jet ventilation** using venturi entrainment effects (**Note**: the tip of the jet ventilator to be kept inside the laryngoscope to help to avoid barotraumas, low pressures 30-50 psi, inspiration 1.5 sec and expiration 6 sec at rate 6-7 breaths per min)
    - **High-frequency PPV** through side arm

ANESTHETIC SETUP

- **Drugs**
    - Remifentanil, esmolol (potent short acting agents to blunt sympathetic response to surgery)
- **Equipment**
    - Standard CAS monitors + 5 lead EKG
    - Nerve stimulator if paralysis considered
    - Consider Art line
        - Patient considerations (ischemic heart disease)
        - Prolonged procedure to monitor CO_2
    - Difficult airway equipment
    - Small ETT to facilitate surgery (5.5 – 6.5) if ETT required & variety of other tubes available
    - Ensure surgeon with rigid bronchoscope available in advent of airway obstruction
    - **Laser precautions**
        - OR personnel
            - Protective goggles and appropriate masks
            - Notice on door and windows blinded
        - Patients
            - Should have tape on eyes and double layer with saline saturated eye pads
            - Saline soaked gauze / towels to cover all exposed skin / mucous membranes
        - ETT
            - Prefabricated laser shielded ETT (PVC highest risk)
            - Methylene blue and saline for ETT cuff to indicate rupture
        - Be prepared to extinguish fire with bucket of saline

MANAGEMENT OF ANESTHESIA

- **Induction**
    - If any question about the airway, awake direct laryngoscopy or awake FOI with laser-shielded tube and spontaneous ventilation
    - If airway okay, IV induction
        - Use short acting agents: IV (propofol / remifentanil ± SCh ± mivacurium) or inhalational (sevoflurane)
    - Assess airway with laryngoscopy and ease of BMV prior to turning patient over to surgeon
    - Topicalize vocal cords
- **Maintenance**
    - Require deep plane of anesthesia with crisp emergence & muscle relaxation preferred
    - TIVA ± NMB esp. with open airway techniques (propofol / remifentanil) or inhalational ± NMB if intubated
    - Muscle relaxation options include SCh boluses or drip for brief cases (monitoring for a phase II block); or for longer cases (> 30 min) mivacurium
    - CVS stability during periods of rapidly varying surgical stimulation
        - Provide baseline level of anesthesia (TIVA vs. IH) and supplement w/ short acting agents (propofol / remifentanil) or sympathetic antagonists (esmolol) during periods of increased stimulation
        - Consider regional block of CN IX or superior laryngeal nerve
    - Minimize FiO_2 and avoid N_2O b/c of the risk of fire, ventilatory strategies as above
    - Vigilance for adequate ventilation and oxygenation w/o development autoPEEP, barotrauma, airway or other fire
- **Emergence**

- Suction pharynx @ end to decrease laryngospasm risk (secretions, blood)
- Ensure airway is dry and all packs removed
- Ensure awake, minimal respiratory depression and maintaining airway (intact reflexes)

DISPOSITION & MONITORING

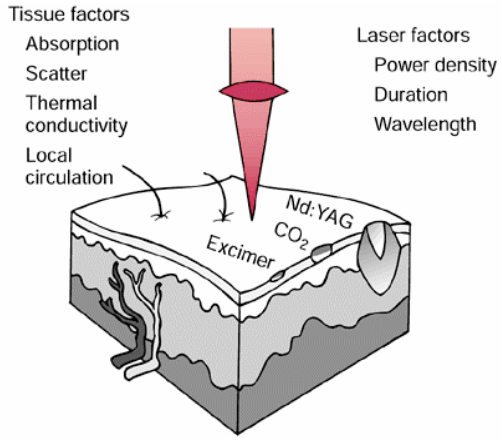
- Head-up position to decrease edema
- Consider steroids and racemic epinephrine if laryngeal edema
- Humidified O_2
- Observe in PAR for bleeding / laryngospasm / edema / airway obstruction
- Observe for respiratory distress secondary to pneumothorax, distal / proximal airway obstruction from bleeding / surgical debris
- Myocardial ischemia surveillance in those at risk

COMPLICATIONS

- Airway obstruction → can't ventilate
- Hypertension, tachycardia or arrhythmias
- Barotrauma
- Airway Fire:
  - **Life threatening situation requiring immediate intervention**
  - Risk of direct thermal injury and distal thermal and chemical injury to lung parenchyma
  - **Management**:
    - Stop ventilation & disconnect O_2 source at Y piece & immediately remove combustible material (ETT / pledgets) (avoid blowtorch effect)
    - Irrigate site with prepared cold saline to extinguish any remaining fire
    - BMV with minimal FiO_2 required and re-intubate
    - Flexible / rigid bronchoscope to evaluate damage and presence of foreign bodies
    - Consider low tracheostomy ± mechanical ventilation, humidified gas
    - Consider steroids, ± Abx
    - Admit ICU, and follow with oximetry, ABGs, CXRs, watching for airway obstruction & / or respiratory failure from parenchymal damage

PATHOPHYSIOLOGY

- Microlaryngoscopy involves examination of the glottis ± biopsy ± laser resection with a suspension laryngoscope
- **Indication for surgery**
  - Airway surgery: laryngeal papilloma, tracheal scarring, webs, synechiae, subglottic stenosis
  - Ophthalmology: cornea
  - Dermatology / vascular: vascular malformations, pigmented lesions, coagulation
- Preexisting airway obstruction is major concern with induction, ± intra- and postoperatively b/c of laryngospasm, bleeding / secretions / tumor debris, and edema
- Lesions of subglottis or tracheobronchial tree may require more distal examination and resection with rigid and flexible bronchoscopy
- **LASER – acronym for Light Amplification by Simulated Emission of Radiation**
- LASER light is monochromatic (1 wavelength), coherent (oscillates in same phase) & collimated (narrow parallel beam w/ minimal dispersion)



- Longer the wavelength, greater absorption by H_2O, less tissue penetration / edema
  - CO_2 laser
    - Far infrared (10,600 nm)
    - Absorbed by H_2O in 1st few layers of cells
    - Local / superficial effects
    - Target – surface tissue (excision of upper A/W lesion)
  - Nd:YAG (neodymium-yttrium aluminum garner) laser
    - Near infrared (1064 nm)
    - Less absorbed by H_2O
    - Diffuse / deeper effects
    - Target – tracheobronchial lesions (hemostasis, palliative treatment of obstructive lesion)
  - Ruby laser
    - Red (694nm)

        - Absorbed by cells containing pigment (melanin)
        - Target – tattoos, nevi
    - Argon laser
        - Green (514nm) and blue (488nm)
        - Transmitted by H_2O; absorbed by Hb and melanin
        - Diffuse / deeper effects
        - Target – penetrate skin / ocular structures and coagulate vascular or pigmented regions
- Advantages of LASER
    - ↑ precision
    - ↓ bleeding (hemostasis)
    - Complete sterility
    - ↓ tissue reaction (↓ post-op edema / pain)
- **Risks** of LASER
    - **Atmospheric Contamination**
        - Laser plume may be mutagenic, teratogenic or vector for viral infection
        - Evacuate smoke at surgical site and wear special high-efficiency mask to catch laser plume particles
    - **Tissue / Vessel Perforation**
        - Viscous or large blood vessel (>5mm not coagulable) perforated by misdirected laser
        - W/ Nd:YAG laser may not occur until edema / necrosis maximal (several days)
    - **Embolism**
        - Venous gas embolism w/ Nd:YAG (associated with gas coolant system of Nd:YAG laser contact probes)
    - **Energy Transfer to Inappropriate Location**
        - **Airway / drape fire** (O_2, N_2O support combustion; helium, N_2, modern volatiles are non-flammable; ↑likelihood of ignition if PVC > red rubber tubes, ↑wattage of laser, ↑duration of exposure) → thermal and chemical injury, bronchospasm, edema and respiratory failure
        - **Eye injury** (CO_2 = corneal burn, Nd:YAG, ruby, argon = retinal burn); therefore patient & OR staff need eye protection

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