Thoracic surgery

*Anaesthetic management of bronchopleural fistula*

*Outline your approach to tracheal stenosis surgery*

*Preparation for lung surgery*

*One lung ventilation*

*Mediastinoscopy*

*Tracheal resection*
Anaesthetic management of bronchopleural fistula

Bronchopleural fistula
- Communication from major bronchus to pleural space
- Commonly associated with pneumonectomy, trauma, abscess or empyema

Relevant complications
- Pus may contaminate other lung
- Associated injuries with trauma

Surgery
- Usually semi-elective
- Resuturing of bronchial stump, muscle flap to stump, drainage of abscess
  - High risk surgery requiring GA and one-lung ventilation
- If incidental surgery, GA may be avoided, regional preferred
  - Positioning still important to avoid soiling

Patient
- Commonly debilitated, may have coexistent medical problems
- Respiratory function assessed
  - Clinical, spirometry, ABGs
- Routine assessment for thoracic surgery
  - Consideration of epidural

Decision to proceed
- Respiratory function optimized
- Chest drain inserted to avoid tension pneumothorax and drain pleural collection

Induction
- Objectives
  - Maintain oxygenation and ventilation, avoid tension pneumothorax
  - Avoid soiling good lung
- Protection of lung requires DLT, bronchial lumen to good side
- Small leak without infection may be manageable with single-lumen ETT
- Paediatric patients are typically too small for DLT or FOB ⇒ blocker or endobronchial intubation
- Fistula reduces effectiveness of mask IPPV, so spontaneous ventilation
  - Ideally awake DLT intubation
    - Topical local anaesthetic to airway
    - Position head-up and bad side down
    - Sedation for intubation
  - Alternatively spontaneously ventilating GA with DLT insertion when deep
- Verification of DLT position with differential ventilation or FOB

Maintenance
- IPPV to healthy lung
- Lung with fistula may benefit from small $V_T$ ventilation or CPAP below critical pressure for fistula or HFJV

Emergence
- Avoid high airway pressures if fistula has been repaired
  - Hand ventilation or SIMV

Postoperative
- Epidural analgesia
- HDU monitoring post-op
  - High incidence of arrhythmia post-thoracotomy
Outline your approach to tracheal stenosis surgery.

Surgery
Elective, high risk
Cervical level: neck incision
More distal stenosis: thoracotomy or sternotomy

Stenosis
Extrinsic compression e.g. goitre
Usually tracheomalacia: soft tracheal stenosis
May be easily splinted with ETT
Surgery may not involve opening trachea

Scarring
Usually firm fibrous stenosis

Assessment
Routine plus
History
Symptoms of airway compromise: positional dyspnoea, sleeping position
Examination
Respiratory examination: upper airway sounds
Investigations
Pulse oximetry, ABG if obvious compromise
Spirometry: may be only slightly blunted by significant stenosis
Tomography or CT: define anatomy

Preoperative
Sedative premedication may worsen function as may anxiety
Aspiration prophylaxis: H₂ blocker
Anticholinergic to reduce secretions

Monitoring
Routine plus
Left radial arterial line (compression of innominate artery during surgery)

Induction
Technique depends on degree of stenosis and airway control
Mild, flexible stenosis with little compromise
Conventional IV induction
Tracheostomy in situ
IV induction and armoured tube in tracheostomy
Replacement by surgeon with sterile tube
Critical stenosis
Inhalational induction with potent volatile agent in 100% O₂
May take 20 min to achieve anaesthesia
e.g. sevoflurane in O₂ plus BP support if required

Intraoperative
Rigid bronchoscopy should delineate degree of stenosis
Allow decision about method of ventilation
Ventilation options
Conventional IPPV
Armoured ETT or DLT passing stenosis: sterile or non-sterile
Reinforced ETT above stenosis, sterile tube across surgical field
Jet ventilation using small catheter
Cardiopulmonary bypass
Deep hypothermic arrest
Head is usually in flexion at the end of the surgery, may be sutured chin-to-chest

Emergence
Aim for extubation to minimize tension on tracheal anastomoses
Spontaneous ventilation, suctioning, extubation either deep to minimize coughing or light with adequate narcotics
Fibreoptic scope available in case of need for reintubation
Preparation for lung surgery

Assessment

Associated disease: IHD, PVD, COAD

History

Exposures (smoking, occupation)

Symptoms

Bronchopulmonary, extrapulmonary

Intrathoracic, extrathoracic

Metastatic, non-metastatic

Examination

Investigation

FBE, U&E, enzymes

CXR, CT

Pulmonary function testing

Whole lung: ABG, spirometry, diffusing capacity

Single lung: $\dot{V}/Q$ testing, split function testing

Simulation: occlusion of main stem bronchus or pulmonary artery

Exercise testing

Risk factors for poor outcome

PaCO$_2$ >45 mmHg, MBC or FEV$_1$ <50% predicted, RV >50% of VC, raised PVR (>190 dyne.s.cm$^{-5}$)

Requirements for surgery

Predicted postop: FEV$_1$ >0.85 l, PAP <40 mmHg, PaCO$_2$ <60 mmHg, PaO$_2$ >45 mmHg

Preparation

Optimize respiratory function

Cease smoking, bronchodilate, treat infection, mobilize sputum, educate for physio

Optimize associated diseases

Intraoperative

Monitoring

Tiered approach

Routine

FiO$_2$, O$_2$ fail, SpO$_2$, gas analysis, NIBP, ECG, airway P, disconnect, nerve stimulator, temperature

Sick patient or major procedure

Arterial line, gases, spirometry and derived measurements, CVC

Sick patient and major procedure

PA catheter and derived measurements, S$_v$O$_2$ and derived measurements

Lateral position

Placement of PA catheter may need to be verified on II (if in deflated lung, CO and S$_v$O$_2$ measures are inaccurate)
One lung ventilation

Physiology

Hypoxic pulmonary vasoconstriction
- PVR is locally responsive to $PO_2$
- Reduced shunt fraction in lung which is partially hypoxic
- Most effective in reducing fall in $PaO_2$ when 30-70% of lung is hypoxic
- Inhibited by some agents
  - Volatiles inhibit HPV \textit{in vitro} but not significantly in humans
  - No intravenous anaesthetics inhibit HPV
  - Direct arterial dilators inhibit HPV (SNP, GTN, $Ca^{2+}$ antagonists, $\beta$ agonists), though aminophylline and hydralazine may be safe

Distribution of blood flow
- Lateral positioning reduced lung blood flow by 10% of CO
- Non-ventilation reduces lung blood flow by 50% due to HPV
- 1 MAC of isoflurane inhibits HPV to 40% reduction in flow
- The inhibition of HPV by volatiles is difficult to detect in practice
- No significant difference from TIVA

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Anaesthetic technique

Recommendations
- High $FiO_2$, precludes $N_2O$ use
- Potent volatile or propofol reduces airway reactivity
- Narcotic analgesia or thoracic epidural diminishes hypnotic requirement

Intubation
- Response blunted with adequate anaesthesia, narcotic and lignocaine

Indications for DLT
- Absolute
  - Lung isolation for bronchopleural fistula, bullous disease, bleeding, infection, bronchopulmonary lavage
  - Conducting airway surgery or trauma
  - VATS
- Relative
  - Surgical exposure: aortic, lung, mediastinal, oesophageal, vertebral surgery
  - Differential lung ventilation following unilateral massive PE thrombectomy or with unilateral lung disease

DLT insertion

Types
- Carlens left with hook
- Robertshaw left or right
  - 26, 28, 35, 37, 39 or 41 Fr (4.0 to 6.5 mm lumen diameter)
- Left side most commonly used unless proximal left main lesion

Protocol
- Check cuffs and connections
- Conventional laryngoscopy
- Tip passed with curvature concave-forward
- Rotated if hook present so hook passes anteriorly through larynx
- Rotated so tip points to side to be endobronchially intubated and...
head turned to opposite side
Advanced until resistance is met (typically at 29 cm + 1 cm per 10 cm height over 170 cm)
Tracheal cuff inflated and bilateral lung ventilation verified
If unilateral, may be in too far, withdraw until bilateral
Bronchial cuff inflated, bronchial lumen ventilated
If bilateral lung inflation ± leak from tracheal lumen, tube
is not advanced far enough
If lower lobe inflation only, tube is advanced too far
If right lung isolation, tube is in right bronchus
Verify lung isolation
Tracheal lumen ventilated
If no apparent ventilation, tube may be too far advanced in either bronchus or entirely in the trachea so deflate bronchial cuff and ventilate to determine position
Verify lung isolation
Verify position with tracheal lumen fibreoptic bronchoscopy, particularly with right-sided tubes to verify upper lobe bronchus position relative to cuff
Verify isolation again after patient positioning
Other methods to verify position
X-ray, differential capnography or flow-volume loops, surgical palpation
Underwater bubble test to verify total lung isolation
Other lung isolation techniques
Univent, bronchial blockers
Place with FOB assistance
Ventilation
Principles
Maintain two-lung ventilation as long as possible
High FiO₂
Initial OLV V₁ of 10 ml/kg
Titrate ventilation to normal PaCO₂
Strategy to maximize HPV in non-ventilated lung
Avoid vasodilation in non-ventilated lung due to
Systemic vasodilators, ↑ PA pressure, ↑ P\textsubscript{a}O₂, ↓ PCO₂
Avoid vasoconstriction in ventilated lung due to
Hypoxia, ↓ PA pressure, ↑ PCO₂, high PEEP
Managing falling PaO₂
Low PEEP to ventilated lung
CPAP with 100% O₂ to non-ventilated lung
Intermittent two-lung ventilation
Early PA clamping if lung resection
Other options
HFPPV, HFJV
Lower mean airway pressures
Less movement
Low flow apnoeic ventilation
Theoretically feasible for up to 20 minutes
High PaCO₂ and severe respiratory acidosis
Mediastinoscopy

Surgery
   Suprasternal notch incision
   Blunt dissection anterior to trachea, posterior to aortic arch down to carina

Intraoperative
   Monitoring
      Routine, plus
      Right radial arterial line (for great vessel compression) and left NIBP
      Large bore IV access in arm and leg (in case of SVC disruption)
   Induction
      Conventional relaxant GA (reduced risk of air embolus)
      Reinforced ETT
   Maintenance
      Extreme vigilance required
      Head-up position reduces bleeding but increases risk of air embolus

Complications
   Massive haemorrhage requiring sternotomy
      Have rapid infusion device available and blood crossmatched
      Venous disruption may cause air embolus and require lower limb access for drug administration
   Pneumothorax
      Common postoperatively, usually small
   Recurrent laryngeal nerve injury
      50% permanent
   Compression of aortic arch branches
      Especially right innominate: cerebral ischaemia
      Detect with right arm arterial line or pulse oximeter
   Autonomic reflexes
      Especially bradycardia, hypotension

Postoperative
   CXR to detect pneumothorax
   Repeat mediastinoscopy is usually impossible due to scarring
Tracheal Resection

Preop
PREOPERATIVE CONSIDERATIONS
- Uncommon major surgery with a shared airway
- Often poses significant difficulty in maintaining ventilation while allowing surgical access: initially due to disease, then surgical disruption, then fragile reconstructed airway with awkward positioning
- Requires excellent communication between surgeon and anesthesiologist

PHYSICAL FINDINGS
- Degree of obstruction
- Ability to lie supine
- Careful evaluation of airway
- Ability to cough and clear secretions
- Respiratory examination

WORKUP
- Usual assessment of comorbidities (often smokers with coronary disease)
- Delineation of lesion: Xray, tomography, fluoroscopy, CT, MRI
- Imaging of adjacent structures: barium swallow, angiography
- Respiratory function testing: characteristic flow-volume loop
- Bronchoscopy, biopsy
- Not all lesions are resectable: palliation with dilatation, stent or laser
- Detailed plan for airway management must be discussed and agreed with the surgeon

CHOICE OF ANESTHESIA
- General anesthesia
- Airway management plan agreed before surgery: IPPV, HFPPV, jet or spontaneous ventilation or cardiopulmonary bypass or a combination thereof
- Epidural placement for postoperative analgesia if a thoracotomy is planned

Intraop
MONITORS/LINE PLACEMENT
- Preoperative sedation used with great caution or not at all in incipient obstruction
- Large IVs, routine monitors: ECG, SpO2, gas analysis
- Arterial line indicated (on left for right thoracotomy)
- Central line or PA catheter only if cardiac disease demands it
- Sterile circuit and selection of ET tubes at hand including small diameters, armored, and extra-long tubes
- High frequency positive pressure (or jet) ventilator and second anesthesia machine available if their use is being considered
- Cardiopulmonary bypass machine primed and ready if its possible use is planned

INTRAOPERATIVE CONCERNS
- Possibility of obstruction on induction: have assistance and surgeon present with rigid bronchoscopes available
- Slow inhalational induction probably safest, alternatively awake fiberoptic-guided intubation after topical anesthesia to the airway if rigid bronchoscopy is not planned
- Maintenance with intravenous anesthetic agents allows use of 100% oxygen

INTRAOPERATIVE THERAPIES
- Ventilation strategies during tracheal resection include:
  - Jet ventilator catheter passed through ETT (which is above resection) for manual or high-frequency jet ventilation
IPPV through sterile ETT inserted by surgeon into trachea below resection (intermittent extubation while sewing anastomosis)
For low lesions, bronchial intubation by the surgeon and IPPV to one lung or both separately
Spontaneous ventilation (complicated by hypercarbia, coughing and possible airway soiling)
Cardiopulmonary bypass (complications of systemic anticoagulation)
After anastomosis, airway pressures must be minimized: spontaneous ventilation or low tidal volume IPPV
Aim for extubation at end of surgery to minimize exposure of anastomosis to positive airway pressure
Reintubation will be difficult (head flexed, edematous airway) and will require a fiberoptic scope both for intubation and to verify the tube tip is not touching the anastomosis

**Postop**

**POSTOPERATIVE PAIN**
Carefully titrated narcotics or epidural infusion

**COMPLICATIONS**
- Anastomotic dehiscence is associated with poor outcome
- Greater risk of dehiscence with post-op ventilation, steroids, infection, extensive tracheal disease
- Reduced risk of dehiscence with use of vascularized flap covering anastomosis
- Minimize tracheal tension with head flexion (maintained postoperatively with a suture from chin to anterior chest for several days)
- Head flexion may cause cervical spinal cord compression

**Surgical Procedure**

**INDICATIONS**
- Uncommon surgery for tumor, fistula, stenosis or trauma
- Tumor must not be invading mediastinum
- Likely post-operative ventilation is a relative contraindication

**PROCEDURE**
- Cervical/sternotomy approach to high lesions. Initially head extended and roll between scapulae. Repositioning required for anastomosis with head flexed and roll deflated or removed
- Right thoracotomy, head flexed approach to low or carinal lesions

**SURGICAL CONCERNS**
- Tracheal mobilization to allow anastomosis without tension
- Maintaining tracheal blood supply

**TYPICAL EBL**
- Highly variable