ANAESTHESIA FOR THORACIC SURGERY

Who gets thoracic surgery
  Timing of surgical pathway – cancer surgery
Preoperative assessment
Preoperative investigations
Principles of thoracic anaesthesia
  Introduction to airway management
  Analgesic strategies for thoracic patients
  Post-op recovery and care
One lung ventilation and management

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## Curriculum

<table>
<thead>
<tr>
<th>Competence</th>
<th>Description</th>
<th>Assessment methods</th>
<th>GMP</th>
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</thead>
<tbody>
<tr>
<td>CT_IS_09</td>
<td>Demonstrates ability to assess and recommend treatments to optimise a patient about to undergo thoracic surgery</td>
<td>A,C,D</td>
<td>1,2,3,4</td>
</tr>
<tr>
<td>CT_IS_10</td>
<td>Demonstrates safe delivery of perioperative anaesthetic care to patients for minor thoracic procedures, including bronchoscopy, the safe use of the Sanderson injector</td>
<td>A,C,D,M</td>
<td>1,2,3,4</td>
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<tr>
<td>CT_IS_11</td>
<td>Demonstrates correct selection of appropriate airway management for the intended procedure and the ability to correctly insert single or double lumen endobronchial tubes and bronchial blockers [Ref: AM_IS_05]</td>
<td>A,D</td>
<td>1,2</td>
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<tr>
<td>CT_IS_12</td>
<td>Demonstrates correct use of clinical and endoscopic methods to confirm correct tube placement</td>
<td>A,D</td>
<td>1,2</td>
</tr>
<tr>
<td>CT_IS_13</td>
<td>Demonstrates safe delivery of perioperative anaesthetic care for major thoracic procedures, including correct airway and ventilatory management, positioning and patient protection</td>
<td>A,C,D</td>
<td>1,2,3,4</td>
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### Skills

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<tr>
<td>CT_IS_14</td>
<td>Demonstrates the ability to manage a patient undergoing one lung ventilation</td>
<td>A,D</td>
<td>1,2</td>
</tr>
<tr>
<td>CT_IS_15</td>
<td>Demonstrates the ability to formulate correct post-operative care plans, taking into account the patient’s condition and the surgical procedure, including an assessment of the need for management in intensive care or high dependency</td>
<td>A,C,D,M</td>
<td>1,2,3,4</td>
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Thoracic Surgery

- Lung Cancer
  - Bronchoscopy and Mediastinoscopy
    - Staging of cancer or diagnostic for mediastinal lymph nodes
  - Lobectomies (via thoracotomy or VATS)
  - Sleeve resections (and double sleeve)
  - Pneumonecotomy
- Lung Nodules
  - Wedge excisions
- Pleural Disease and Effusions
  - Pleural biopsy and pleurodesis
  - Empyemas
- Pneumothorax
- Thymectomy
- Diaphragmatic Plication
- Rib plating for trauma
- Emphysema
Bronchoscopy

- 1897 Gustav Killian
- Flexible vs. Rigid and LA vs. GA
- Pre-med – Nil or Anticholinergic
- Induction + NMB drug + Opiate
- Maintenance - bolus or continuous iv drug
- Monitors - Oximeter, ECG, Auto BP

- Rigid – Jackson, Negus, Storz
- Oxygenation - apnoeic oxygenation
  - deep volatile anaesthesia and SV or CV
  - HFV - Saunders injector - bursts of O₂ from 60 psi (410 kPa)
    - entrains air, inflates lungs
  - SWG 16 = 25 - 30 cm² water
    - SWG 14 = 50 cm² water
    - open proximal end to atmosphere

- Trauma to teeth, pharynx, larynx
- Airway perforation – pneumothorax
- Poor oxygenation
- Awareness
VATS vs open thoracotomy
Pathway

- Clinical Presentation and CXR
- CT
- Flexible Bronchoscopy / tissue by EBUS
- CT guided biopsy
- CT Brain / CT Body / PET
- Surgical Bronchoscopy / Mediastinoscopy
  - Sampling of lymph node tissue
- Surgical resection
  - effective for Non-Small Cell Cancers (possible 20% resection rate)
  - 5 year survival
  - NSCC - 70% with surgical resection
Preoperative assessment of thoracic patients

- History and Examination
  - Functional Status, routine Anaesthetic questioning
  - Bronchoscopy (Flexible or previous Operation)
- Lung function tests
  - How much & how quickly can the lungs move volume?
- Echo / exercise tests.
- Radiology
  - What is the pathology and can it be removed
  - Assessment of cardiac risk
- Scores
  - Dyspnoea score, Performance Index => Thoracoscore.
Respiratory mechanics

- Spirometry (FVC & FEV$_1$)
  - Post-bronchodilator
  - Corrected for age, sex, body size

  - FEV$_1$ > 1.5L fit for lobectomy
  - FEV$_1$ > 2.0L fit for pneumonectomy

- No further lung function tests needed

- Role of prehabilitation?
Borderline Lung resection

- Calculate predicted post-op
  - $\text{FEV}_1\%$
  - $\text{T}_{\text{LCO}}\%$
  - Using 19 bronchopulmonary segments
Gas Exchange

- Transfer factor for carbon monoxide ($T_{LCO}$)
  - Quantity of carbon monoxide transported across the alveolar-capillary membrane (each minute per unit of pressure gradient)
  - Corrected for age, sex, body size
- Transfer coefficient $K_{CO}$
  - Diffusing capacity per unit volume of lung, standardised for VA
- Alveolar Volume VA
  - Lung volume in which carbon monoxide diffuses into during a single breath-hold technique
- $SaO_2$ at rest
- Quantitative isotope perfusion scan
Borderline Lung resection

- **Average Risk**
  - Predicted postoperative $\text{FEV}_1$ and $T_{LCO} > 40\%$
  - Oxygen saturation ($\text{SaO}_2$) $> 90\%$ on air

- **High Risk**
  - Predicted postoperative $\text{FEV}_1$ and $T_{LCO} < 40\%$

- **Risk uncertain**
  - $\text{SaO}_2$ on air $< 90\%$
  - poor exercise tolerance and/or comorbidity
    - exercise test and/or lung perfusion scan
Myaesthenia gravis - VATs Thymectomy

- Autoimmune Ds of NMJ due to IgG auto-AB reducing the number of ACh receptors
- 0.4 per 100,000, women > men, any age
- Muscle weakness and fatigue; improves with rest; Ptosis; double vision
- 75% have abnormal thymus (hyperplasia 85%, thymoma 15%)
- Management - Anticholinesterase drugs - Steroids then Azathioprine
- Thymectomy - Thymoma or Hyperplasia  Remission rates of 30% over 1 year  Significant benefit in 50%
- Thymic Carcinoma  
  - stage I 75% 5 year survival 
  - stage IV 20% 5 year survival
- OLV and Carbon Dioxide insufflation
Cardio-Respiratory Reserve

• Estimation of cardio-respiratory reserve
  • amount of $O_2$ consumed at maximum work
  • Patient history may suggest limitation

• Cone shuttle test
  • below 250m (25 shuttles) higher risk
  • Desaturation SaO$_2$ >4% higher risk

• VO$_2$ max is gold standard
  • Below 10ml/kg/min for lobectomy is high risk
  • Below 15 ml/kg/min for pneumonectomy
Lung cancer resectable

What is the most extensive surgery likely to be needed for cure?

Lobectomy (wedge resection)

Perform post-bronchodilator spirometry

FEV$_1$ > 1.5 l?

No

Yes

Operable

Calculate estimated postoperative FEV$_1$(epoFEV$_1$)

Using the following equation:

epoFEV$_1$ = preFEV$_1$ \times \frac{(19 - \text{segs. to be removed})}{19}

If any segments obstructed use:

epoFEV$_1$ = preFEV$_1$ \times \frac{(19 - a) - b}{19 - a}

a = no. of obstructed segments
b = no. of unobstructed segments to be resected

Segments as follows:
Right upper lobe 3/ middle lobe 2/
right lower lobe 5/ left upper lobe 3/
lingula 2/ left lower lobe 4

Pneumonectomy

Perform post-bronchodilator spirometry

FEV$_1$ > 2 l?

No

Operable

Perform quantitative perfusion scan

Calculate estimated postoperative FEV$_1$(epoFEV$_1$)

Using the following equation:

epoFEV$_1$ = preFEV$_1$ \times (1 - \text{proportion of lung to be resected})

Perform transfer factor
Sao$_2$ on air
Calculate estimated postoperative Tlco (epoTlco) using the above formulae
Express absolute epoFEV₁ and epoTlco as % predicted (from table of normal values)

Allocate to ONE of the following boxes

- %ppoFEV₁ <40% AND %ppoTlco <40%
  - High risk

- Any other combination

  Exercise testing required*

  Shuttle walk test (best of 2)

  - <25 shuttles or desaturation >4%
    - Refer to high risk box

  - >25 shuttles and <4% desaturation
    - Full cardiopulmonary exercise test
      - Peak $\dot{V}O_2$ <15 ml/kg/min
        - Average risk
        - Refer to high risk box
      - >15 ml/kg/min
        - Average risk

High risk box
Patient is at high risk for the planned procedure.
Consider a less extensive resection.
Consider radical radiotherapy.

*Note: Ideally, full cardiorespiratory exercise testing should be performed. Although it is not available in many district general hospitals, these facilities are usually available at cardiothoracic centres. If the facilities are not readily available, consider a screening shuttle test.
Cardiovascular fitness

• preoperative ECG
• audible cardiac murmurs
  • echocardiogram
• Myocardial Infarction
  • delay lung resection for 6 weeks
  • within 6 months - cardiology opinion
• previous CABG
  • not be precluded from lung resection
  • Assessed as other patients

Co-morbidity and other tests

- Refer for cardiology advice if high risk
  - Unstable coronary syndromes
  - Congestive cardiac failure
  - Severe valve disease
  - Major arrhythmias

- Cerebrovascular disease
  - TIA or stroke for carotid Doppler studies
Rib plating Surgery v Conservative

- Standard treatment of flail chest has been "internal splinting" using mechanical ventilation.
- Various methods of plating /stabilizing rib fractures have been developed but not widely adopted.
- Optimum timing for operative intervention not known.
- Results can not be generalised to the population of mechanically ventilated patients with flail chest as exactly which patients gain the most benefit is not known.
Principles of Thoracic Anaesthesia

- Pre-operative assessment
  - Respiratory Disease
  - Cardiovascular Disease
  - Other Morbidity
    - Diabetes
    - Peripheral Vascular Disease

- Monitoring
  - Oxygen delivery
    - Cardiorespiratory Monitoring
  - CO2 removal
    - Ventilator parameters
  - Depth of Anaesthesia
    - Cardiovascular
    - Cerebral Function
Principles of Thoracic Anaesthesia

• Anaesthetic Technique
  • IV / Gas induction
    • Muscle relaxation
    • Cardiovascular stability
    • Analgesia
  • TIVA / Volatile Maintenance
    • Cardiovascular stability
    • Analgesia
  • Reversal / Waking
    • Reversing muscle relaxation
    • Analgesia
    • Establishing spontaneous ventilation
    • Extubation avoiding post operative hypoxia

• Post-op recovery and care
VATS vs open thoracotomy
Principles of Thoracic Anaesthesia

• Airway Management
  • Secure airway – but what about rigid bronchs?
  • Lung Isolation
    • Double lumen tube
      • Positioning (Patient and Tube)
    • Bronchial blocker
      • Positioning (Patient and Blocker)
    • Laryngeal Mask
      • Two lung ventilation

• Breathing / Ventilation
  • One Lung Ventilation
    • 1) Respiratory mechanics - Volumes
    • 2) Diffusion capacity
    • 3) Cardio-Respiratory reserve
One Lung Ventilation

- One-lung ventilation was originally performed to prevent infectious material spilling from one lung to the other during thoracic surgery and for broncho-spirometry.
- Gale and Waters first reported the use of selective lung ventilation during thoracic surgery in 1931.
- Early endobronchial anesthesia was performed using modifications of single-lumen tubes, including double cuffs and bronchial blockers.
- Carlens in 1949 designed a double-lumen tube with tracheal hook and then Robertshaw introduced a DLETT without a hook in 1962.
- OLV is most commonly used today to create a quiet operating field for the performance of surgery. OLV is frequently carried out with only a small effect upon oxygenation and ventilation. However, significant hypoxemia may occur, and the incidence has been reported to be as high as 40%–50% in some series.
Double LETT with carinal hooks

**Carlens** (1949)-left

**White** (1960)-right
Double Lumen ETT

- 1959 - Bryce-Smith: Left, lumen front to back, circular x-section, no hook
- 1960 - Bryce-Smith-Salt: Right, slit for Right Upper Lobe, circular x-section, no hook
- 1962 – Robertshaw: Left or Right, large slot in R bronchial cuff to align with RU orifice
- 1978 – Plastic DLETT
Double Lumen ETT

Robertshaw (1962)

- Right Tube orifice slit - 21 mm

Plastic PVC Tubes (1978)

- Right Tube orifice slit – 11 mm
Indications for DLETT

**Absolute indications**
- Risk of soiling with infection or haemorrhage
- Control of ventilation due to BPF, giant cyst or bulla, or trauma of airways (bronchial disruption)
- Broncho-pulmonary lavage (Alveolar proteinosis)

**Relative indications**
- Surgical exposure - high priority
- Thoraco-abdominal vascular repair
- Pneumonectomy
- Lobectomy
- Cardiac ops - MID-CAB & Mini Mitral repair
- Oesophageal resection
- Thoracic spinal surgery
Contraindications for DLETT

- Large airways obstruction
- Difficult intubation
- Instability of cervical spine
- Children < 10 years
- Full stomach
DLETT placement - Fibreoptic
All the ways it can go wrong
Other Methods of OLV

- Single-lumen COETT with insertion of balloon-tipped catheter
  - Range of catheters: Fogarty embolectomy catheter, Magill or Foley, and Swan-Ganz catheter (children < 10 kg)
  - Bronchial Blockers
  - Inability to suction or control bleeding/pus

- Endobronchial intubation with single-lumen ETT
  - Easiest and quickest way of separating one lung from the other: likely to go into right lung especially pediatric
  - May cause hypoxemia or bronchial damage

- LMA
Fuji Univivent Blocker

- **Swivel connector**: Enables rotation of the circuit if the patient is moved and facilitates FOB insertion.
- **Quick release for easy removal**: Uniblocker™ is easily removed without disconnecting the swivel connector from the anaesthesia circuit using the quick release connector.
- **Torque control blocker (TCB)**: The Uniblocker™ shaft incorporates a metallic mesh which gives torque control enabling smooth manipulation and ease of placement.
- **High volume gas barrier (GB) cuff**: Soft high volume cuff made of silicone with GB properties to reduce diffusion of gas into or out of the cuff.
Physiology of the Position

Upright position

Lateral decubitus position
Summary of V-Q relationships in the anaesthetised, open-chest and paralysed patient in LDP
One lung ventilation

• Problems include
  ■ Hypoxia
    • V/Q Shunt, tube misplacement, bronchospasm, secretions
  ■ Hypercapnia
    • minute volume constant – reduce Vt and increase Rate
    • Permissive hypercapnia
    • Surgical use of CO2 to collapse the lung down
  ■ Ventilator pressure
    • control tidal volume – IPPV v Pressure mode
  ■ Blood pressure
    • Hypotension aggravates V/Q mismatch
  ■ RV dysfunction due to increased PVR
Management of OLV - Theatre

- Saturation probe
- Increase FiO2 before going onto OLV - ? 70-100%
- Listen to chest or bronchoscope or watch Paw change
- Commonest problem – not ventilating L or R upper lobe
- DLETT has changed side or slipped out
- Secretions, Bronchospasm, Pneumothorax
- Check circuit & connections
- Consider improving BP – Preload or Vasopressor
- Use PEEP up to + 10 cm/water
- Accept >84% saturation
- Insufflate O2 into collapsed lung(poor) or CPAP(better)
- Re-inflate lung (discuss with surgeon)
Hypoxia with One Lung Ventilation

- Hypoxic pulmonary vasoconstriction (HPV) is a mechanism whereby pulmonary blood flow is diverted away from hypoxic/collapsed areas of lung.
- Improves oxygenation during OLV.
- Local vasoconstriction of pulmonary artery smooth muscle. Vasoactive substances released by hypoxia or effect of hypoxia (K⁺ channel) on pulmonary artery smooth muscle.
- Volatile anaesthetic agents depress HPV minimally
- Intravenous agents (propofol) do not inhibit HPV
WTF?
Principles of Thoracic Anaesthesia

• Circulation
  • Poor tissue perfusion / cellular oxygenation leads to perioperative complications and poor outcomes
    • Hypovolemia > effective fluid management
    • Low Cardiac Output > titration of vasoactive drugs
  • maintain adequate oxygen delivery (DO2)
  • prevent fluid overload

• BP = CO x SVR
• CO = SV x HR
Principles of Thoracic Anaesthesia

- Arterial pressure
- Central venous pressure
- Cardiac output monitoring
  - Doppler echocardiography
  - Pulmonary artery catheter
  - Other cardiac output monitoring devices
    - Pulse contour analysis
    - Doppler monitoring devices
    - Applied Fick principle and dye dilution
    - Bioimpedance and bioreactance
- Fluid management
  - Static indicators of preload
  - Functional hemodynamic parameters
- Mixed venous oxygen saturation
- Blood lactate concentrations
Principles of Thoracic Anaesthesia

- Hypovolemia:
  - altered tissue perfusion
  - renal failure
  - anastomotic breakdown
  - confusion
  - CVA
  - splanchnic ischemia
  - MOF

- Hypervolemia:
  - edema
  - intraabdominal hypertension
  - respiratory failure
  - impaired healing
  - altered mobilization
  - MOF

- Complications

- Volume Status
Pain

- Acute/Chronic pain in thoracic surgery
  - Intensity and Prevalence of pain
  - Affects function
  - Affects respiration
- Type of Surgery
  - video-assisted thoracic surgery (VATS)
  - Thoracotomy.
- Noxious input associated with thoracic surgery
- Predisposing factors
Pain

• Multimodal Analgesia
  • Systemic
    • Paracetamol
    • NSAID
  • Opiates
  • Alternatives
    • Clonidine
    • Magnesium
    • Ketamine
Pain

- Multimodal Analgesia
  - Regional/Local Anaesthesia
    - Epidural
    - Paravertebral blockage or catheter
    - Extrapleural injections or catheter (surgically inserted)
    - Intercostal Nerve blocks
  - Novel techniques
    - Serratus anterior
    - Erector spinus
Post op recovery and care

• Recovery
  • Highest risk of problems here
    • Hypoxia
    • Hypercarbia
    • Analgesia
    • Cardiovascular instability

• Post op care
  • Ward/HDU/ITU
  • Physiotherapy
  • Pain
  • Drains
RV failure post-lung resection

• Any resection of lung will result in a small increase in PVR
• Patients with PAPs greater than 40 mmHg will have a greater risk in the post-op period
• Patients with significant chronic pulmonary disease will have developed a degree of Right ventricular hypertrophy
• Limited studies demonstrating RV failure with Pneumonectomies are few
• RVEDP does increase but RV failure is very rare
Any questions?