Applied Physiology of One Lung Ventilation
One Lung Ventilation

- Usual situation
  - Thoracic surgery
  - Lateral decubitus position
  - GA, paralysis, PPV
  - Non-dependant lung collapsed and non-ventilated
  - Chest may be open or closed
Normal Physiology
Lateral Decubitus Spont Vent

- V/Q maintained
- Non-dependant lung
  - ↓Q due to gravity
  - ↓V due to position on compliance curve
- Dependant lung:
  - ↑Q due to gravity
  - ↑V due to
    - Diaphragm advantage
    - Position on compliance curve
Lateral Decubitusus Ventilated

- Non-dependant lung further ↑ V/Q
  - ↓ Q due to gravity
  - ↑ V due to position on compliance curve
  - Further ↑ V if chest opened

- Dependant lung further ↓ V/Q
  - ↑ Q due to gravity
  - ↓ V due to
    - Position on compliance curve
    - Loss of diaphragm advantage
    - Greater impact of abdominal contents and mediastinum
    - Sub-optimal positioning
OLV Physiology

- Main problem is obligatory shunt through the non-ventilated lung
- Main compensatory measure is hypoxic pulmonary vasoconstriction
OLV Physiology

Fractional blood flow

Two lung ventilation

Nondependent lung

Fractional blood flow

PaO₂ = 400 mm Hg
Qs/Qt = 10%

60%

Dependent lung

One lung ventilation

Fractional blood flow

PaO₂ = 150 mm Hg
Qs/Qt = 27.5%

22.5%

© Elsevier Science 2005

© Elsevier Science 2005
V/Q ratio in OLV

- **Non-dependant lung**
  - Zero V
  - ↓Q due to
    - HPV – major factor, 50% reduction
    - Gravity
    - Surgical interference
    - Pre-existing disease

- **Dependant lung**
  - As previously discussed for later decubitus, GA, PPV
Determinants of HPV

- Decreased by
  - Drugs
    - Volatile anaesthetics, GTN, SNP, NO, some Ca channel antagonists, PDE, α agonists, β agonists
    - Mechanisms: direct vasodilatation, increasing PVR in the ventilated lung, increasing PAP
    - Dopamine extensively studied – no significant effect
  - High PAP
    - Poor smooth muscle overcome by pressure
  - Low PAP
    - Creates zone 1 areas in ventilated lung
    - Non-ventilated lung already zone 1 (atelectatic)
    - Some blood diverted non-ventilated lung
  - High PvO2
    - reverse diffusion of O2
  - Low PvO2, Low FiO2
    - induces HPV in ventilated lung
    - Some blood diverted to non-ventilated lung
Determinants of HPV

- Decreased by
  - Hypercapnia
    - causes pulmonary vasoconstriction in ventilated lung
  - Hypocapnia
    - causes pulmonary vasodilatation in non-ventilated lung
  - High AWP
    - Increases PVR in ventilated lung
  - Ventilated lung PEEP
    - Diverts blood to non-ventilated lung by increasing PVR

- Maximise by
  - Normocapnia, lower AWP, normal PAP
  - Use of FiO2 50% initially
Hypoxia under OLV

- General causes
  - Failure of O2 supply
  - Failure of O2 delivery
    - External:
      - machine, circuit, airway
    - Patient:
      - V/Q mismatch or shunt, including any cause of alveolar hypoventilation or reduced CO
      - diffusion abnormality
  - Increased O2 demands
    - e.g. sympathetic drive, hyperthermia, shivering

- Causes more common in OLV
  - Malpositioned, blocked or kinked DLT
  - Increased shunt fraction
  - Other
    - Absorption atelectasis of ventilated lung
    - Gradual resorption of residual O2 in non-ventilated lung
    - TRALI preferentially affects ventilated lung
Management - General

- “Attempt to rapidly diagnose the problem, while simultaneously providing general management until specific management can be implemented”
- Quickly confirm oximetry probe position and waveform
- 100% O2
- Scan the monitor for any change: BP, ETCO2, AWP, ECG, FiO2
- Auscultate chest
Management - Specific

- If DLT problem is suspected, check position with fiberoptic bronchoscope
- Apply PEEP to the ventilated lung
- Apply CPAP to the non-ventilated lung
- Differential PEEP/CPAP
- Intermittent two-lung ventilation
- Clamping of the PA to the non-ventilated lung
% PEEP

- PaO2 may be increased, decreased or unaffected
- Diseased lung often responds more favourably
- Start with no more than 5 cmH2O, to minimise the increase in PVR
CPAP

- External circuit, non-tidal
- Shunt is reduced
- O2 uptake is possible from the non-ventilated lung
- Often results in significant increases in PaO2
- Interferes with surgery
  - Must be applied during deflation following a large tidal volume
  - Does not tend to affect technical difficulty
Differential PEEP/CPAP

- Highly efficacious
- Exact distribution of blood flow becomes less important
External CPAP circuit

**Requirements**
- O2 source
- Pressure regulating device
- Manometer
Broncho-Cath CPAP system