New concepts in the management of one-lung ventilation

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CASE #1: 70 Y.O. MALE, LUNG CA., SMOKER, LEFT THORACOTOMY, LEFT DLT,

- During one-lung ventilation
- Sudden paw ↑ 50 cmH₂O
- PETCO₂ 10 mmHg
- Rapid SpO₂ 60%
- ? Rx

CASE #2: 60 Y.O. MALE, LUNG CA., NON-SMOKER, R. THORACOTOMY, LEFT DLT, FEV₁ = 98%

- 20 min one-lung vent
- No change paw 24 cm
- PETCO₂ 44 mmHg
- Grad. SpO₂ 89%
- ? Rx
**CASE #3: 67 Y.O. MALE, LUNG CA., EMPHYSEMA, LEFT VATS UPPER LOBECTOMY**

- 20 min. of OLV
- Grad. SpO₂ 86%
- No improvement with recruitment/PEEP
- Surgeon refuses CPAP
- ? Rx

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**INCIDENCE OF HYPOXEMIA DURING ONE-LUNG ANESTHESIA (FIO₂ 1.0)**

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Hypoxemia</th>
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<tbody>
<tr>
<td>Tarhan</td>
<td>1973</td>
<td>25%</td>
</tr>
<tr>
<td>Kerr et al</td>
<td>1974</td>
<td>24%</td>
</tr>
<tr>
<td>Slinger et al</td>
<td>1993</td>
<td>8%</td>
</tr>
<tr>
<td>Sticher et al</td>
<td>2002</td>
<td>10%</td>
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</tbody>
</table>

(Why did hypoxemia decrease?)

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**Lung Collapse During One-lung Ventilation vs. Gas Mixture During Two-lung Ventilation**

- Encourage collapse
- Avoid collapse

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WHICH PATIENT MORE LIKELY TO DESATURATE DURING OLV?

55 y.o. F, emphysema
FEV1 = 28%

Left VATS
Lung Bx

60 y.o. M, lung Ca.
Non-smoker, FEV1 = 98%

R thoracotomy, upper lobx.

• Right vs. left thoracotomy
• Lung elastic recoil
• Low PaO₂ during
• 2-lung ventilation
• V/Q ratio to surgical side

VENTILATION DURING OLV PREVENTION AND TREATMENT OF HYPOXEMIA
- High FiO₂
- CPAP non-ventilated lung
- PEEP ventilated lung
- HFPPV, partial vent.
- Selective pulmonary vasodilation

**BEST ANESTHETIC AGENTS DURING ONE-LUNG VENTILATION?**

- Halothane/enflurane
- Isoflurane/desflurane/sevoflurane
- Total intravenous anesthesia (TIVA)
- Combined TEA plus general anesthesia

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Oxygenation vs. Cardiac Output During One-lung Ventilation

Slinger P, Scott WA. Anesthesiology 1995, 82:940
Russel WJ, James MF. Anaesth Intens Care 2004, 32: 644

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Intraoperative Position vs. \( \text{PaO}_2 \) During One-lung Ventilation


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Intraoperative Position vs. \( \text{PaO}_2 \) During One-lung Ventilation

Imagine That You’re a Red Cell in the RV…

Zone 1

Total PVR

HPV

At el,

V/Q

Large vessels

Small vessels

1.0 2.0 3.0 4.0 5.0

RV FRC TLC

Lung volume (LV)

Pulmonary vascular resistance (PVR)

Transpulmonary pressure

Static Compliance Curve of the Ventilated (dependent) Lung, 57 y.o. Female, FEV1= 72%


One-Lung, Static Compliance Curve


32 y.o. Male, FEV1= 102%

Treatment of Hypoxemia during One-lung Ventilation


55 Y.O. MALE, DAY 3 POSTOP. RIGHT PNEUMONECTOMY

- Gradual onset dyspnea x 24 h
- $\text{SpO}_2$ 90% with $\text{FiO}_2$ 0.5
- Hemodynamics stable

POST-PNEUMONECTOMY PULMONARY EDEMA

**POST-PNEUMONECTOMY PULMONARY EDEMA**

Turnage WS, Lunn JL. Chest 103: 1646-50, 1993

- 806 pneumonectomies, 21 cases
- Right pneumonectomy 16 vs. left 5
- Mortality 21/21 (ARDS)
- Cases vs. controls:
  - Fluid balance (n.s.)
  - Fluid administration (n.s.) mean PAOP: initial 10, final 13 (n.s.)

POST-PNEUMONECTOMY PULMONARY EDEMA

- Incidence 2-4%
- Onset day 1-3 postop.
- Mortality 50-100%
- R > L pneumonectomy
- Assoc. excess fluids
- ARDS pathology

CAUSES OF POST-PNEUMONECTOMY PULMONARY EDEMA

Probable:
- Endothelial injury
- Capillary pressure
- Lung lymphatic damage
- Fluid overload
- Lung hyperinflation

Possible:
- RV dysfunction
- Cytokines
- Oxygen toxicity

PULMONARY ENDOTHELIAL PERMEABILITY CHANGES AFTER MAJOR LUNG RESECTION

PNEUMX. = 24, LOBX. = 11, RAD-LABL. ALB., 8 H POST-OP

- Permeability pneumx. > Lobx. ($p < .01$)
  (Low-Press., hi-Prot. PE fluid)
- Increase perm. $\alpha$ increase PVR
- Increase MPAP $\alpha$ / pre MPAP


THE MORTALITY FROM ACUTE RESPIRATORY DISTRESS SYNDROME AFTER PULMONARY RESECTION IS DECREASING

<table>
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<tbody>
<tr>
<td>ARDS incidence</td>
<td>3.2%</td>
<td>1.6%</td>
</tr>
<tr>
<td>ARDS mortality</td>
<td>72%</td>
<td>45%</td>
</tr>
<tr>
<td>Incidence of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pneumonectomy</td>
<td>17.4%</td>
<td>6.4%</td>
</tr>
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[n = > 1,300 Pulm. resections (2000-5)]
[decreased postop. tidal vol. ($p = .001$)]
Slinger P. New concepts in the management of one-lung ventilation

**INDIVIDUALIZING ONE-LUNG VENTILATION**

<table>
<thead>
<tr>
<th>Tidal vol.</th>
<th>5-6 mL/kg</th>
<th>Exceptions</th>
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<tbody>
<tr>
<td>PEEP</td>
<td>Total 5 cm</td>
<td>Pk. a/w P &lt; 35</td>
</tr>
<tr>
<td>FiO₂</td>
<td>1.0</td>
<td>Plat. a/w P &lt; 25</td>
</tr>
<tr>
<td>Resp. rate</td>
<td>12</td>
<td>Decreas. as tol.</td>
</tr>
<tr>
<td>Mode</td>
<td>Vol-C Vent./P-C Vent.</td>
<td>Mild hypercap. OK</td>
</tr>
</tbody>
</table>

Exclusions:
- Pk. a/w P < 35
- Plat. a/w P < 25

**MANAGEMENT OF HYPOXEMIA DURING ONE-LUNG VENTILATION:**

Severe/acute:
Resume two-lung ventilation

Gradual desaturation:
1. Assure FiO₂ = 1.0
2. Check DLT/BB: FOB
3. Optimize cardiac output
4. Recruit ventilated lung
5. Apply PEEP 5 cm vent lung (except COPD)
6. Apply CPAP 1-2 cm non-vent. lung (Recruit 1st)
7. Intermit. Re-inflation
   - N-V Lung
8. Partial vent. N-V lung:
   - i) Lobar re-inflation
   - ii) Lobar collapse
9. Mechanical restriction of non-vent. lung pulmonary blood flow

**FOB-Guided lobar insufflation with O₂**