Lung Injury and Protection in the Perioperative Period

Non-injured Lungs:
- Perioperative Experience (Surgeon)

Injured Lungs:
- Anesthesiologist
78 y.o. Male, Chronic Gallstone Pancreatitis, Cholecystectomy

- 100 pack/year smoker
- Dyspnea > 1 flt. stairs
- WHY dyspneic?
- Rule-out Cardiac etiol: ECG, TTEcho, Myocardial perfusion stress assess
- Rule-in Respiratory etiology
Preoperative Assessment

- History: cough, sputum, exercise Tol. (Infection)
- Auscultation (Bronchospasm)
- Lab tests: CXR, Spirometry, ABG
Preoperative Assessment

- History: cough, sputum, exercise Tol. (Infection)
- Auscultation (Bronchospasm)
- Lab tests: 
  - CXR
  - Spirometry
  - ABG
Spirometry:

- **Forced Expiratory volume (FEV1%)**
  - mild 80=50%
  - mod. 50-35%
  - severe < 35%

- **FEV1/FVC ratio**
  - < 0.7 = obstruction

- **Post-bronchodilator FEV1% increase**
  - >10% = a/w reactivity
**Bronchospasm after Tracheal Intubation**  

FEV1 < 70%, increase >10% post-bronchodil.

<table>
<thead>
<tr>
<th>Preop. Therapy:</th>
<th>Post-Intub. B’spasm:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albuterol 2 puffs x 1</td>
<td>8/10</td>
</tr>
<tr>
<td>Albuterol t.i.d. x 5 days</td>
<td>7/9</td>
</tr>
<tr>
<td>Albuterol + Methylpred. p.o. x 5 days</td>
<td>1/15 (p&lt;.01)</td>
</tr>
</tbody>
</table>

(Pentothal/ Fentanyl/ Vecuronium)
Preventing Intraoperative Bronchospasm

- Decrease preop. a/w hyper-reactivity
- Avoid instrumenting the airway
- Instrument the airway during deep anesthesia
- Use broncho-dilating anesthetics
Preoperative Assessment

- History: cough, sputum, exercise Tol. (Infection)
- Auscultation (Bronchospasm)
- Lab tests:
  - CXR
  - Spirometry
  - Arterial Blood Gas
Helping Surgical Patients Quit Smoking


Surgical Benefits:
- Decrease ST changes intraop.: 2 days
- Decrease wound complic’s: ≥4wk.
- Decrease Resp. Complications:
  - Cardiac: ≥8 wk.
  - Thoracic: 4 weeks

Abstinence @ 1yr:
- After ACB: 55%
- Angioplasty: 25%
- Angiography: 14%
Preoperative Physiotherapy

- Proven decrease in pulmonary complications in COPD
- Particularly in patients with excessive secretions
- No proven superior modality

Warner DO, Anesthesiology 2000, 92: 1467
Protecting Non-Injured Lungs:

- The Perioperative Experience (Surgeon) Atelectasis
Pulmonary Atelectasis

Duggan M, Kavanagh B. Anesthesiology 2005, 102: 838-54
Atelectasis

Intra-op.

Recovery Room
CPAP Treatment of Post-op. Hypoxemia
Squadrone V, et al. JAMA 2005, 293: 589-95

**Patients:**
- n= 209
- PaO2/FiO2<300 post-op. in Rec.Room
- FiO2 0.5 by mask or CPAP until PaO2/FiO2 stable >300 (19-28h)

**Results:**
- CPAP decreased sepsis (p= .03)
- Decreased pneumonia (p= .02)
- Decreased re-intubation (p< .01)
CPAP devices

Squadrone V, JAMA 2005

Maitre B, AJRCCM 2000
Reduction of Respiratory Complications in Lung Resection by Thoracic Epidural

Epidural Anaesthesia and Analgesia and Outcome of Major Surgery (MASTER trial)
n =888, random., ASA >/=3, Abd./Esoph. Surg., 225/ 447 Epidural > 72h.

- Mortality Epidural vs. IV: ns.
- Cardiac/Renal/GI/ Sepsis:  ns.
- Resp. Fail. Epid. vs. IV: 23% vs. 30% (.02)
- Analg. Epid. vs. IV: @ rest ns, cough <.001

Protecting Non-Injured Lungs:

- The Perioperative Experience (Surgeon)
- Open vs. Closed Surgery
Anesthesia and Lung Injury

- Does Routine Intra-op. Ventilation (10-12 ml/kg x 10/min) injure the lungs?
Patients with Lung Injury:

- ARDS/ALI
- Lung Transplantation
- Major Pulmonary Resection
- Cardio-pulmonary bypass
55 y.o. Male, R Mid+Lower Lung Ca.

- Smoker
- FEV1 78%, DLCO 83%, Ex. Tol. > 3 flights
- V/Q scan: R/L = 45/55
55 y.o. Male, Postop.
Right Pneumonectomy

Day #1

Day #3
Post-pneumonectomy pulmonary edema: analysis and risk factors


“...we see so often our anesthetic colleagues believe that you can actually oxygenate the patient with Ringer’s lactate...

...I think it is up to us to control what our anesthesia colleagues do, both in the operating theatre and postoperatively.” Dr. B Ross
Postpneumonectomy Pulmonary Edema.
- Turnage and Lunn, 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.)
  - PAOP (initial) 10, (final) 13mmHg (n.s.)
## Post-operative Lung Injury and Oxidative Damage


<table>
<thead>
<tr>
<th>Operation</th>
<th>Increase Plasma Protein Carbonyl %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumonectomy</td>
<td>26 (p&lt;.05)</td>
</tr>
<tr>
<td>Bi-lobectomy</td>
<td>10</td>
</tr>
<tr>
<td>Lobectomy</td>
<td>5</td>
</tr>
<tr>
<td>Wedge/Biopsy</td>
<td>0</td>
</tr>
<tr>
<td>Abdominal Surgery</td>
<td>0</td>
</tr>
</tbody>
</table>

(n= 8/group)
Pulmonary Endothelial Permeability Changes after Major Lung Resection

Pneumx. = 24, Lobx. = 11, rad-labl. Alb., 8h post-op.

- Permeability Pneumx. > Lobx. (p < .01)
  (Low-Press., hi-Prot. PE fluid)
- Increase Perm. $\propto$ Increase PVR
- Increase MPAP $\propto$ 1/ pre MPAP

Modern Anesthetic Techniques for Thoracic Operations

“Tidal volume (10-12 ml/kg) should remain the same when changing from two-lung to one-lung ventilation, as relatively large tidal volumes are needed to recruit alveoli in the dependent ventilated lung.”

Tidal Volume vs. Post-pneumonectomy Respiratory Failure

- 30/170 Post-pneumx. Resp. Failure, p<.001
- 15/30 Acute Lung Injury
- Mortality 6/30 vs. 7/140
- LOS 32 vs. 7 days

One-lung, Static Compliance Curve

32 y.o. male, FEV1 = 102%
Atelectasis Causes Lung Injury in Non-Atelectatic Lung Regions


- Rat lung injury model
- Distal airway injury all regions
- Alveolar injury more severe in non-dependent, non-atelectatic regions
Principles of Lung-Protective Ventilation:

- Mimic normal spontaneous ventilation
- FiO2 as low as safe
- Tidal volumes 4-6 ml/kg
- Frequent recruitment maneuvers
- Vary position / vary tidal volume
- Pressure-control ventilation
- PEEP to maintain FRC

### Individualizing One-lung Ventilation:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Vol.</td>
<td>5-6 ml/kg</td>
<td>Pk. a/w P&lt;35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plat. a/w P&lt;25</td>
</tr>
<tr>
<td>PEEP</td>
<td>Total 5 cm.</td>
<td>Not added if COPD</td>
</tr>
<tr>
<td>Resp. Rate</td>
<td>12</td>
<td>Maint. N PaCO2</td>
</tr>
<tr>
<td>Mode</td>
<td>Vol.-Cont. Vent.</td>
<td>P-C V:LTx, Pneumnx</td>
</tr>
</tbody>
</table>
Patients with Lung Injury:

- ARDS/ALI
- Lung Transplantation
- Pneumonectomy
- Cardiopulmonary Bypass
Pulmonary Inflammatory Mediators During Mechanical Ventilation after Cardiac Surgery

Zupanich E, et al. JTCS 2005, 130: 378-83
Protecting the Lungs

Non-Injured Lungs:
- Aggressive Rx atelectasis
- D/C smoking, Chest Physio, TEA
- Minimally invasive surgery

Injured Lungs:
- Lung-Protective Ventilation
70 y.0. Female
Post-op. R pneumonectomy + chest wall resection
Underwater seal chest drain
- 70 y.o. Female
- Post-op. R pneumonectomy + chest wall resection
- Balanced chest drain system
Chest Drainage Systems

Standard (series)

Pneumonectomy (parallel)
Low Tidal Vol. + PEEP Prevents Alveolar Coagulation in Patients Without Lung Injury

N=40, Abd. Surg. 5h PPV,
VT= 12ml/kg vs. 6 ml/kg +/- 10cmH2O PEEP
Static Compliance curve of the Ventilated (dependent) lung, 57 y.o. female, FEV1= 72%