Update on Thoracic Anesthesia

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Objectives

• Understand controversies in fluid management for lung resections and how they apply to specific types of patients and resections.
• Be able to identify and discuss common problems in positioning double-lumen endobronchial tubes.
• Understand the anatomy and physiology of esophagectomy
• Explain anesthetic techniques for esophagectomy
• Understand pros and cons of different anesthetic techniques for one lung ventilation.
• Compare risks and benefits of paravertebral blocks versus thoracic epidural analgesia

Update on Thoracic Anesthesia

• Lung Isolation
  – Indications, techniques, hypoxemia
• Fluid Management
• Esophagectomy Considerations
• Analgesia: Paravertebral Block vs TEA
• Robotic Thoracotomy

Speaker Recommendation: Recent SCA Workshop

F. Indication for lung isolation
1. Absolute
   • a) Minimizing cross contamination due to:
     • (1) Blood
     • (2) Pus
     • (3) Protein
     • (4) Disruption of the bronchial tree with inadequate ventilation (bronchopleural fistula)
2. Relatively absolute:
   • a) Thoracic surgery, excluding:
     • (1) Purely elective, rare
     • (2) Surgeon able to operate using lung retraction, rare

Double Lumen Tube Modifiers

• Open thoracotomy (vs VATS)
  – Pulmonary retraction is plausible in some open thoracotomies – incision size an issue
• Difficult intubation: Consider bronchial blocker + SLT
• Pre-existing severe shunt/hypoxemia
  – Medical ICU patients defying Dx, not responding to Rx, on ventilator for advanced hypoxemia with severe infiltrates
  – Consider intermittent apnea with SLT
  – May need ICU ventilator in OR: TIVA

Difficult DLT Placement: Unexpected

• Follow ASA Algorithm to maintain gas exchange and place single-lumen ETT
• Now what? Several options:
  – One lung ventilation for case if feasible (our surgeons dislike)
  – Bronchial blocker (our surgeons dislike)
  – Use tube-changer to place DLT
Tube Changer for DLT

- Tube changer depth key: generally assume past carina in R mainstem: Hence will need FOB-guided reposition of bronchial lumen into L side if L sided DLT
- Often hangs up at larynx: DL may help even if you can’t see cords
- Consider 2 tube changers (11 F rather than 14), one in each lumen of DLT, then DL with video laryngoscope during tube advancement through larynx

DLT vs Bronchial Blocker

**DLT**
- Ease of suction
- Rapid Lung collapse
- Positioning usually easy
- Greater airway rupture incidence (still low)
- Lesser chance of migration once positioned

**Blocker**
- Difficult airway advantage
- Slow Lung collapse
- Marginal suction capability
- Reduced chance of bronchial rupture
- Facilitates post-op ventilation
- Positioning can be a challenge
- Selective lobar blockade possible

Bronchial Blocker Options

<table>
<thead>
<tr>
<th>Arndt Blocker</th>
<th>Cohen Blocker</th>
<th>Fuji Flexible</th>
<th>EZ Blocker</th>
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<tbody>
<tr>
<td>Size</td>
<td>M</td>
<td>P</td>
<td>R</td>
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<tr>
<td>Balloon shape</td>
<td>Spherical or elliptical</td>
<td>Spherical</td>
<td>Spherical</td>
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<tr>
<td>Resistance moment</td>
<td>None</td>
<td>Some, preplaced to deflect the tip</td>
<td>None</td>
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<tr>
<td>Inside diameter recommended for central use</td>
<td>8F (4.3 SLT), 9F (5.6 SLT)</td>
<td>9F (8.0 SLT)</td>
<td>9F (8.0 SLT)</td>
</tr>
</tbody>
</table>


Bronchial Blocker Positioning

**Right**
- Proximal cuff ~ 1 cm distal to carina
- But still CAN be over RUL orifice

**Left**
- Proximal cuff 1-2 cm distal to carina
- Harder to place, easier to stabilize

Campos JH, SCA Thoracic Workshop Syllabus 2012
Generally OK, but presumes knee-jerk transfer of lung protective ventilation from ARDS setting to OLV setting

Concerns:
1. Permissive hypercapnia in the context of RV afterload and it may increase Q to nondependent lung
2. PEEP in setting of emphysema/ventilated dependent lung. FRC may increase Q to nondependent lung and auto-PEEP to ventilated lung. Lohser J, Anes Clinics 2012;30:683

Higher L-R ETCO2 Difference during 2LV in lateral position predicts higher PaO2 during OLV

• Makes sense:
  • Higher ETCO2 in dep lung from higher blood flow
  • Another predictor of higher PaO2: L lung is collapsed and “up”

Higher SpO2 > 90% seems reasonable

• Modifiers: Surgical field (risk vs benefit of re-expansion of lung), Pt baseline SpO2, coronary artery disease /ECG ischemia
• Zebra: CONSIDER low CO as a contributor to OLV hypoxemia (via low SVO2): In which case volume bolus or inotrope infusion could help

OLV Hypoxemia: Respect the DLT

• Cases of neurologic injury and cardiac arrest do occur — not a time for timidity
• Call for help early
• Engage the surgeon early
• Malposition of the tube is the most common malady, but stat simultaneous application of two maneuvers will “save” you
  1. RE-EXPAND OF COLLAPSED LUNG
  2. DEFLATION OF BRONCHIAL CUFF
• IF SPO2 < 80, DO BOTH BEFORE REACHING FOR THE BRONCHOSCOPE

Findings: SpO2 < 90% in 24%
- Mean lowest SpO2 79% and 83% (2 groups)
- Duration means 5-10 min

Mean highest ETCO2 54+5 mmHg

Mean highest PIP 45+6

Anesthesia Information Systems:
Blessing vs Curse

Ehrenfeld JM, JCTVA 2010;24:598-601

- One lung anesthesia database reviewed for 196 Pts
- Findings: SpO2 < 90% in 24%
  - Mean lowest SpO2 79% and 83% (2 groups)
  - Duration means 5-10 min
- Mean highest ETCO2 54+5 mmHg
- PIP > 35 cm H2O in 34%
  - Mean highest PIP 45+6

How much hypoxemia should you tolerate during OLV?

No definitive answer, but SpO2 > 90% seems reasonable

Would head down position with venous congestion explain?
Hypoxemia and OLV: Primary Interventions

- Hypoxemia during Thoracotomy
  - Increase FiO₂
  - Initial respiratory support

- Critical incidents
  - Secure airway
  - Lung isolation
  - Control ventilation
  - Immediate reposition of operating lung

Lohser J, Anes Clinics 2012;30:683

Hypoxemia and OLV: More advanced interventions

- Oligophasic hypoxia
- Consider advanced interventions

Lohser J, Anes Clinics 2012;30:683

Subtleties of OLV Management

- Pre-existing lung disease: More hyperinflation (emphysema, increased FRC, breath stacking) vs more hypo-inflation (restrictive/infiltrative Dz) – the latter responds well to recruitment maneuvers/PEEP to ventilated lung
- Surgeon capacity to help with hypoxemia varies with exposure and procedure:
  - Distortion or pressure to “crimp” a lobar PA, early exposure and clamping of PA in lobectomy or pneumonectomy

Remember that any insufflation technique requires partial re-inflation of collapsed lung to work

Fig. 3. Schematic representation of the Intermittent Positive Airway Pressure technique. A bloodless filter is attached to the 15 mm connector of the non-ventilated DLT lumen. Tubing with an oxygen flow of 2 L/min is connected to the sampling port of the filter. The open port of the filter is occluded for 2 seconds and open for 8 seconds. See text for details. (Reproduced from Russell VJ. Intermittent positive airway pressure to manage hypoxia during one-lung anesthesia. Anesthesiology 2009;110:433; with permission.)

Advanced Hypoxemia Management

Lohser J, Anes Clinics 2012;30:683

Update on Thoracic Anesthesia

- Lung Isolation
- Fluid Management
  - Philosophical shift, goal-directed Rx, Postpneumonectomy Pulmonary Edema, hypotension management
- Esophagectomy Considerations
- Analgesia: Paravertebral Block vs TEA
- Robotic Thoracotomy
Clinical Result

- Practitioners are afraid to give fluids during major abdominal and thoracic procedures
- Previous anathema of masking hypovolemia or CV depression with alpha-agonists is now embraced
- Several hours of phenylephrine “pops” or infusion without consideration of adverse effects
  - Variation on theme: vasopressin

Granted

- Too much fluid was given in past: The direction of change has been good
- But has pendulum swung too far?
- Example: 8 hour Whipple with epidural – after 4 ml 0.25% bupiv, BP in 60s. Total crystalloid 2.0 L, 1 U RBCs, 1000 mL 5% albumin, Hgb 8, EBL 1500.
  - Surgeon happy with fluid management, tendency to micromanage
  - Surgeon notes that bladder is empty, advises fluid
  - 3 L of plasmalyte in 15 min, Pt responds well

Pulmonary Surgery: Fluids

Higher risk patients likely to reside at top of this pyramid, i.e., narrower span:
- Bilobectomy and Pneumonectomy
- Advanced COPD
- Known CVD
- DM, Renal impairment

Searl CP, Anes Clinics 2012;30:641
• Possible pathogenesis of post-pneumonectomy pulm edema involving one-lung ventilation

• Other factors potentially contributing:
  – Fluids, direct surgical trauma, altered lymphatic drainage (even contralateral to resection)

Postpneumonectomy Pulm Edema and Intra-op Fluids

• Statistical relationship to Positive Fluid Balance is anecdotal at best, no randomized trials

• Much is made of 1 retrospective study of 10 cases of which 4 suggested a possible fluid mgmt connection (Zeldin RA, JTCVS 1984;87:359)

• Subsequent studies: No such connection (Turnage WS Chest 1993;103:1646; Waller DA ATS 1993;55:140)

• One report links intraop fluids > 2 L with PPPE (Parquin F Eur J CTS 1996;10:1996)

High-risk Pts undergoing Major Pulmonary Resections (Bilobectomy, Pneumonectomy, maybe Decort)

Best fluid mgmt? Consider Goal-directed even in absence of controlled studies

• Invasive or noninvasive CO has the most support

• PAC? Out of favor, but consider

• Esophageal Doppler, TEE: Reasonable alternatives

• Goal? CI>3, DO2>600, MAP>65 (70?) using fluids, RBCs, inotropes

• Focusing 1° on SBP/MAP using vasoconstrictors lacks evidence-based support

Considerations re Phenylephrine

• What if Pt is indeed hypovolemic?

• What if Pt is too deep?

• What if Pt has reduced myocardial contractility? LV afterload implications

• What if Pt has increased pulmonary vascular resistance? RV afterload implications

• What is the minimal acceptable BP for any given Pt?

If we are to embrace restrictive fluid strategy, we should do it strategically

• Tenuous science gleaned from low-risk colon resection and pneumonectomy Pts is being extrapolated into one-size fits all for open and closed laparotomies and all thoracotomies including VATS wedge resections in ASA I Pts

• We need to consider adverse consequences of hypovolemia/ low cardiac output/high SVR states
  – Likely OK in ASA I-II Pts for short periods
  – Likely not OK in ASA II-IV Pts for multiple hours

How do we assess when fluid restriction is not OK?

Monitoring of Circulatory system “happiness”

• CVP? “Random number generator”

• PA catheter with CI/CO? Passe – in need of a “comeback” award?

• TEE for preload/SV assessment? Selectively OK

• Pulse or Pleth volume/contour? Tends to fail when “stressed”

• Doppler cardiac output? Promising, but would love to have preload assessment as well
A Systematic Review and Meta-Analysis on the Use of Preemptive Hemodynamic Intervention to Improve Postoperative Outcomes in Moderate and High-Risk Surgical Patients

Mark A. Hamilton, FRCP, FRCA, Maurizio Cocconi, MD, and Andrew Rhodes, FRCP, FRCA

- 29 studies, 2420 Pts, most interventions were fluids/inotropes (not pressors), goals were a mix dominated by CI and DO₂
- Types of surgery not given, no known trials in thoracotomy Pts (Abdominal>Total hip>>others)
- Mortality OR 0.48 (0.33-0.70) unless isolated to higher Jadad (quality) scores, then 0.62 (0.39-1.01=NS). But Cx reduced either way (OR 0.43-0.44, CI 0.28-0.59)

Can Changes in Arterial Pressure be Used to Detect Changes in Cardiac Output during Volume Expansion in the Perioperative Period?

Karnick Le Manach, M.D., Ph.D., Christoph K. Hoyer, M.D., Ph.D.,

- Anesthesiology 2012;117:1165-74
- Looked at 500-mL colloid bolus effects on various intra-arterial pressure permutations in 402 surgical Pts
- Measured CO with one of four (I) methods

Le Manach Y, Anes 2012;117:1165

- Decrease in Resp PPV >3% detects an increase in CO of >15% with Sens 90%, Spec 77%, “gray zone” of only 14% of population (Ooh BABY, how great is that?)
- No mention of vent settings, CO measurement reliability/variability

More benefit ascribed to PA Cath, CI/DO₂, and supranormal targets

Hamilton MA Anesth Analg 2011;112:1392

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>No. at risk</th>
<th>No. at outcome</th>
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Table 2. Subgroup Analysis for Mortality

Le Manach Y, Anes 2012;117:1165

Hypotension: Are thigh-high SCDs an answer?
Systemic hemodynamic effects of sequential pneumatic compression of the lower limbs: a prospective study in healthy volunteers

Soffia Fasoli MD (Professor), Michele Zaza MB (Resident).

- Supine healthy awake volunteers
- Compression from ankles to upper thigh
- Compression increased MAP and SVRI with slight decreases in HR and CI (bioimpedance method)
- A consideration to compensate for reverse T-berg often seen in thoracotomies (and other procedures)

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**Speaking of High-risk Procedures: Esophagectomy**

- Depending on stage, 5-year survival 3-49%
- Operative mortality 8-9% (higher at lower volume centers)
- Morbidities: PULMONARY, Anastomotic leaks (leading to PULMONARY)
- Anastomotic viability aided by epidural/sympathectomy, but compromised by vasoconstrictor Rx

  — Jaeger JM, Anes Clin 2012;30:731-47

**Esophagec: Resp Cx Multifactorial: But few have benefit of prospective trials**

- Anesthetic
  - Absence of Epidural
  - XS Fluids (> 4 L?): Maybe targeted CD/SV helps
  - Transfusion
  - OLV duration
  - Delayed extubation
  - High Tidal Volumes: Maybe (inflammation evidence)
  - DLT Cx/hypoxemia

  — McKevith JM, Curr Opin Anaesth 2010;23:34-40

- Surgical/Oncologic
  - Blood Loss
  - Procedure duration
  - Recurrent Larm Injury (Aspiration: may be higher with min invasive)
  - Anastomotic Leaks
  - Induction chemo/rad pre-op (increases colonization of Resp tree)

**Impact of a multidisciplinary standardized clinical pathway on perioperative outcomes in patients with esophageal cancer**


- 2 institutions, not randomized, mix of simultaneous and historical controls, large variation in group sizes (12,12,12,74)
- Slightly different protocols, main focus post-op
- Key elements: same-day extubation, sits up DOS, epidural to Day 5, sit day 1, walk day 2, jejunal feedings day 2

Esophagectomies: McKevith JM, Curr Opin Anaesth 2010;23:34-40
Impact of a multidisciplinary standardized clinical pathway on perioperative outcomes in patients with oesophageal cancer

K. B. Posner1, S. B. Markert1, C. R. Bricker1, V. Sonaw1, S. Singh1 and D. F. Love1

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To whom correspondence should be addressed: Dr. K. B. Posner, Department of Thoracic-Surgical Oncology, University of Virginia, Charlottesville, VA 22908, USA

Key elements: TEA intra- and post-op 5-6 d, “conservative” fluids (but median 650 mL/hr intra-op), vasopressors prn for SBP w/in 20%, U/O goal 0.3-0.5 mL/kg/hr

- Largest group also had LIDCO goal-directed fluid Rx for first 6 hrs post-op
- Principal outcome improvements other than protocol per se: Decreased ICU LOS (1 vs 3 D), decreased hospital LOS (mean 13-17 vs 7-8)

Association of No Epidural Analgesia with Postoperative Morbidity and Mortality after Transthoracic Esophageal Cancer Resection


- Peculiar epidural vs non-epidural groupings inadequately explained
- Yet: biggest risk factor for pneumonia was absence of epidural (41% vs 25%, N=185 total)
- Absence of epidural almost doubled reintubation (15% vs 29%) and ICU LOS (2.8 vs 5.8 D)

 observational Esophagectomy Multimodal Approach

- Neal JM et al., Reg Anes Pain Med 2003;28:328

- Key elements: TEA intra- and post-op 5-6 d, “conservative” fluids (but median 650 mL/hr intra-op), vasopressors prn for SBP w/in 20%, U/O goal 0.3-0.5 mL/kg/hr

- N=56, 0 mortality, all extubated in OR, CV Cx 9% (arrhythmia #1), Resp Cx 15% (Pneumonia #1)

- Vasopressor frequency/dosing not given

Esophagectomy anastomotic blood flow (laser) and epidural

- Epidural decreased MAP, SVR, and CI
- Epid bolus: No change in HR, but epi (dose?) increased HR and CI to above baseline (NS)
- Al-Rawi OY, Anesth Analg 2008;106:884

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Post-thoracotomy Analgesia Questions

Fact: Thoracic Epidural Analgesia = Gold Std

Question: Are Paravertebral or Intercostal Blocks underutilized? Subqueries:
- Is PVB as effective as TEA?
- Does PVB technique matter?
- Does PVB offer greater safety than TEA?
- Does VATS merit regional analgesia?
- Are Pt expectations about chronic post-thoracotomy pain realistic?
**Distressing Aspects of Post-thoracotomy Pain**

- Multimodal therapy: Added benefit unproven
- IV opioid PCA: Helps a little, no better than RN-controlled IV opioids in ICU/stepdown setting
- “Complete” post-op analgesia uncommon
- Chronic pain is common (50% plus)
  - Pre-emptive analgesia benefit? Unproven to date

**Paravertebral Space Anatomy**

Source: Ultrasound for Regional Anesthesia, Toronto Western Hosp

**Paravertebral Block Techniques**

- Traditional “blind”
- Nerve stimulator-guided
- Ultrasound guided
- Direct vision (surgeon placed)

Prospective comparisons lacking, greatest number of reports use direct vision

**PVB Complications vs TEA**

Daly DJ, Curr Opin Anes 2009; 22:38-43

- Less hypotension: Decidedly
- Lower hematoma risk? Probably, but ASRA guidelines re anticoag are the same
- Less itching for sure: Virtually nil with PVB
- Less urinary retention? Probably, but most often moot
- LOS: ND

**Respiratory Cx and Function: PVB vs TEA**

Davies RG; BJA 2006; 96:418-26

<table>
<thead>
<tr>
<th>Outcome</th>
<th>PVB</th>
<th>TEA</th>
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<th>0.05</th>
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Table 1 Summary of findings from a systematic review and meta-analysis of trials comparing paravertebral block with epidural analgesia on side-effects associated with analgesic therapy.
Rare Prospective 3-group comparison of TEA (LA vs LA+O) and PVB (LA)

Grider JS, JCTVA 2012;26:83

Best Analgesia: TEA LA+O

<table>
<thead>
<tr>
<th>Spirometry: TEA LA=O by a hair</th>
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<tr>
<td>Table 1. VATS Cases, Inflation Spirometry Data, and Intravenous PCA Inefficiency from All Collection Points.</td>
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<td>0.4</td>
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<td>0.3</td>
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</table>

Higher dose calculates to 0.5% @ 8 mL/hr or 0.25% @ 15 mL/hr

Kotze A, BJA 2009;103:626

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- **Robotic Thoracotomy**

Robotic-Assisted Thoracotomy

Steenwyck B, Anes Clinic 2012;30:699

Robotic Assisted Thoracic Surgery (RATS)

Offers some advantages to surgeon over VATS
- Principally more instrument control, degrees of freedom, rotational capability (360°)
- Learning curve issues
- Positioning quirks depending upon specific procedure: Slightly more intense “field avoidance” issues than VATS