Basic Science in Laparoscopic Surgery

Suthep Udomsawaengsup, MD.
Laparoscopic and Bariatric Surgery
Contents

• Pneumoperitoneum
• Patient positioning
• Laparoscopic instrumentation
• Access into the abdomen
Laparoscopic Surgery

- Minimally Invasive Surgery (MIS)
- Keyhole Surgery
- Pinhole Surgery
Contraindication

- Uncorrected coagulopathy
- Inability to tolerate laparotomy
- Inability to tolerate general anesthesia
- Hypovolemic shock
- Uncompensated cardiopulmonary disease
Pneumopeitoneum

Mechanical effect (Primarily)

1. Upward displacement of diaphragm
   - ↑ Intrathoracic pressure
   - ↓ Diaphragmatic motion
   - ↓ Lung volume “↓vital capacity, ↓ compliance”
   - ↑ Airway pressure “↑ peak, ↑ mean airway pressure”
   - ↑ Work of breathing
Pneumopeitoneum

Metabolic effect

• 1. CO2 absorption
  – Leads to hypercarbia and acidosis
    “In healthy individuals: corrected by ventilation and body buffering system”
    “In COPD: risk to develop hypercarbia
    Expired CO2 (ETCO2) levels are unreliable: arterial CO2 needed
Hypercarbia

- Moderate increase in PaCO2 15-30 mmHg produce a hyperdynamic state: SVR, CVP, HR and BP “no effect on CO”
- Marked increase in PaCO2 > 30 mmHg: cardio depressive predominate, cardiovascular collapse, severe acidosis, fatal dysrhythmias
- Minute ventilation must be increased 20-30%
Hypercarbia

- Lowering IAP to 10-12 mmHg
- Alternative gas: Helium
- Gasless laparoscopy
- Converted to open surgery
### Table 1

Ventilatory parameters in nine anaesthetized patients, without heart or lung disease scheduled for cholecystectomy, recorded in different body positions (horizontal and a head-up tilt of 15–20°) in the absence or presence of pneumoperitoneum.

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<tr>
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<td>18(5)</td>
<td>24(4)**</td>
<td>22(4)**‡</td>
<td>22(4)**</td>
</tr>
<tr>
<td><strong>V₇ (ml)</strong></td>
<td>627(174)</td>
<td>633(150)</td>
<td>643(151)</td>
<td>642(152)</td>
</tr>
<tr>
<td><strong>RR (breaths/min)</strong></td>
<td>10(0)</td>
<td>10(0)</td>
<td>10(0)</td>
<td>10(0)</td>
</tr>
<tr>
<td><strong>FiO₂ (%)</strong></td>
<td>35(3.0)</td>
<td>36(3.0)</td>
<td>36(3)</td>
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</tr>
<tr>
<td><strong>ETCO₂ (kPa)</strong></td>
<td>3.6(0.4)</td>
<td>4.1(0.6)**</td>
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<td>4.4(0.8)**‡</td>
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<td><strong>PaO₂ (kPa)</strong></td>
<td>21.7(5.9)</td>
<td>24.7(4.8)**</td>
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<td><strong>P(A-a)O₂ (kPa)</strong></td>
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</tr>
<tr>
<td><strong>Arterial pH</strong></td>
<td>7.46(0.06)</td>
<td>7.40(0.05)</td>
<td>7.39(0.08)</td>
<td>7.38(0.07)</td>
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Data are mean (SD); Intra-abdominal pressure (IAP) = 11–13 mmHg.

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*Acta Anaesthesiol Scand 2002; 46: 552–560*
ETCO2
Ventilation change

• 1. High inspiratory airway pressure
• 2. Decrease FRC
• 3. Increase V/Q mismatch
Cardiovascular change

- Initially: ↑ venous return due to the blood volume sequestrated in splanchnic vasculature
  “Increase mean arterial pressure”
- Later on: ↓ venous return, ↑ arterial resistance, ↑ CVP
  “Resulted in compensatory ↑ HR”
  “Net effect = no change in CO”
- IAP > 20 mmHg: IVC is compressed then venous return is impeded
- IAP > 40 mm Hg, venous return drop precipitously
Table 2

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<td>MAP (mmHg)</td>
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<td>87 (15)**</td>
<td>76 (17)†</td>
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<td>CVP (mmHg)</td>
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<td>CI (l/min m⁻²)</td>
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<td>SVR (units)</td>
<td>1143 (276)</td>
<td>1758 (844)*</td>
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<td>1447 (452)</td>
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<tr>
<td>PVR (units)</td>
<td>86 (50)</td>
<td>77 (50)</td>
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HR, heart rate; MAP, mean arterial pressure; CVP, central venous pressure; PCWP, pulmonary capillary wedge pressure; MPAP, mean pulmonary artery pressure; CI, cardiac index; SVR, systemic vascular resistance; PVR, pulmonary vascular resistance.

Patient Positioning

• Head-down (Trendelenburg position)
  – ↑Central blood volume and pressure
  – ↑Cardiac output
  – ↑Chest wall resistance, ↑ dead space

• Head-up
  – ↓Venous return & Cardiac output
  – ↑Femoral venous pressure
  – ↑risk of DVT or pulmonary embolism
### Pneumoperitoneum and Ventilation Positioning

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Arrhythmia

- Vagal reflex because of sudden stretching peritoneum with rapid insufflation provoke AV dissociation, nodal rhythm, sinus bradycardia and asystole
- Raise PaCO2: sympathetic response
- Embolism
- Underlying cardiac disease
Renal Blood Flow

- Decreased RBF and GFR
  Increase in renal vascular resistance, reduction in glomerular filtration gradient and decrease in CO
- Decreased urine output and insensible fluid losses
Renal Blood Flow $ Pre-load $ Pneumoperitoneum

Fig. 3. Renal cortical perfusion at baseline and under pneumoperitoneum, stratified according to left ventricular end-diastolic diameter. Left ventricular end-diastolic diameter (LVEDD) $\leq 4.1$ cm (dashed line), LVEDD $> 4.1$ cm (solid line); $n = 4$ for both groups; $^* p < 0.05$ within group; $^\dagger p < 0.05$ between groups.

Lactic Acidosis

• Elevation in IAP produces lactic acidosis, probably by severely lowering CO and impairing hepatic clearance of blood lactic acid
Intracranial and Intraocular change

- Increase cerebral blood flow from hypercarbia
- But increase intracranial pressure, intraocular pressure in the cases that have underlying diseases
Metabolic Effect of CO2

Increase in PaCO2

1. Absorption of CO2 from the peritoneal cavity
2. V/Q mismatch
3. Impaired CO$_2$ excretion capacity (e.g., COPD, cyanotic CHD)
CO2 Emboli

- Presenting signs
  - Hypotension
  - Jugular vein distension
  - Tachycardia
  - Mill Wheel Murmur
CO2 Emboli

• Early (< 0.5ml/kg of emboli):
  – TEE CO₂ bubbling in right heart
  – splashing sound with precordial doppler
  – millwheel murmur
  – hypoxemia, high increasing PaCO2,
  – high ΔPaCO2-ETCO2

• Late (>2ml/kg of emboli):
  – increase CVP, PAP
  – hypotension, arrhythmia
  – cardiac arrest
Fig. 2. Lung dead space/lung tidal volume ($V_d/V_t$) in the 4 h following CO$_2$ embolization, expressed as the mean ± standard deviation. The squares denote the mean of the two control animals.
Fig. 6. Arterial carbon dioxide ($P_a CO_2$) in the 4 h following CO$_2$ embolization, expressed as the mean ± standard deviation. The squares denote the mean of the two control animals.

Fig. 1. End-tidal CO$_2$ (ETCO$_2$) in the 4 h following CO$_2$ embolization, expressed as the mean ± standard deviation. The squares denote the mean of the two control animals.

CO2 Emboli

• Treatment
  – Evacuate pneumoperitoneum
  – Left lateral decubitus, head down position
  – Introduce central venous catheter
Laparoscopic Equipment

- Laparoscopes
- Video Tower
- Gas Supply
- Suction Device
- Equipment Table
Laparoscopes
Laparoscopes

• Deliver light from a light source
• Conduct image to eyepiece
Laparoscopes

30° Rigid laparoscope
Video Tower

Light source

Light cable
Imaging systems

- Camera Head Unit
- Camera Control Unit
Gas Supply

- Gas tank
- Gas
  - CO2
    - Readily available
    - Inexpensive
    - Not support combustion
  - N2O
  - Helium
Insufflator

– Control the flow of gas from the cylinder to the abdomen
– High flow insufflator can deliver 10 or more liters of gas per minute and rate can adjust from low to high
Insufflator

Control panel

- Indication system listing the preset abdominal pressure
- The current abdominal pressure
- The flow rate of the gas
- Amount of gas used
Gas Supply

• A sterile line takes gas from the sufflator to the patient (Luer lock or push on tube

• Some line have a filter in place
Suction Devices

• Multiple suction devices are needed
  – Anesthesiologist
  – Nasogastric tube
  – Laparoscopic instruments
Video Tower

• Video monitor
Resolution

- 640
- 480
- 720
- 1280
- 1920
- 1080
Definition
Full HD
Full HD
Full HD

- 16:9 ratio for natural vision
- 16:9 ratio provides lateral extension of field of vision
- Great color brilliance
- 1920 x 1080 offers 7 times the SD resolution at 480 lines
- Clear differentiation of tissue structures
### Impeded view

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Flow</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>High</td>
<td>Leak</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>Empty</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td>Relaxation/Occlusion</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td>Multifactorial/multifunction</td>
</tr>
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</table>
Energy Source

• Electrosurgery
  – Monopolar cauter
  – Bipolar cauter
• Ultrasonic
Injury from Energy Source

- Direct Coupling
Injury from Energy Source

- Indirect Coupling
Ultrasonic Coagulation

- Relies on mechanical energy to produce effects
Operating Room Set-up

• Patient positioning
• Video-endoscopic equipment
• Ancillary equipment
• Personnel
Patient Positioning

- Supine
- Lateral Decubitus
- Lithotomy
Supine

• Arms out
  – Upper abdomen
  – Incisional hernia
Supine

- Tucking arms
  - Pelvis and lower abdomen
Patient Positioning

- Tendelenberg
- Reverse Tendelenberg
DVT Prevention
Personnel
Personnel
Primary Access

• Open “Hasson”
Primary Access

• Direct vision
Primary Access

• Veress Needle
# Direct vs Veress (RCT)

Table 2. Results of DTI vs VN

<table>
<thead>
<tr>
<th>Results</th>
<th>DTI&lt;sup&gt;a&lt;/sup&gt; (n = 275)</th>
<th>VN&lt;sup&gt;a&lt;/sup&gt; (n = 323)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success rate&lt;sup&gt;b&lt;/sup&gt;</td>
<td>100%</td>
<td>98.7% (319/323)</td>
<td>NS</td>
</tr>
<tr>
<td>Failed entry&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0%</td>
<td>1.3% (4/323)</td>
<td>NS</td>
</tr>
<tr>
<td>Minor complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcutaneous emphysema</td>
<td>0%</td>
<td>5.9% (19/323)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Extraperitoneal insufflation</td>
<td>0%</td>
<td>3.4% (11/323)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Major complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid organ lesions</td>
<td>0%</td>
<td>0.6% (2/323)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>NS</td>
</tr>
<tr>
<td>Visceral injuries</td>
<td>0%</td>
<td>0.3 (1/323)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>NS</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
<td>0.3 (1/323)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>NS</td>
</tr>
<tr>
<td>Reintervention</td>
<td>0%</td>
<td>0.3 (1/323)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>NS</td>
</tr>
<tr>
<td>Gas embolism</td>
<td>0%</td>
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<td>Mortality</td>
<td>0</td>
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Current Laparoscopic Surgery

- LC
- CBD exploration
- Anti-reflux surgery
- Achalasia
- Hernia (inguinal, ventral)
- Peptic ulcer operation
- Splenectomy

- Adrenalectomy
- Trauma
- Large and small bowel
- Appendectomy
- Gastric surgery
- Morbid obesity
- (endoscopic thyroid Sx)
Conclusion

Preoperative assessment

Patient is scheduled for laparoscopic surgery

Define patient as comorbid if: ASA III-IV, COPD, NYHA III-IV, CRF etc. (see text for details)

Pre-surgery interventions

Administer adequate preoperative volume loading (grade A)

Is patient comorbid?

Yes

Start invasive measurement of blood pressure or circulating volumes (grade A)

- Insert urine catheter (grade B)
- Consider pharmacological interventions (e.g. β-blocker, nitroglycerin) (grade A)

No

Start monitoring of end tidal CO₂-concentrations (grade A)

Start gasless laparoscopy (grade B)

In COPD patients, consider helium as alternative gas (grade B)
Conclusion

Is patient comorbid?

- Yes
- No

Estimated duration of surgery >2h?

- Yes
- No

Surgical interventions

Establish pneumoperitoneum either by open or closed access technique (grade A)

Apply lowest possible pressure level (grade A)

Use small instruments, if suitable (grade A)

Perform surgery

At the end of operation, remove residual gas (grade B)

- Use intermittent pneumatic compression (grade C)
- Use external heating devices