Coelioscopic surgery in children: the anesthesiologist's point of view
Plan

- Indications
- Physiologic consequences
- Additional risk: $CO_2$ embolism
- Medical contraindications
- Anesthetic management
- New crisis situations
Indications

- diagnostic: impalpable testis, contralateral hernia staging

- therapeutic:
  - appendicectomy, cholecystectomy, splenectomy, fundoplication, adhesiolysis
  - nephrectomy, pyeloplasty, adrenalectomy
  - pyloric stenosis, pull-through
  - ductus arteriosus, TOFistula ...
Coelioscopic vs open surgery

+ : less postoperative pain?
   better cosmetic result
   quicker functional recovery
   shorter hospital stay

- : increased cost: equipment, disposables
   unfamiliar physiologic consequences
   new anesthetic crisis situations
Physiologic consequences

model: laparoscopy

= insufflation into peritoneal cavity
  ⇝ increased intraabdominal pressure
  ⇝ absorption of exogenous CO$_2$
+ positioning of the child
  ⇝ retroperitoneal
  ⇝ intrathoracic
  ⇝ intravesical
Increased IAP

- respiratory mechanics
  1) cephalad shift of diaphragm
     - thoracic compliance
     - functional residual capacity
     - airway resistance
  2) peak inspiratory pressure
     - leak and Vt if uncuffed tube
     - $P_{ETCO_2}$ & $PaCO_2 - P_{ETCO_2}$
Pig: insufflation up to 10 mmHg IAP with CO₂ or He

<table>
<thead>
<tr>
<th></th>
<th>CO₂ base</th>
<th>CO₂ ⇝ 10</th>
<th>He base</th>
<th>He ⇝ 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{paO}_2)</td>
<td>261 ± 49</td>
<td>189 ± 33</td>
<td>266 ± 30</td>
<td>212 ± 21</td>
</tr>
<tr>
<td>(\text{paCO}_2)</td>
<td>35.0 ± 1</td>
<td>57.9 ± 6</td>
<td>32.8 ± 1</td>
<td>43.5 ± 4</td>
</tr>
<tr>
<td>(P_{ET}\text{CO}_2)</td>
<td>29.0 ± 2</td>
<td>47.2 ± 5</td>
<td>27.8 ± 5</td>
<td>36.8 ± 3</td>
</tr>
<tr>
<td>RAP</td>
<td>3.0 ± 1.7</td>
<td>4.7 ± 1.5</td>
<td>2.7 ±1.5</td>
<td>6.7 ±1.5</td>
</tr>
<tr>
<td>pIVC</td>
<td>5.2 ± 1</td>
<td>12.5 ± 1</td>
<td>4.8 ± 1</td>
<td>13.0 ± 2</td>
</tr>
</tbody>
</table>
Increased IAP

- hemodynamics:
  - IAP < RAP (6 mmHg): $\uparrow$ venous return
    $\Rightarrow$ $\uparrow$ CO
  - IAP > RAP (12 mmHg): $\downarrow$ venous return
    $\Rightarrow$ $\downarrow$ CO
  - $\uparrow$ systemic resistance (vasopressin, Nepi)
  - falsely elevated CVP
    $\Rightarrow$ $\uparrow$ hypovolemia!
Increased IAP

- **fluid balance**
  - less sensible & insensible losses?

- **splanchnic organs**
  - ↓ renal & splanchnic blood flow
    - ↓ urine output
  - ↓ or ↔ flow in portal vein
    - hepatic arterial buffer response?
Adult: portal vein flow vs IAP
Increased IAP

- **intracranial pressure**
  - ↑ cerebral blood volume & velocity
  - reduced venous drainage
  - reduced outflow from VP shunt

- check free flow of CSF

- monitoring of ICP
  - e.g., transcranial doppler

- postoperative clinical monitoring
Absorption of $CO_2$

1) varies with intraabdominal pressure:
   in the pig model (*Anesthesiology* 1994; 80: 129-36)
   * if < 10 mmHg: absorption of $CO_2$ \(\uparrow\) with insufflation pressure (recruitment)
   * if > 10 mmHg: absorption of $CO_2$ stable but increased deadspace ventilation (\(\Rightarrow\) Pa$CO_2$)
Excretion of $CO_2$ vs IAP
$\text{paCO}_2$ vs IAP (piglet !)

![Graph showing $\text{paCO}_2$ vs Insufflation Pressure (mmHg)](image)

- $\text{CO}_2$
- $\text{He}$
Absorption of CO$_2$

2) effects of hypercarbia:

- **systemic**: ↑ sympathetic tone
  ↘ vasoconstriction, increased BP

- **regional**: vasodilation
  e.g., mesenteric vessels
  ↘ partial compensation of ↓ portal flow?
Absorption of $CO_2$

3) portal hypertension:
   $\uparrow$ absorption of $CO_2$

4) a large amount of absorbed $CO_2$ is buffered in bone, muscles and tissues and eliminated through the lungs after the procedure

$\text{if poor respiratory function}$
Retroperitoneal insufflation

+ * no increase in $P_{ET}CO_2$ in children
  * no increase in airway pressures

- * ventilatory effects of position
  * increased risk of subcutaneous diffusion to pleura, mediastinum... ?
  * increased absorption of $CO_2$ ?
  (adults × children?)
Thoracoscopy

- usually: one-lung-ventilation
  - bronchial blocker

- if no OLV:
  - low insufflation pressure
  - pleural absorption of CO₂
Vesical insufflation

* to correct vesico-ureteral reflux

* still experimental

* absorption of $CO_2$ ?
* risk of embolism ?
Gasless laparoscopy
Child’s position

- **head-down:**
  - respiratory effects of increased IAP

- **head-up:**
  - hemodynamic effects of increased IAP

- **lateral decubitus:** V/Q mismatch

- **prone:** \(\downarrow\) CO
Child’s position
$CO_2$ embolisation

- probably frequent but no clinical signs

- piglet model of 0.6L/min iv $CO_2$:
  - mortality ↑ with insufflation pressure
  - 0% if 5 mmHg  ⇒  50% if 15 mmHg
**CO₂ embolisation**

- **« driving pressure »**
  \[ \text{IAP} = \text{IA} \text{pressure} - \text{intravascular pressure} \]

  - **IAP > IV**: vessel collapse
  - **IAP < IV**: bleeding
  - **IAP ≅ IV**: bubbles can enter vessel
    - can remain trapped
    - ↠ embolism at exsufflation!!
Medical contraindications

- severe cardiac disease
  - physiologic effects on CO
  - paradoxical embolism through shunt
- severe pulmonary disease
  - increased $CO_2$ load
- reduced intracranial compliance
- liver disease ?
- history of spontaneous pneumothorax
- acute trauma: volemia, vessel damage
Preoperative evaluation

- same as for any pediatric patient
  - Cave: cholecystectomy & Hb SS
- Premedication:
  - according to age, emotional status, local habits ...
  - atropine for prevention of vasovagal reflex at insufflation?
Monitoring

- usual: ECG, NIBP, SpO\textsubscript{2}, P\textsubscript{ET}CO\textsubscript{2}
  airway pressures, compliance

- PaCO\textsubscript{2} - P\textsubscript{ET}CO\textsubscript{2}: varies during procedure
  can become negative!

- P\textsubscript{Tc}CO\textsubscript{2}?

- fragile patient: TEEchocardiography
Minimal invasive surgery can mean minimal access anesthesia!
Anesthetic management

- Cuffed ET tube
- Gastric emptying
- Venous access in upper limb
- Controlled ventilation
- IV fluids: ?
- Volume loading prior to insufflation?
- Slow and progressive tilting!
- Prevention of hypothermia
Anesthetic management

- Monitoring of insufflation pressure!
  - It should be kept as low as possible
- Additionnal intracavitary pressure if a gas coagulator is used
  e.g.: Argon beam = 4L/min!
- \( N_2O \) ? can support combustion if intestinal perforation
- Muscle relaxation?
Videohypnosis
Unusual crisis situations

- $CO_2$ or coagulator gas embolism
- bronchial intubation
- pneumothorax (« capnothorax »)
- subcutaneous emphysema
- hemorrhage
Differential diagnosis

- capnothorax
  \[ \uparrow P_{ET}CO_2 \quad \uparrow \text{Paw} \quad \downarrow \text{SpO}_2 \]

- subcutaneous emphysema
  \[ \uparrow P_{ET}CO_2 \quad \Leftrightarrow \text{Paw} \quad \Leftrightarrow \text{SpO}_2 \]

- endobronchial intubation
  \[ \Leftrightarrow P_{ET}CO_2 \quad \uparrow \text{Paw} \quad \Leftrightarrow \text{SpO}_2 \]
Postoperative care

- **Pain**:  
  - exsufflation of \( CO_2 \)
  - infiltration of trocar ports with LA
  - NSAID’s for shoulder pain
  - IV opioids or locoregional blockade

- **Vital signs**:  
  - breathing: accumulated \( CO_2 \) load!
  - vital signs: delayed hemorrhage?
Conclusion

- Better understanding of physiologic consequences of $CO_2$ insufflation in infants and children
- Reliable non-invasive monitoring
- Better postoperative pain treatment