We could increase abdominal compliance!

Mulier J P. AZ Sint-Jan Brugge-Oostende AV, Belgium
32 nd int symp Intensive Care and Emergency Med.

Studio Bozar 15:15
What is abdominal compliance?

- Change in volume/change in pressure.
- Most organs have a non-linear relation between pressure and volume.
  - Compliance varies according to the volume status.
  - Constant compliance ( = linear pressure volume relationship).
- Is the abdomen an exception?
**PV loop**

- Flow and pressure monitor between insufflator and abdomen
- Slowly inflate and deflate the abdomen while measuring pressure and integrating flow to volume

---

**abdominal inflation - deflation**

Man 47 y  BMI 48  162 kg  183 cm

PV0: 7.25 mbar

E: 3.57 mbar/liter
Fitting of cross section abdomen when inflated at 15 (yellow) versus 25 (red) mmHg

- **Yellow:**
  - Long axis: 43.23 cm
  - Short axis: 30.00 cm
  - Circumference: 115.96 cm
  - Area: 1018 cm²

- **Red:**
  - Long axis: 40.80 cm
  - Short axis: 34.23 cm
  - Circumference: 118.06 cm
  - Area: 1097 cm²

Mulier J.P., Coenegrachts. CT analysis of the elastic deformation and elongation of the abdominal wall during colon inflation for virtual coloscopy. Eur J Anesthesia 2008 Suppl
Diameter circle decreases while inflating abdomen

Abdomen is a fixed box covered by elastic cover

pressure volume relation of different structures

Globe
Tubing
Membrane
2 membranes

Mulier JP 2008
What is abdominal compliance?

- The Abdominal pressure volume relation (APVR)
  - Compliance C:
    - change in volume/change in pressure
  - Elastance E: E=1/C
    - Change in pressure/change in volume
  - PV0: Crossing of Y axis
    - Pressure at zero volume
- APVR is linear in humans
  - To a value of 20 mmHg
  - Except if abdomen has an apple shape.
    - central obesity with intra abdominal fat
Exception in intra abdominal adiposity

Subcutaneous Fat  Visceral Fat

Intra visceral adiposity
Subcutaneous fat is scant and intra abdominal fat is thick and

Extra visceral adiposity
Subcutaneous fat is thick and intra abdominal fat is scant.
Compliance (C) and Elastance (E) 

\[ C = \frac{\text{change in V}}{\text{change in P}} (C = \frac{1}{E}) \]

Higher insufflation pressures needed

\[ PV_0 = 5 \]

\[ E = 4 \text{ mmHg/l} \]

Insufficient intra abdominal volume

J Mulier, B Dillemans, M Crombach, C Missant, A Sels
On the abdominal pressure-volume relationship.

*The Internet Journal of Anesthesiology. 2009; 21: 1.*
Pneumoperitoneum monitor connected between patient and inflator to measure E, the abdominal elastance and PV0, the pressure at zero volume according to the Mulier abdominal model.

Mulier Jan Paul,
Department of Anesthesiology, AZ St-Jan, Antwerp, Belgium

Contact: Email: jan.mulier@azstjan.be
More info: www.publications.net/jan.mulier

Introduction and goal of the study:
- Every patient has a different abdomen
- E and PV0 characterizes the abdomen
  - Setting the inflation pressure to reach a
    certain volume
  - Try to improve workspace
  - Decide to change to laparotomy
  - Understand why insufficient workspace
  - Improve lung ventilation
- Calculate automatically instead of manual
  - Faster
  - More accurate
  - PV loop gives more information

Materials and Methods

Results: examples of measurements:

Conclusion
- Monitor is possible but should be standardized.
- E and PV0 can be calculated.
- Separate pressure monitoring line is needed.
- Relation not linear at higher pressure

References
1. Obes Surg. 2007, 7
3. Acta Chir Belg. 2007, 62 SPP

PV0 : 7
E: 1 mmHg/L
Example: 1.2 L versus 7.2 L

Maximal NMB helps but is not sufficient alone

NMB needed? Depends on the IAP used?
BMI effect on abdominal P/V relation

- J Mulier ISPUB 2009
  - Pressure volume relation is linear
  - PV0 and E are patient determined

- J Mulier IFSO 2007
NMB change PV0 and not the C

Abdominal pressure volume relation

IAP mmHg

Volume insufflated Liter

Vol with no NMB
Vol with NMB
## Determinants of E and PV0

<table>
<thead>
<tr>
<th></th>
<th>PV0</th>
<th>$P_{VO}$ sig</th>
<th>E</th>
<th>E sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Neg</td>
<td>0.828</td>
<td>Pos</td>
<td>0.003*</td>
</tr>
<tr>
<td>Length</td>
<td>Neg</td>
<td>0.356</td>
<td>Neg</td>
<td>0.245</td>
</tr>
<tr>
<td>Body weight</td>
<td>Pos</td>
<td>0.012*</td>
<td>Pos</td>
<td>0.294</td>
</tr>
<tr>
<td>Bmi</td>
<td>Neg</td>
<td>0.054</td>
<td>Neg</td>
<td>0.272</td>
</tr>
<tr>
<td>Sex</td>
<td>Neg</td>
<td>0.596</td>
<td>Neg</td>
<td>0.536</td>
</tr>
<tr>
<td>Gravidity</td>
<td>Neg</td>
<td>0.305</td>
<td>Neg</td>
<td>0.049*</td>
</tr>
<tr>
<td>Prev abd operation</td>
<td>Neg</td>
<td>0.191</td>
<td>Neg</td>
<td>0.009*</td>
</tr>
<tr>
<td>Muscle relaxation</td>
<td>Neg</td>
<td>0.001*</td>
<td>Neg</td>
<td>0.376</td>
</tr>
</tbody>
</table>

* Sig $p<0.05$

Mulier JP 2007

32 int symp Int Care Emerg Med 2012
How to change E: hip flexion

Mulier JP Obes Surg 2009

Effect of position on E in mmHg/L

- E: 3.6 > E: 2.7, vol increase: 600ml
- E: 3.6 > E: 2.6, vol increase: 1100ml

Only leg flexion affects E
Effect of table position on APVR

- PV0 decreases
- E no change

<table>
<thead>
<tr>
<th>PV0</th>
<th>5,037</th>
<th>&gt;</th>
<th>4,122</th>
<th>&gt;</th>
<th>3,835</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>3,459</td>
<td>=</td>
<td>3,368</td>
<td>&gt;</td>
<td>3,217</td>
</tr>
</tbody>
</table>

Mulier JP Obes Surg 2009
Effect of leg flexion on APVR

- PV0 no change
- E decreases

PV0: 4,320 = 4,765
E: 3,459 > 2,660
PV0: 5,037 = 4,910
E: 3,368 > 2,577

Mulier JP Obes Surg 2009
Impact of patient’s body position on the intraabdominal workspace

Reverse trendelenburg      Beach chair

E (mmHg/L)  3,4      2,6
PV0 (mmHg)   5,0      4,9
IAV (L)     2,99     3,76

Impact of the patient's body position on the intraabdominal workspace during laparoscopic surgery.
Mulier JP, Dillemans B, Van Cauwenberge S.
Begin – End of first laparoscopy

- Abdominal compliance changes during pneumoperitoneum
- Inflation volume rises more than 1 liter!
- No NMB needed at end of operation?

One Hour Laparoscopy at 15 mmHg
Elongates the Abdominal Wall
Mulier IFSO 2009
Impact of laparoscopy depends on

- J P Mulier, I Casier, K Verbeke, B Vanacker 2010 ESA

Vol increase at end lap
Problems yes!
ARM ?
Conclusion

- Compliance is determined by the fascia.
  - Some prediction is possible
    - Multiple parity
    - Weight reduction
    - History of many laparoscopies
    - Apple shape obesity
    - abdominoplasty
  - It is difficult to change compliance.
    - Flexing the hips (legs)
    - Abdominal recruitment, performing a laparoscopy?
  - It is difficult to measure at the intensive care