Ins and outs of anaesthesia parameters in robotic surgery:
which ventilation strategy in obese patients?

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Robotic surgery and obesity

• Steady development in France
• Numerous indications
• Possibly long time processes
• Obese people are increasing
• Setting and positioning of obese patient
• Impact of pneumoperitoneum (IAP)
Obesity in France

- Major problem in public health
- Predicting of surmorbidity and mortality
- In Europe, increase of prevalence but lower than US
- Obesity prevalence in France is 14.5% in 2009

(Severe obesity BMI ≥ 35 kg/m² = 2.8%; morbidly obesity BMI ≥ 40 kg/m² = 1.6%)

(Calle EE, N Engl J Med 1999; Obepi-Roche 2009)
Setting of obese patient

- Supine position with head down more than 30° more or less lateral rotation
- Positioning of the legs set apart, half flexed into boots
- Both arms along the body, palms upward, maintained with a sheet rolled around the patient
- Head in line with the body with a head block (gel donut)

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Positioning of the table

- Predefined location of the leg of the table according to the position of the robot.
- Stabilization of the patient through velcro straps crossed around the chest and boots, straps maintained by screwed blocks.
- Initial trial of positioning before covering with surgical sterilized sheets.

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Possible mapping in the operating room

Lost access to the head, to venous system, to monitoring devices under full surgical sterilized sheets

Anaesthesia device
Cas clinique

Rhabdomyolyse et syndrome des loges des deux avant-bras lors d’une chirurgie robotique de longue durée

Rhabdomyolysis and compartment syndrome of two forearms after robotic assisted prolonged surgery

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Monitoring and per operative equipment

- **Usual**: ECG, NIAP, oxymetry, 2 peripheral venous lines, tracheal tube, urinary and stomachal catheters

- **Compulsory**: ET CO₂, NMT, warm covers and temperature control, antithrombotic stockings or socks

- **And also**: monitoring IAP, insufflation rate of CO₂ at the beginning of insufflation and ventilatory parameters (Pmax AW, C)

- **Optional**: invasive arterial pressure (ASA 3 - 4), BIS (old people), CPI (high risk thrombo embolism), central venous line (if bad peripheral venous system)
DaVinci and IAP: « decoding of the impact »

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The panel recommends use of the lowest IAP allowing adequate exposure of the operative field rather than using a routine pressure (grade B). An IAP lower than 14 mmHg is considered safe in a healthy patient (grade A). Abdominal wall-lifting devices have no clinically relevant advantages compared to low-pressure (5--7 mmHg) pneumoperitoneum (grade B).

If technically feasible, gasless or low-pressure laparoscopy might be an alternative for patients with limited cardiac function (grade B).
Pneumoperitoneum and haemodynamic status

- The decrease of CO is proportional to the importance of IAP: ↓ 25-35% depending on studies, 50% with head lifted up
- There is a decrease of venous rate and an increase of systemic and pulmonary arterial vascular resistances due to splanchnic compression and to vasoactive agents (ADH, catecholamines, RAS…)
- The effects are volumic dependant

These effects are predictable
Pneumoperitoneum and haemodynamic status

- These impacts are maximum at the beginning of the process and related to cardiac precharge:
  - prophylactic fluid pre loading
  - declive position before pneumoperitoneum
  - proclive only if steady status

- Adverse effects are the highest with proclive, fast rate insufflated CO₂, high Pmax AW and reduced with declive and not dependant on the kind of gas

Handling of these effects is necessary

Pneumoperitoneum and ventilation

• Increase in Pa CO₂ is attributed to CO₂ uptake secondary to CO₂ insufflation: biphasic: proportional to IAP and then by ventilation-perfusion mismatch (dead space and shunt), absorption 20 to 40 ml/mn

• Absorption of CO₂ is measured by End Tidal CO₂ (ET CO₂): capnography

• Factors associated with greater CO₂ absorption: higher insufflation pressure, flow rate, patient’s height and weight, prolonged insufflation time, operative site and subcutaneous emphysema
Pneumoperitoneum and ventilation

- Elevation of ET CO$_2$ can have deleterious effect: $\uparrow$ PaCO$_2$ from 8-10 mm Hg, ET CO$_2$ $\uparrow$ 15-20% in 20 min usually by $\uparrow$ dead space

- $\downarrow$ 30% of pulmonary compliance and $\uparrow$ 30% pulmonary resistances, improved by limitation of IAP and full neuromuscular paralysis

- No clinical significance if normal respiratory function, but risk with cumulated CO$_2$ if preexisting respiratory problem (COPD) or cardiac disorders

- Impact depends on table position (head up position)

- To limit hypercarbia and acidemia: use of mechanical hyperventilation with increase volume of ventilation per minute to remove the excess CO$_2$ and lower IAP


Study of respiratory dysfunction
Respiratory function and obesity

- Difficulties in ventilation are frequently encountered
- Difficult intubation and mask ventilation
- Restrictive and obstructive syndromes
- Abnormal ventilatory mechanics during laparoscopic surgery, particularly in supine position:
  - reduced functional residual capacity
  - increased closing volume
  - consequent atelectasis
  - negative effect on gas exchange
- There is increased risk for postoperative respiratory complications and prolonged hospital length of stay

(Eichenberger Anesth Analg 2002;95)
Various intraoperative ventilatory strategies

- Safety of a pre-set tidal volume and minute ventilation
- VCV requires the clinician to appropriately set the inspiratory flow, flow waveform and inspiratory time
- Airway pressure increases in response to reduced compliance, increased resistance (obese)
- VCV may increase the risk of ventilator-induced lung injury (high pressure alarm)

Volume-Controlled Ventilation (VCV)
Various intraoperative ventilatory strategies

- PCV limits the maximum airway pressure delivered to the lungs
- PCV may result in variable Vt and minute ventilation
- Titration by clinicians the inspiratory pressure to the measured tidal volume
- The ventilator determines inspiratory flow and flow waveform
- Potential reduction in ventilation caused by pressure limitation

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Various intraoperative ventilatory strategies

- The effects of VCV or PCV are always discussed: the effectiveness of these strategies has not been shown to improve and to maintain intraoperative and postoperative arterial oxygenation in obese patients, with no sustained beneficial effect on morbidity.

- Hybrid mode?: dual-control mode with volume targeted, pressure-limited and time cycled breaths.

- High peroperative FiO$_2$ ≥ 50% induces lung collapse.

(Futier E and al, SFAR 2011)
Compliance $\Delta V/\Delta P$ and IAP

The elastic pulmonary function is studied by volume-pressure ratio. A low post-operative compliance can show a diagnosis of atelectasis.

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Monitoring and coelioscopy: how to decode?

- Ventilation pressure in airway tract
- Compliance
- ET CO$_2$ is compulsory:
  - adjustment of per minute ventilation
    - fast $\uparrow$ and then standard level = small GE
    - gradual and durable $\uparrow$ = extraperitoneal diffusion
    - fast $\downarrow$ more than 3 mmHg = failure CO, significant GE to consider

Use a lower IAP reduces risk of gas embolism

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Neutral supine position
No pneumoperitoneum

▲ Pressure AW et ▼compliance

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Understanding of management
Atelectasis and pneumoperitoneum

- Consequent and early atelectasis in obese patient: increase intrapulmonary shunt, ventilation-perfusion mismatch

- IAP of 11-13 mmHg increases atelectasis more than 60%

- A cephalic moving up of diaphragm 1 to 3 cm is associated

- Particularly in non-dependent lung (posterior area in the supine patient)

During anaesthesia and mechanical ventilation, the distribution of ventilation to perfusion is altered with lung regions having both increased low and high ventilation to perfusion ratios:

How to prevent the dynamic airway collapse?

Anesthesiology 2005;102, Anesth Analg 2009, 109

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How to improve gas exchange?

Different intraoperative strategies have been investigated with variable effects:
- large tidal volume (> 10-12 ml/kg)
- high ventilatory frequency
- or both
- PEEP….

Recently, alveolar recruitment: maneuver using repeated and sustained inspiratory pressure in obese patients
• n= 60 patients ASA 2 with BMI ≥ 30 kg.m⁻²
• Elective laparoscopic banding under GA
• Patients were randomized to one of the four intervention groups:
  - group P: PEEP of 10 cm H₂O until end of surgery
  - group R: sustained of Inspiratory Pressure (IP) 40 cm H₂O for 15 s only once
  - group RP: like group R and PEEP 10 cm H₂O
  - group RRP: like group RP but IP every 10 min
A

Respiratory compliance (ml cm H₂O⁻¹)

- INT
- T10
- T20
- T30
- T40
- T50

Group P
Group R
Group RP
Group RRP

B

$P_{O2}$ (kPa)

- INT
- T10
- T20
- T30
- T40
- T50

Group P
Group R
Group RP
Group RRP

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Which ventilation in obese patients?

- Concept of « opening up the lung and keeping it open » by repeated alveolar recruitment and PEEP
- « Lung protective » approach (Vt 6 ml/kg)
- Low IAP improve pulmonary compliance
- Full neuromuscular paralysis and monitoring
- Risk of hypotension with high inspiratory pressure: fluid bolus, vasopressor
- Sustained improvement after tracheal extubation but better postoperative respiratory function and reduced length of hospital stay?
Robotic surgery and level of pneumoperitoneum

- Best visualization with 3D and HD
- A limited working space is possible
- Easy use with joysticks
- Surgery devices are suitable
- Tractive pull of arms on abdominal wall

Has the stepping down of IAP same efficiency as conventional laparoscopy?
No Robot war will not occur!

The anaesthesia station

The surgical robot

ACRM

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