Laparoscopic Surgery

A Review

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RPH
Introduction

- Laparoscopic surgery was first introduced into clinical practice in the 1960’s

- 1970’s Gynaecology had braced laparoscopy for both diagnostic and operative procedures

- General surgery followed in the 1980’s to perform cholecystectomy laparoscopically
Procedures

- Elective and emergency diagnostic and staging procedures, cancer surgery as well as emergency procedures such as appendicectomy

- Weight reduction surgery for the morbidly obese is carried out laparoscopically routinely in the United States of America
Pro’s
1) Reduced Stress Response

- Afferent neurones from the operative site convey impulses via the hypothalamus to trigger a neuroendocrine response.

- *Stimulation* of the sympathetic nervous system to release catecholamines.

- Humoural response that *increases* the release of catabolic hormones:
  - ACTH
  - Prolactin
  - Glucagon
  - Catecholamines
  - Growth hormone
• *reduces* the release of anabolic hormones
  – Insulin
  – Testosterone
  – T3
• The net effect is of an *increased* breakdown of carbohydrates, lipids and protein and *reduced* peripheral utilization of glucose.
Cytokines

• Tissue damage by surgery stimulates production of activated leucocytes, fibroblasts and endothelial cells - produce cytokines

• Mediate the inflammatory response to tissue injury

• IL-1 and TNF-α
• IL-6 - Acute Phase Response

• Tissue damage is limited as IL-6 activates the repair process by stimulating the release of acute phase proteins
  – C-Reactive Protein, fibrinogen, complement and interferons
IL-6

- Circulating levels of IL-6 increase after all types of major surgery.
- Detected as early as 30 minutes after skin incision and can become significantly raised 2 to 4 hours post surgery.
- The IL-6 response to surgery reflects the extent of tissue damage.
- Levels have been shown to be reduced in laparoscopic surgery. (1, 6, 7)

- Nitrogen balance and immune function maybe better preserved.
But

- Endocrine response to Lap and Open Cholecystectomy does not differ significantly
- Plasma and urinary conc of cortisol & catecholamines are similar
- Combined GA and Epidural for Lap Chole doesn’t result in a decreased stress response

- Pain, haemodynamic and ventilatory changes from PnP may contribute to the stress response
2) Reduced Analgesic Requirements
• Acute pain after laparoscopy has been shown to be significantly less and of shorter duration than that caused by laparotomy (6,7,45).
• Less superficial trauma
• Smaller incision
• Less dissection through tissue layers (2).
• Long term pain has also been shown to be less common after laparoscopy (88)
• Type of pain different - visceral eg biliary colic, pelvic spasm, shoulder tip pain
• treatment options - topical / infiltration / intraperitoneal / removal of residual CO2 / ? Epidural
• ➔ Multimodal approach
3) Improved Post-Operative Respiratory Function
Reduced postoperative pain causes less
  – splinting of the rib cage
  – tachypnoea
  – shallow breathing
  – suppression of the cough reflex

⇒ Reducing atelectasis and respiratory infection (9.)
• Karayiannakii et al showed that FRC, FEV1, FVC and FEF 25-75% were significantly better after laparoscopic cholecystectomy when compared to open cholecystectomy.

• Significantly lower incidence of atelectasis and better oxygenation (2)

• Diaphragmatic function is also significantly impaired after Laparoscopy

• Post-op respiratory function recovery is slower in elderly, obese, COPD and smokers, but less impaired than after laparotomy
• 4) Reduced Recovery Time
• 5) Reduced post operative ileus
• 6) Reduced fasting and IV infusion

• ➡ Hospital stay significantly reduced

• 7) Improved Cosmetic Appearance

• 8) Improved visualisation of the Operative field
Con’s
• Physiological consequences of pneumoperitoneum
• Raised intra-abdominal pressure
• Operative position of the patient
• Technical difficulty of the procedure
• Unsuspected visceral injury
• Difficulty in evaluating amount of blood loss
• Gas embolism / Pneumothorax / Surgical Emphysema
• Vessel trauma
Physiological Effects of Laparoscopy

Pneumoperitoneum

• Pathophysiological effects of laparoscopy are associated
  – Insufflation of gas into the peritoneum (pneumoperitoneum)
  – Operative position of the patient

• Carbon dioxide is most commonly used gas for insufflation

• Advantages of using CO2
  – Colourless gas
  – Does not support combustion
  – Highly soluble
  – Inexpensive
• Intra abdominal pressures should be approximately 14 mmHg
• 25 mmHg for pelvic procedures (9).
• Higher pressures are associated with faster CO2 absorption, gas embolism and significant cardiorespiratory effects. (9)
Cardiovascular Effects

• Raised intra abdominal pressure
• Hypercarbia
• Intra-operative position of the patient
• Duration of the procedure
• Rate and volume of gas used for insufflation
• Age of the patient
• Coexistent cardiopulmonary disease
• Intravascular volume status of the patient (9)
Effects due to raised intra-abdominal pressure (IAP)

- Intra-abdominal pressure of 14mmHg raises systemic vascular resistance (SVR) by
  - Direct compression of the abdominal aorta
  - Increased venous resistance
  - Increased afterload due to release of catecholamines, vasopressin and rennin-angiotensin activity (9)
• MAP, HR & caval pressures ↑ but stroke volume ↓
• CO initially ↑ because of splanchnic compression ⇒ ↑ VR but within mins ↓
• CO falls 10 - 30 %
• As IAP increases to 30mmHg, cardiac index ↓ 50% of preoperative values within 5 minutes
• IAP of 40mmHg ↓ CO by 17% in normovolaemic patients and by 53% in hypovolaemic patients

• Fluid loading pre and intra-operatively improves the preload, thus CO
• Increased SVR
  – reflex sympathetic response to ↓ CO
  – patient position
• Mediated by mechanical and neurohumoral factors
• Catecholamines, renin - angiotensin system & vasopressin released during PnP
• Vasopressin conc have been correlated
  – Time course that parallels SVR
  – Changes in intrathoracic pressure and transmural RA pressure
  – Mechanical stimulation of peritoneal receptors
• Increase in SVR = arterial pressure↑ when CO ↓

• α2 adrenergic agonist - clonidine significantly reduces both haemodynamic changes and anaesthetic requirements
Figure 56-5. Schematic representation of the different mechanisms leading to decreased cardiac output during pneumoperitoneum for laparoscopy.
Figure 56-6. Changes in cardiac index and systemic vascular resistance during laparoscopy in two groups of patients. Group 1 (control; filled bar): pneumoperitoneum was induced with patients in 10-degree head-up position. Group 2 (volume loaded; empty bar): patients received 500 mL lactated Ringer solution before anesthesia induction and were insufflated in the supine position. N = 10 in each group, data are mean ± SEM.
Laparoscopy in Cardiac Disease

- Maybe extremely hazardous if they are unable to compensate
- The reduction in preload causes the HR to increase to maintain CO
- Increased afterload $\Rightarrow$ $\uparrow$ ventricular wall tension $\Rightarrow$ $\downarrow$ coronary blood flow $\Rightarrow$ myocardial ischaemia
- Changes qualitatively similar to healthy pts
- Quantitatively more marked
• ASA 3/4 SvO2 decreased in 50% of pts despite pre op haemodynamic optimisation using PAOP
• Most severe changes were pts with inadequate O2 delivery with low pre op cardiac output and CVP, high MAP & SVR = *depleted intravascular vol*

• IV GTN, dobutamine and nicardipine to manage haemodynamic changes induced by IAP
• Normalisation of haemodynamics does not occur for 1 hr post op - congestive heart failure may ensue
Table 56–2. Management of Patients With Cardiac Disease for Laparoscopy

Preoperative evaluation: echocardiography
If left ventricular ejection fraction <30%
Intraoperative monitoring
  Intra-arterial line
  Pulmonary artery catheter
  Transesophageal echocardiography?
  Continuous ST segment analysis?
Gasless laparoscopy?
Laparotomy?
Intraoperative management
  Slow insufflation
  Low intra-abdominal pressure
  Hemodynamic optimization before pneumoperitoneum (preload augmentation)
Patient tilt after insufflation
Anesthesia: isoflurane
  vasodilating drugs (nicardipine, nitroglycerin)
  cardiotonic agents
Experienced surgeon
Postoperative care
  Slow recovery from anesthesia (benefit of clonidine)
• Hypercarbia may cause direct and indirect sympathetic stimulation

• Cardiac arrhythmias during laparoscopy are due to multiple causes - don’t correlate with the increase in PaCO2. (28)

• Often occur during insufflation - pathophysiological changes are most intense

• Reflex vagal stimulation from sudden peritoneal stretch ⇒ bradycardia or asystole
Respiratory Effects

- Changes in the respiratory system occur secondary
  - Hypercarbia from absorbed CO2
  - Raised IAP \( \Rightarrow \) altered pulmonary mechanics
Effects from Hypercarbia

- PaCO2, mixed venous blood PaCO2 and PACO2 rise by 10mmHg in young healthy patients within 5 minutes of insufflation

- Transperitoneal absorption & mechanical impairment of diaphragmatic & intercostal muscles from the pneumoperitoneum
  - ⇒ acidosis

- Minute ventilation should therefore be increased by 12-16% to maintain normocapnia in healthy patients (9)
Table 56–1. Causes of Increased $\text{PacO}_2$
During Laparoscopy

1. Absorption of $\text{CO}_2$ from the peritoneal cavity
2. $\text{VA/Q}$ mismatch: increased physiologic dead space
   - Abdominal distention
   - Position of the patient (steep tilt)
   - Controlled mechanical ventilation
   - Reduced cardiac output
   - These mechanisms are accentuated in sick patients (obese, ASA II–III, ...)
3. Increased metabolism (insufficient plane of anesthesia)
4. Depression of ventilation by anesthetics (spontaneous breathing)
5. Accidental events:
   - $\text{CO}_2$ emphysema (subcutaneous or body cavities)
   - Capnothorax
   - $\text{CO}_2$ embolism
   - (Selective bronchial intubation)
Effects from raised IAP

- Airway pressure & plateau pressures $\uparrow$ by 50% and 81% respectively
- Pulmonary compliance is $\downarrow$ by 47%
- $\Rightarrow$ Increase Work Of Breathing(9)
- Once PnP created & constant, compliance is not affected by pt tilting or $\uparrow$ min ventilation
- compliance and PV loop monitoring good for diagnosing complications - wheeze / pneumothorax
Figure 56-1. Change in total respiratory compliance during pneumoperitoneum for laparoscopic cholecystectomy. The intra-abdominal pressure was 14 mm Hg, and the head-up tilt 10 degrees. Illustration of airway pressure (Paw) versus volume (V) curves and data were obtained from the screen of a Datex Ultima. A, before insufflation; B, 30 min after insufflation; TV (mL), tidal volume; Ppeak (cm H₂O), peak airway pressure; Pplat (cm H₂O), plateau airway pressure; C (mL/cm H₂O), total respiratory compliance; PETCO₂ (mm Hg), end-tidal PCO₂.
• Diaphragmatic movements ↓ secondary to the ↑ IAP and the trendelenburg position ⇔ ↓ FRC.

• FEV1 is also reduced because of the decreased total lung capacity from the cephalad position of the diaphragm.

• Quantitative reduction in FEV1 and FVC after laparoscopy is variable but is always significantly less compared to laparotomy (9).

• Endobronchial intubation may occur during pnp because of cephalad movement of the carina from the diaphragm. (28)
Subcutaneous Emphysema

• Complication of accidental or intentional extraperitoneal insufflation
• Lap fundoplication for HH diaphragmatic hiatus ⇒ CO2 mediastinum
• Increase in PETCO2 after plateau conc reached = SE
• Interrupt surgery
• Readily resolves
Pneumothorax / Pneumomediastium

• Potential channels of communications
• Defects in diaphragm
• Pleural tears during surgery
• Increased alveolar inflation from increased min ventilation
• Pre-existing bullae
• CO2 - spont resolution within 30 - 40 mins
- Stop N2O
- correct hypoxaemia
- PEEP
- reduce IAP
- avoid chest drain

• Pneumothorax from bullae no PEEP, and for chest drain
Other Physiological Effects

• **Renal**
  – ↓ renal blood flow and GFR to below 50% baseline from ↓ CO
  – Renal function may deteriorate in patients with precarious renal function.

• **Gastrointestinal**
  – ?acid aspiration during laparoscopy
– Splanchnic blood flow, CO2 PnP may cause local vasodilatation which counteracts the mechanical effect of the IAP
– Rare reports of mesenteric ischaemia - effects of PnP on splanchnic blood flow not clinically significant

• Cerebral
  – CBF velocity increased in response to ↑PaCO2
  – Normocarbia PnP with trendelenberg - no harmful changes in intracranial dynamics
  – pigs - intracranial pressure rise during CO2 - PnP independently of PaCO2 - also shown in children with VP shunts
• Ocular
  – IOP not affected by PnP with no pre-existing eye disease
  – Animal model of glaucoma PnP slightly increases IOP
Physiological effects of the Operative Position

• Positions for surgery can further stress the cardiorespiratory system

• Particular attention should be made to avoid injury to the patient, disconnections of intravenous lines and the endotracheal tube

• Positions commonly used are:
  – Trendelenburg / head down tilt for pelvic and inframesocolic surgery
  – Reverse trendelenburg / head up tilt for supramesocolic surgery
  – Lithotomy
  – Lateral
Trendelenburg position

• **Cardiovascular system**
  – ↑CVP & CO. Baroreceptor reflex adjusting to this raised pressure
    ⇒ vasodilation & bradycardia
  – Usually insignificant if the patient is fit
  – Patients with coronary heart disease with poor left ventricular function - ↑ central blood volume, pressure changes maybe deleterious
• **Respiratory**
  – Facilitates the development of atelectasis
  – FRC, total lung volume, and pulmonary compliance is reduced in steep head down position

• **Cerebral circulation**
  – If the intracranial compliance is low
• **Cardiovascular System**
  – VR is reduced thus reducing CO and MAP
  – Compounded by the pnp.
  – Venous stasis occurs in the legs- aggravated by the lithotomy position

• **Respiratory system**
  – Respiratory changes are less significant in this position.
Nerve Injury

• Nerve compression is always a potential hazard

• Prevent over extension of arms and padding over bony prominences

• The common peroneal nerve is particularly vulnerable during lithotomy
Complications of Laparoscopy

- Gynae mortality 1 per 10,000 to 1 per 100,000 cases
- Conversion to laparotomy 2 - 10 per 1000
- 30-50% intestinal & vascular injuries
- Lap chole mortality 0.1 - 1 per 1000
- Conversion to laparotomy 1%, bowel perforation, CBD injury & haemorrhage
- Large vessel injury
- Retroperitoneal haemorrhage
- Gas embolus
- GI Tract injury
Gasless Laparoscopy

- Allows the peritoneal cavity to be expanded by using abdominal wall lifts.
- Restricts the haemodynamic and respiratory sequelae of raised IAP.
- In addition renal and splanchnic circulation is maintained.
- The disadvantage - technical difficulty & compromised exposure of the surgical field.
Local & Regional Anaesthesia

• Local with sedation
  • pain and discomfort
  • PnP and sedation - hypoventilation and desaturation
  • organ manipulation, steep trndelenburg - difficult spont breathing
  • IAP as low as possible

• Regional Anaesthesia
  – useful in Gynae
  – better muscle relaxation
  – shoulder tip pain and abdominal distension incompletely alleviated
  – extensive sensory block T4 - L5
  – epidural opiates and clonidine
- Haemodynamic effects of PnP under epidural sympathetic block may facilitate vagal reflexes
- Vasodilatation and avoidance of IPPV may reduce CVS effects during PnP
- Useful with Gasless Laparoscopy
Conclusion

• Laparoscopic surgery has documented advantages

• Potentially hazardous in significant cardiorespiratory disease

• More complex surgery is performed on an aging patient population with multiple co-morbidities

• The Anaesthetic technique should therefore reflect the prolonged surgery and medical status of the patient

• ? LMA and laparoscopy
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