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-á
- 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 CO_2 / ? 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 14mmHg
- 25mmHg for pelvic procedures (9).
- Higher pressures are associated with faster CO_2 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 ↓

- $\alpha 2$ adrenergic agonist - clondine significantly reduces both haemodynamic changes and anaesthetic requirements

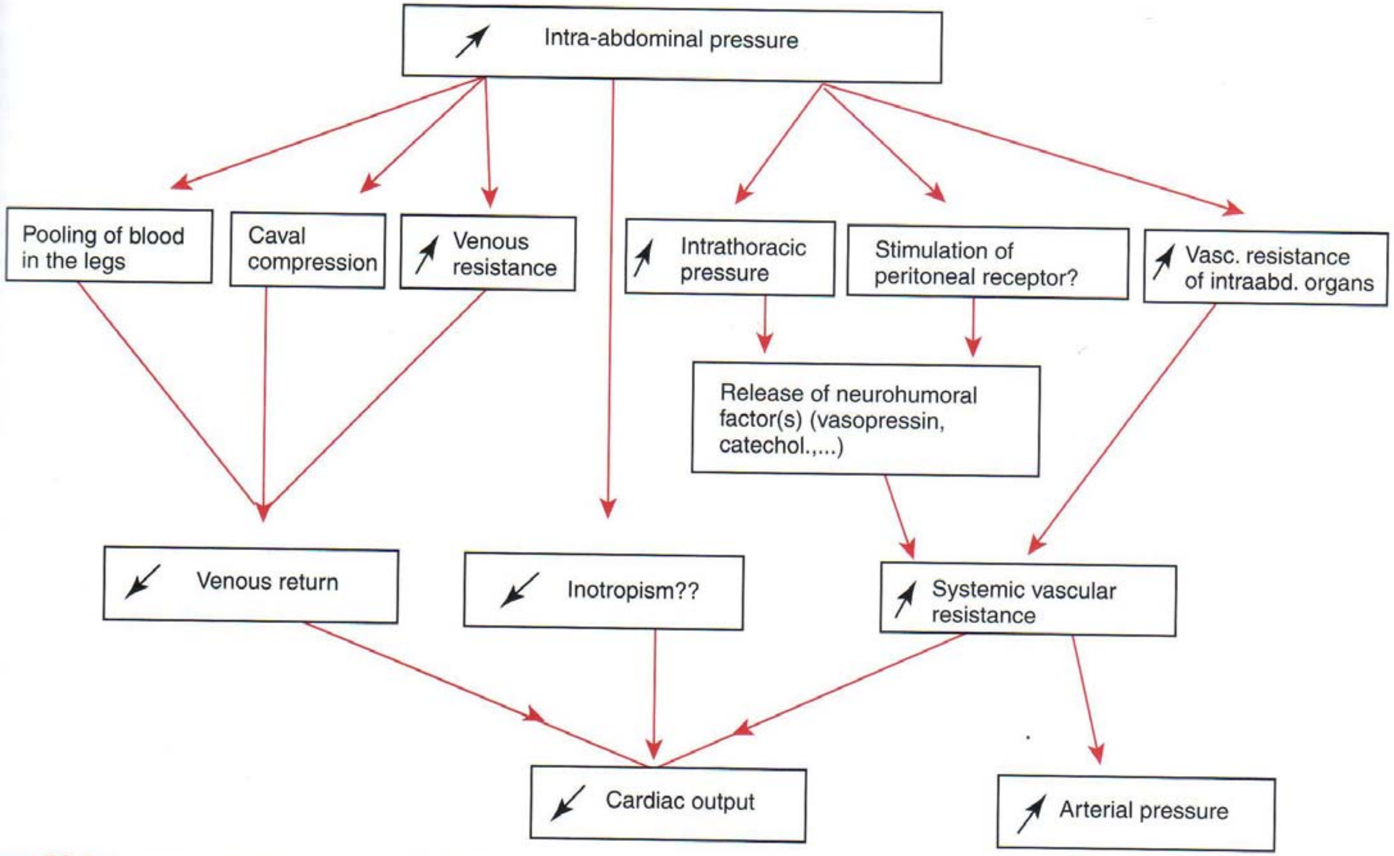


Figure 56–5. Schematic representation of the different mechanisms leading to decreased cardiac output during pneumoperitoneum for laparoscopy.

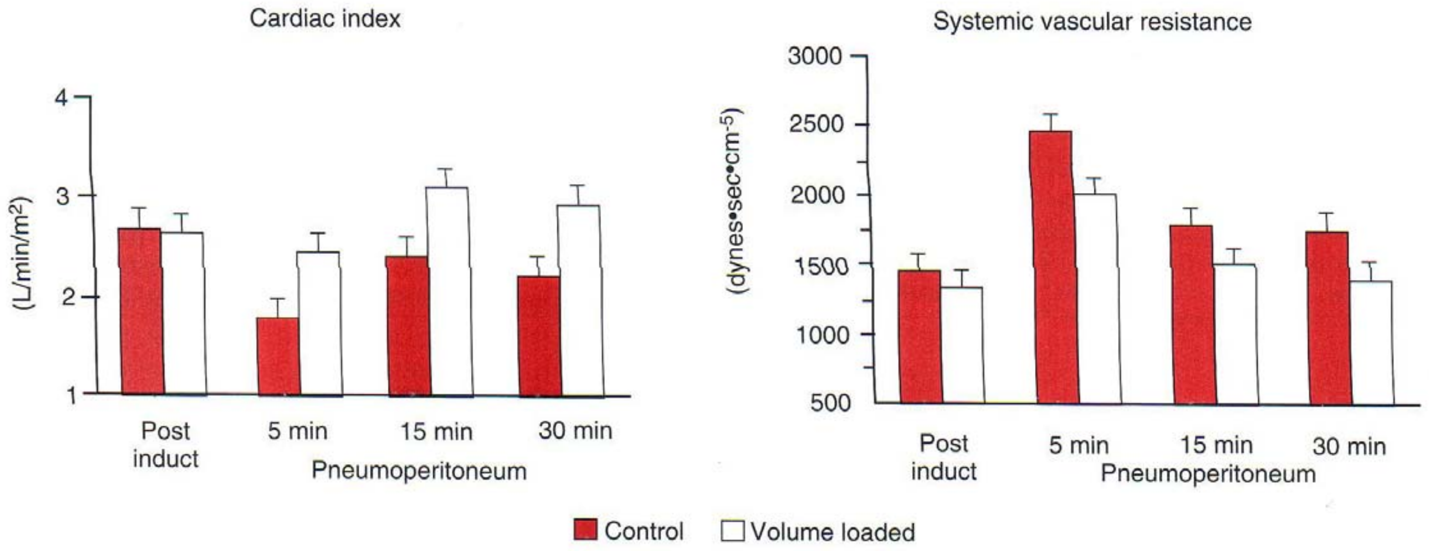


Figure 56–6. Changes in cardiac index and systemic vascular resistance during laparoscopy in two groups of patients. Group 1 (control; filled bar): p moperitoneum was induced with patients in 10-degree head-up position. Group 2 (volume loaded; empty bar): patients received 500 mL lactated Rin solution 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 ⇨ ⇧ ventricular wall tension ⇨ ⇩ coronary blood flow ⇨ myocardial ischaemia
- Changes qualitatively similar to healthy pts
- Quantitatively more marked

- ASA 3/4 SvO_2 decreased in 50% of pts despite pre op haemodynamic optimisation using PAOP
- Most severe changes were pts with inadequate O_2 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 $PaCO_2$. (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 CO_2
  - Raised IAP ⇨ 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)

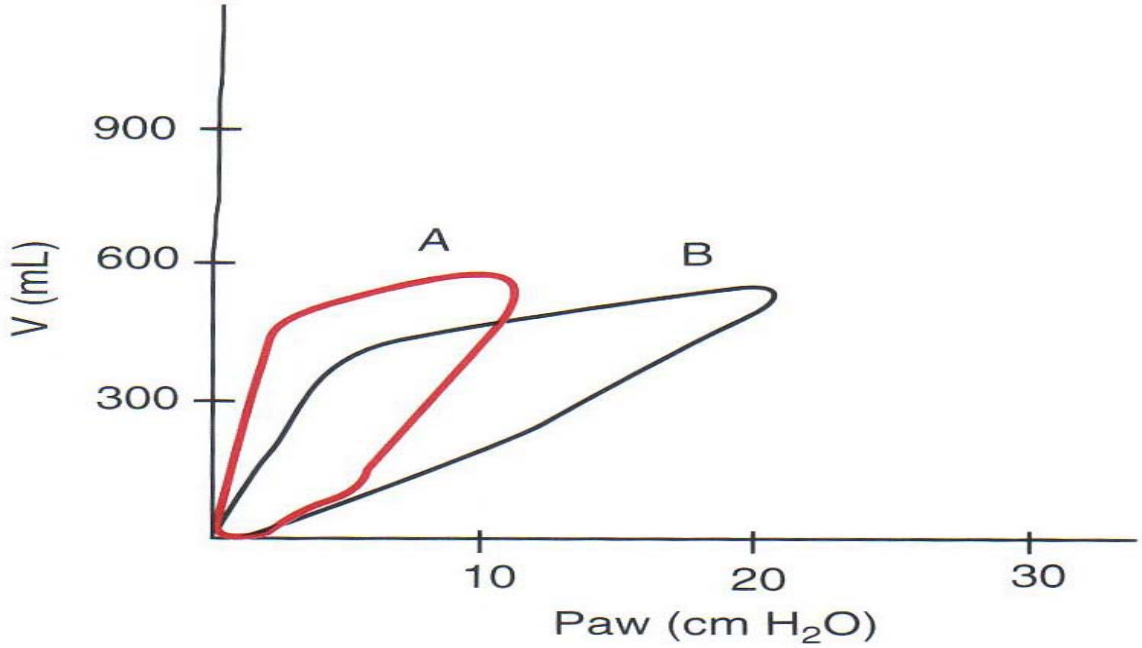
Table 56–1. Causes of Increased Pa_{CO_2} During Laparoscopy

1. Absorption of CO_2 from the peritoneal cavity
2. $\dot{V}_A/Q$ 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:
   - CO_2 emphysema (subcutaneous or body cavities)
   - Capnothorax
   - CO_2 embolism
   - (Selective bronchial intubation)

Effects from raised IAP

- Airway pressure & plateau pressures ⇧ by 50% and 81% respectively
- Pulmonary compliance is ⇩ by 47%
- ⇨ ***Increase Work Of Breathing(9)***
- Once PnP created & constant, compliance is not affected by pt tilting or ⇧min ventilation
- compliance and PV loop monitoring good for diagnosing complications - wheeze / pneumothorax



	TV	Ppeak	Pplat	C	$P_{ET}CO_2$
A	522	12	9	56	31
B	525	21	19	27	39

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 the 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 H_2O), peak airway pressure; Pplat (cm H_2O), plateau airway pressure; C (mL/cm H_2O), total respiratory compliance; $P_{ET}CO_2$ (mm Hg), end-tidal P_{CO_2}.

- 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 ⇨ CO_2 mediastinum
- Increase in $P_{ET}CO_2$ 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
- CO_2 - 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, CO_2 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 ⇧$PaCO_2$
  - Normocarbia PnP with trendelenberg - no harmful changes in intracranial dynamics
  - pigs - intracranial pressure rise during CO_2 - PnP independently of $PaCO_2$ - 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

Reverse Trendelenburg

- **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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