LACTATE AND ACID BASE CHANGES DURING LAPAROSCOPIC CHOLECYSTECTOMY

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Abstract

Background: The observation of hemodynamic and metabolic impairment related to CO2 pneumoperitoneum and postoperative mesenteric ischemia reports following laparoscopic procedures have raised concern about local and systemic effects of increase intraabdominal pressure during laparoscopic procedures. The present study aims to evaluate the metabolic and acid base responses of using high pressure versus low pressure pneumoperitonium in patients undergoing laparoscopic cholecystectomy in a prospective randomized clinical trial.

Patients and method: 20 ASA I-II patients scheduled for elective laparoscopic cholecystectomy were randomly allocated to one of two study groups; high pressure pneumoperitoneum 12-14mmHg (HPP, n=10) versus low pressure pneumoperitoneum 6-8mmHg (LPP, n=10) undergoing laparoscopic cholecystectomy. Arterial blood gases and lactate levels were determined after induction of anesthesia (before pneumoperitonium), then after 10 min, then 30 min after insufflations

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and at the end of surgery and 1 hour postoperatively. Nurses in recovery unit reported pain assessment starting postoperatively until 3 hours on a 10mm VAS (0-10). Statistical significant was established at $P<0.05$.

Result: Bicarbonate was significantly ($P>0.0412$) lower in high pressure group at 30 min and 60 min after insufflations. In high pressure group lactate levels increased significantly as compared to low pressure group, (at 30 minutes after the establishment of abdominal pneumatic inflation $P\leq0.006$ and remained significantly increased ($P<0.001$) until the end of surgery and one hour thereafter) ($P<0.001$). The mean postoperative pain score during second hour (VAS) at HPP group was 7.4 ± 1.17 which is significantly ($P\leq0.006$) higher than pain score in LPP group 5.0 ± 1.886. Shoulder tip pain was reported in 3 patients in the high pressure group and only one patient in the lower pressure group.

Conclusion: High-pressure pneumoperitonium causes statistically significant elevation in the arterial lactate level intraoperatively until one hour post operatively. It also causes higher pain score and shoulder tip pain.

Key words: Laparoscopic cholecystectomy, High pressure CO_2 pneumoperitoneum, acid base.

Introduction

The use of laparoscopic surgery is increasing because of its advantages, including minimum surgical incisions, less blood loss, and shorter hospital stays as compared to the more traditional surgical methods. However, pneumoperitoneum may induce hemodynamic changes, such as increased mean arterial blood pressures (MAP), systemic vascular resistance, and decreased cardiac output, which may complicate anesthetic management[1&2]. These changes may affect visceral perfusion and metabolism. The gastrointestinal tract is especially vulnerable to ischemia and hypoxia resulting from its unique blood flow distribution. Gastrointestinal tract malfunction is regarded

as an important contributor to both the surgical stress response and postoperative complications[3]. Gastrointestinal tract hypo perfusion has been reported to be associated with increased mortality in critically ill patients[4]. Blood flow in the mesenteric artery and intestinal mucosa, as well as hepatic, splanchnic, and renal perfusion decrease when IAP is increased[5&6].

The origin of pain after laparoscopic cholecystectomy is multifactorial: pain arising from incision sites, pressure pneumoperitoneum, and the cholecystectomy[7]. In order to minimize the adverse effects of pneumoperitoneum, the clinical practice was extended to include low pressure pneumoperitoneum, (5-7) mmHg[8]. Increase in blood lactate levels has been attributed to anerobic metabolism probably due to tissue ischemia produced by high intraabdominal pressure. To test this assumption we designed a randomized study comparing a group of patients submitted to high intraabdominal pressure CO_2 pneumoperitonium and low pressure pneumoperitonium undergoing laparoscopic cholecystectomy; assuming that pneumoperitoneum may compromise capillary circulation in intraabdominal organs.

The aim of this study was to evaluate the metabolic and acid base responses in high and low pressure pneumoperitonium in laparoscopic cholecystectomy.

Patients and Methods

After obtaining the approval of our local research ethics committee and informed written consent, 20 patients (ASA physical status I or II) undergoing elective laparoscopic cholecystectomy were enrolled in this study. Patients with a history of respiratory disease, coronary artery disease, coagulopathy, body mass index >30 or previous gastric surgery, were taken as exclusion criteria. Written informed consent was obtained. They were randomly allocated using a sealed envelope method to one of two study groups. The patients were randomly allocated to two groups. In one group, the operation was performed using conventional pressure

pneumoperitoneum (12-14mmHg) with room-temperature CO_2 insufflations (HPP group). In the other group, using low pressure pneumoperitoneum (LPP group) (6-8mmHg).

Patients were premedicated with 3mg Lorazepam and metaclopramide 10mg orally 2 hours before surgery. Normal saline was given iv. $10ml \bullet kg^{-1}$ before surgery and $5ml \bullet kg^{-1} \bullet hr^{-1}$ throughout the operation.. Anesthesia was induced with $1\mu g \bullet kg^{-1}$ fentanyl and $2.5mg \bullet kg^{-1}$ propofol… Tracheal intubation was facilitated with $0.6mg \bullet kg^{-1}$ rocuronium. Neuromuscular block was maintained at 80-90% level with 10mg rocuronium increments, as evaluated by the transcutaneous train-of-four stimulation of the ulnar nerve. Anesthesia was maintained with boluses of sevoflurane and fentanyl.

During surgery, the infusion rates were adjusted at 10-20 ml/kg/h to maintain values of systolic arterial blood pressure and heart rate within ± 20% from control values.

The lungs were ventilated using a Sulla 909V® (Drëgerwerk AG, Lübeck, Germany) ventilator with a rebreathing circuit incorporating a CO_2 absorber. A continuous fresh gas flow of 4 $L \bullet min^{-1}$ (1.5L O_2 and 2.5L air), an inspiratory to expiratory ratio of 1:2 and zero end-expiratory pressure were applied. In both groups, respiratory frequency and inspiratory tidal volume were adjusted to provide an end-tidal carbon dioxide tension ($P_{ET}CO_2$) of 40-45mmHg during surgery. Carbon dioxide pneumoperitoneum was introduced and maintained an intraabdominal insufflation pressure limited to 12-14mmHg in (HPP) group and 6-8mmHg in (LPP) group.

Measurements

After anesthetic induction a radial artery was cannulated, and an oral gastric catheter introduced.

Arterial blood gases and lactate levels were determined after induction of anesthesia (before pneumoperitonium), then after 10 min then 30 min after insufflations and at the end of surgery and 1 hour

postoperatively. Nurses in recovery unit reported pain assessment starting postoperatively until 3 hours on a 10-mm VAS (0-10). The questionnaire, was on a hourly basis, if the pain score was greater than 5, patients received supplementary analgesics (Ketoprofen 1mg/kg) IM. Shoulder pain, and rate of complications were also assessed.

In addition, following induction, the following measurements were continuously performed (Datex-Ohmeda AS/3^{TM} Anesthesia Monitor): respiratory gas concentrations (inspiratory and expiratory CO_2 and O_2), respiratory rate, respiratory volumes (inspiratory and expiratory tidal and minute volume), airway pressures (peak inspiratory, end-inspiratory, end-expiratory), SpO_2, ECG, HR, invasive arterial blood pressures, as well as core temperature from nasopharynx.

In all patients, access was achieved using four working points (Trocars). Pneumoperitonium was created without visual control using a Veress needle inserted through a small skin incision in the umbilical region. Having created the 12mmHg pneumoperitonium, the surgeons proceeded to insert the trocars; in LPP group, pneumoperitonium was decreased to 7mmHg while in the HPP group the parameters were left unchanged. In all patients the exposure of surgical field was corrected placing the patient in the moderate (10-15) degree reversed Trendelenberg position. In the recovery room, arterial samples, ECG, HR, SpO_2, respiratory frequency and invasive arterial blood pressures were continuously recorded, from 20 min to three hours following extubation.

Statistics

Data are presented as the mean ± standard deviation. Demographic data were compared using a Chi-square of Fisher's exact test. Comparison between the mean values of the two groups was done using unpaired Student-t test. Repeated measures (ANOVA) was applied for comparing the mean in the same group. The SPSS statistical package (version 10) was used. Statistical significance was established at $P<0.05$.

Results

The ASA classification and sex distribution in both pressure groups are shown in Table 1. There were no significant differences between the two studied groups regarding age, height, weight, BMI or operative time Table 2.

Table 1
ASA classification and sex distribution in both groups

	High pressure	Low pressure
ASA I	1 (10%)	6 (60%)
ASA II	9 (90)	4 (40%)
M/F	3 (30%) / 7 (70%)	3 (30%) / 7 (70%)

Table 2
Patients data expressed as Mean±SD, in both groups

	High pressure Mean±SD	Low pressure Mean±SD	P value
Age (year)	47.2 ± 6.66	49.9 ± 10.524	0.16
Weight (kg)	74.18 ± 18.23	69.72 ± 13.70	0.544
Height (cm)	165.8 ± 7.41	161.0 ± 9.35	0.219
BMI	26.985 ± 1.9	26.89 ± 2.1	0.916
Operative time	51.9 ± 8.3	55.7 ± 8.6	0.328

P considered significant if $P<0.05$

Low and high pressure laparoscopic cholecystectomies were successfully performed in 100% of patients

MAP and heart rate showed no significant differences in both groups at any sampling time point, when compared to the control level. $ETCO_2$ and SaO2 and pH remained constant during surgery. These values were within the respective normal ranges both during and after pneumoperitoneum in both groups as part of the study protocol, the investigators increased minute volume to control for a rise in $PaCO_2$ during the procedure Table 3.

Table 3
pH values (Mean±SD) in both group

	HPP Mean±SD	LPP Mean±SD	P-value*
Base line	7.39 ± 0.065	7.383 ± 0.036	0.779
10 min	7.364 ± 0.0426	7.385 ± 0.067	0.418
30 min. insuffl.	7.362 ± 0.0248	7.348 ± 0.0559	0.483
End of surgery	7.324 ± 0.0237	7.331 ± 0.0299	0.569
1hr. after surgery	7.354 ± 0.0267	7.34 ± 0.021	0.418

* P considered significant if P<0.05

Bicarbonate was significantly (P<0.0412) lower in high pressure group at 30 min & 60 min after insufflations compared to lower pressure group. At 1 hour, postoperatively bicarbonate level showed no significant difference (P<0.663) in both groups Table 4.

Table 4
Bicarbonate level (Mean±SD) in both groups

	High PP Mean±SD	Low PP Mean±SD	P-value*
Base line	22.74 ± 1.28	22.71 ± 0.964	0.953
10 min.	23.27 ± 1.24	22.26 ± 1.039	0.064
30 min. insuffl.	19.8 ± 1.17	24.55 ± 5.8	0.0412*
End of operation	21.6 ± 1.068	23.02 ± 1.29	0.0304*
1hr. After operation	20.82 ± 8.907	22.08 ± 1.258	0.663

* P considered significant if P<0.05

In the high pressure group, lactate levels increased significantly as compared to low pressure group, (at 30 minutes after the establishment of abdominal pneumatic inflation P≤0.006 and remained significantly increased P<0.001 until the end of surgery and one hour thereafter) P<0.001; Table 5.

Table 5
Lactate level (Mean±SD) in both groups

	HPP Mean±SD	LPP Mean±SD	P-value
Base line	1.3 ± 0.48	1.07 ± 0.249	0.392
10 min.	1.42 ± 0.464	1.01 ± 0.328	0.066
30 min. insuffl.	1.69 ± 0.545	1.05 ± 0.251	0.006*
End of operation	2.77 ± 0.641	1.25 ± 0.481	P<0.001**
1hr. After operation	2.907 ± 0.862	1.31 ± 0.398	P<0.001**

* P considered significant if P<0.05

Postoperative pain scores did not differ between the two groups during the first hour. The mean±SD of postoperative pain score during second hour postoperatively (VAS) at high pressure group was 7.4±1.17 which is significantly P≤0.006 higher than lower pressure group 5.0±1.886. At the third hour postoperative pain still significantly higher high pressure group P≤0.05. Shoulder tip pain was reported in 3 patients of high pressure group and only one patient of lower pressure group.

Discussion

The splanchnic circulation consists of the gastric, splenic, hepatic, pancreatic, small intestinal, and colonic circulations arranged in parallel, and receives 25% of cardiac output. In healthy patients, increase in IAP from 10mmHg to 15mmHg significantly decreases the blood flow, in the stomach by 54%, the jejunum by 32%, the colon by 4%, the liver by 39%, the parietal peritoneum by 60%, and the duodenum by 11%. Splanchnic blood flow decreases along with insufflation time[9]. Flow within the splanchnic circulation is affected by local factors such as direct pressure on vessels, increases in partial pressure of CO_2, and metabolite buildup One report[10] found significantly decreased hepatic blood flow in 16 patients undergoing laparoscopic cholecystectomy. Others[11,12] reported instances of fatal mesenteric ischemia and splanchnic vessel thrombosis after routine laparoscopic cholecystectomy.

The observation of hemodynamic impairment related to CO_2 pneumoperitonium during laparoscopic surgery[13] and postoperative mesenteric ischemia following laparoscopic procedures[14,15], have raised concern about local and systemic repercussion of intraabdominal pressure increase and transperitoneal CO_2 absorption during laparoscopic surgery. It has been reported that high intraabdominal pressure induces intestinal ischemia (decreased jejunal mucosal microcirculation measured by the laser Doppler technique), oxygen free radical production, and bacterial translocation toward the mesenteric lymph nodes, spleen and liver[16]. Others have shown that high intraabdominal pressure was not followed by increase in blood lactate levels in experimental environment[17]. In this study, change in ventilation during intraabdominal insufflation of CO_2 resulted in slight, clinically acceptable CO_2 and pH. Both remained unchanged, provided minute volume of ventilation was increased to maintain constant end-tidal PCO_2. Splanchnic ischemia is defined as critical hypoperfusion of splanchnic organs causing anerobic metabolism.

Our study was on the lookout for changes in the end product of anerobic metabolism. We found a significant difference in intraoperative and postoperative blood lactate level which is higher in high pressure pneumoperitonium. Our results are in accordance with another study[18], which reported that high intra abdominal pressure causes lactic acidosis in patients undergoing laparoscopic procedures with the lactate level still remaining high one hour after deflation.

Controversy exists concerning the nature of the acid-base alteration (i.e., respiratory or metabolic acidosis). Some authors contend that the acidosis is of the respiratory type because of transperitoneal CO_2 absorption[19]. Others claim that the acidosis is predominantly of the metabolic type, produced by a degree of tissue hypo perfusion leading to anaerobic metabolism[20]. Another report[21] showed that the acidosis to be due to metabolic in 44%, mixed in 21%, and respiratory in 8% of patients during CO_2 insufflation. After desufflation, these figures changed, respectively, to 36% (metabolic), 42% (mixed), and 16% (respiratory). Therefore, during insufflation, the acidosis is predominantly of the metabolic type caused by tissue hypo perfusion; results are comparable to

our findings regarding HPP in which tissue hypo perfusion can be detected by an elevation of blood lactate level.

Our results regarding pain score agree with one report[22] who believe that the use of low pressure pneumoperitonium results in a remarkable reduction of pain. The exact mechanism of pain related to pneumoperitonium after laparoscopy may include diaphragmatic stretching, chemical irritation of peritoneum by carbonic acids from carbon dioxide, and sympathetic nervous system activation derived from hypercarbia and leading to amplification of local tissue inflammatory response as well as splanchnic mucosal ischemia[7]. The incidence of right shoulder pain in high pressure pneumoperitonium may be related to diaphragmatic distention that causes irritation at the phrenic nerve distribution area. The removal of the remaining exogenous carbon dioxide at the end of operation reduced the incidence and severity of referred shoulder pain[24].

Conclusions

Our study demonstrated that high-pressure pneumoperitonium causes statistically significant elevation in the arterial lactate level intraoperatively and post operatively; as well higher pain score and shoulder tip pain.

References

1. STRUTHERS A, CUSCHIERI A: Cardiovascular consequences of laparoscopic surgery. *Lancet*; 352:568-70, 1998.
2. JORIS JL, NOIROT DP, LEGRAND MJ, ET AL: Hemodynamic changes during laparoscopic cholecystectomy. *Anesth Analg*; 76:1067-71, 1993.
3. MYTHEN MG, WEBB AR: Intraoperative gut mucosal hypoperfusion is associated with increased post-operative complications and cost. *Intensive Care Med*; 20:99-104, 1994.
4. FINK MP: Gastrointestinal mucosal injury in experimental models of shock, trauma, and sepsis. *Crit Care Med*; 19:627-41, 1991.
5. DIEBEL L, WILSON R, DULCHAVSKY S, SAXE J: Effect of increased intra-abdominal pressure on hepatic arterial, portal venous and hepatic microcirculatory blood flow. *J. Trauma*; 33:279-82, 1992.
6- HASHIKURA Y, KAWASAKI S, MUNAKATA Y, ET AL: Effects of peritoneal insufflation on hepatic and renal blood flow. *Surg Endosc*; 8:759-6, 1994.
7. WILLS VL, HUNT DR: Pain after laparoscopic cholecystectomy. *Br. J Surg*; 87:273-284,
8. RUSIN D, BRASEUD O, VARELA J, SABERR AA, YOU S, ROSENTHAL RJ, COHEN SM: Low pressure laparoscopy may ameliorate intracranial hypertension and renal hypoperfusion. *J Laparoscopic Adv Tech A*; 12:15-19, 2002.
9. SCHILLING MK, REDAELLI C, KRAHENBUHL L, SIGNER C, BUCHLER MW: Splanchnic microcirculatory changes during CO2 laparoscopy. *J Am Coll Surg*; 184:378-382, 1997.
10. ELFETHERIADIS E, KOTZAMPASSI K, BOTISOS D, ET AL: Splanchnic ischaemia during laparoscopic cholecystectomy. *Surg Endosc*; 10:324-6, 1996.
11. PAUL A, TROIDL H, PETERS S, ET AL: Fatal intestinal ischaemia following laparoscopic cholecystectomy. *Br J Surg*; 81:1207, 1994.
12. STERNBERG A, ALFICI R, BRONEK S, ET AL: Laparoscopic surgery and splanchnic vessel thrombosis. *J Laparoendosc Adv Surg Tech*; 8:65-8, 1998.
13. ISHIZAKI Y, BANDAI Y, SHIMOMURA K, ABE. H, OHTOMO Y, IDEZUKL Y: Changes in splanchnic blood flow and cardiovascular effects following peritoneal infusion of carbon dioxide. *Surg. Endosc*; 7:420, 1993.
14. DWERRYHOUSE SJ, MELSOM DS, BURTON PA, THOMPSON MH: Acute intestinal ischemia after laparoscopic cholecystectomy: Case Report. *Br J Surg*; 82L1413, 1995.
15. PAUL A, TROIDL H, PETERS S, STUTTMANN R: Fatal intestinal ischemia following laparoscopic cholecystectomy. *Br J Surg*; 81:1207, 1994.
16. ELEFTHERIADIS E, KOTZAMPASSI K, PAPANATAS K, HELIADIS N, SARRIS K: Gut ischemia oxidative stress and bacterial translocation in elevated abdominal pressure in rates. *World J Surg*; 20:11, 1996.
17. KNOLAMAYER TJ, BOWYER MW, EGAN JC, ASBUN HJ: The effects of pnemoperitoneum on gastric blood flow and traditional hemodyanmic measurements. *Surg Endosc*; 12L115, 1998.
18. TAURÁ P, LÓPEZ A, LACY AM, ANGLADA T, BELTRÁN J, FCRNÁNDEZ CRUZ L, TARGARONA E, GARCIA-VALDECASAS JC, MARIN JL: Prolonged pnemoperitoneum at 15mmHg causes lactic acidosis. *Surg Endosc*; 12:198, 1998.
19. LEIGHTON TA, LIU SY, BONGARD FS: Comparative cardiopulmonary effects of carbon dioxide versus helium pneumoperitoneum. *Surgery*; 113:527-31, 1993.
20. KOTZAMPASSI K, KAPANIDIS N, KAZAMIAS P, ET AL: Haemodynamic events in the peritoneal environment during pneumoperitoneum in dogs. *Surg Endosc*; 7:494-9, 1993.

21. GANDARA V, DE VEGA DS, ESCRIU N, ET AL: Acid-base balance alterations in laparoscopic cholecystectomy. *Surg Endosc*; 11:707-10, 1997.
22. BARCZYNSKI M, AND HERMAN RM: Aprospective randomized trial on comparison of low-pressure (LP) and standard-pressure (SP) pneumoperitonium for laparoscopic cholecystectomy. *Sur Endsc*; 17:533-538, 2003.
23. FREDMAN B, JEDEIKIN R, OLSFANGER D, FLOR P, GRUZMAN A: Residual pneumoperitonium: a cause of postoperative pain after laparoscopic cholecystectomy. *Anesthesia and Analgesia*; 79:152-154, 1994.