THE EFFECTS OF INTRAPERITONEAL CO2 INSUFFLATION ON ETCO2 AND BLOOD GASES DURING LAPAROSCOPIC CHOLECYSTECTOMY

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ABSTRACT

Objective: The aim of this prospective study was to examine the effects of intraperitoneal CO2 insufflation on ETCO2 and blood gases during laparoscopic cholecystectomies.

Methods: Twenty patients ASA I,II, aged 20-65 years were studied. After induction, anesthesia was maintained with 1% isoflurane in 70% N20 and O2. Vecuronium bromide was administered for muscle relaxation and all patients were ventilated mechanically with 10ml/kg tidal volume and 10 / min respiratory rate. Mean arterial pressure, heart rate, ETCO2, SpO2 and peak airway pressure were measured before and after CO2 insufflation, at 5 minutes intervals and blood gases at 15 minutes intervals during operation.

Results: The peak airway pressure and mean arterial pressure increased immediately after CO2 insufflation. ETCO2 increased significantly at 5th minute of CO2 insufflation. At 15th minute PaCO2 increased and pH decreased significantly. A plateau was reached ten minutes later and remained constant during operation. No significant differences were observed in O2 saturation,heart rate and PaO2 values.

Conclusion: Intraperitoneal CO2 insufflation causes significant increases in ETCO2, PaCo2, peak airway pressure and decreases in pH.

Key Words: Laparoscopic cholecystectomy, CO2 insufflation, End tidal carbondioxide, Blood gases, Oxygen saturation, Hypercapnia.

INTRODUCTION

The use of laparoscopic techniques in general surgery has gained increasing popularity. One new technique gaining enthusiasm is laparoscopic cholecystectomy (1). It is thought to be less invasive with small limited incisions and there is the benefit of a faster recovery compared to open laparatomy. However CO2 insufflation into the peritoneal cavity during the operation is essential and may compromise cardiac and pulmonary functions (2-12). The aim of this prospective study was to evaluate the effects of intraperitoneal CO2 insufflation on end tidal carbondioxide (ETCO2) and blood gases during laparoscopic cholecystectomies.

MATERIALS AND METHODS

Twenty patients, 17 females and 3 males, ASA Physical Status I or II, scheduled for elective laparoscopic cholecystectomy gave informed consent to participate in the institutionally approved study protocol. Morbidly obese patients as well as those with a previous lung and cardiac disease were excluded. The main characteristics of patients and duration of surgery and anesthesia are reported in Table I.

All patients were premedicated with pethidine HCl 50mg and atropine sulphate 0.5mg i.m. one hour before surgery. Induction of anesthesia was performed with thiopental sodium 5mg/kg intravenously. Tracheal intubation was facilitated by succinylcholine 1.5mg/kg i.v. Anesthesia was maintained with 1% isoflurane in 70% nitrous oxide and oxygen. Vecuronium bromide 0.1mg/kg intravenously was administered for surgical relaxation and all patients received 10µgr/kg alfentanil i.v before skin incision. At the end of surgery neostigmin 30µgr/kg and atropin sulphate 0.5mg i.v. were administered to reverse residual neuromuscular blockade. The lungs were mechanically ventilated on the controlled mode at a tidal volume of 10ml/kg and respiratory rate of 10/minute during anesthesia.

Laparoscopic cholecystectomy was performed with patients in reverse Trendelenburg position, insufflating the abdomen with CO2 using an automatic insufflator set at 1 lt/min to a maximum pressure of 15mmHg.

A radial artery was cannulated percutaneously with a 20G cannula for arterial blood pressure measurement and blood sampling. All patients were monitorized with pulse oximetry, capnograph and nerve stimulator. Heart rate, mean arterial pressure, oxygen saturation, ETCO2, peak airway pressure and blood gases were recorded during the following periods: Before CO2 insufflation,immediately after CO2 insufflation, blood gases at 15 minutes intervals and the other parameters at 5 minutes intervals during the operation.

Statistical differences in time dependent variables were determined by two way analyses of variance (ANOVA) and Newman Keuls Test. A $p<0.05$ was accepted as statistically significant.

RESULTS

All data obtained from patients at predetermined time intervals are presented in Table II. After intraperitoneal CO2 insufflation peak airway pressure and mean arterial pressure immediately increased significantly when compared with preinsufflation values ($p<0.05$). ETCO2 values increased at 5th minute of CO2 insufflation ($p<0.05$) and reached to a plateau within 15 minutes and remained constant during operation.

At the 15th minutes of CO2 insufflation a significant increase in PaCO2 and a significant decrease in pH values were observed ($p<0.05$). These parameters continued to change slowly but not significantly up to the end of CO2 insufflation.

Oxygen saturation, heart rate and PaO2 values did not change significantly after CO2 insufflation when compared with preinsufflation values ($p>0.05$.).

Table I: Characteristics of patients, duration of anesthesia and surgery

Patients' age (yr)	44.93 ± 11.7
Patients' gender (male/female)	3/17
Patients' weight (kg)	65.70 ± 9.96
Duration of anesthesia (min)	69.50 ± 8.56
Duration of surgery (min)	54.25 ± 7.12

Table II: Patients' ETCO2, SpO2, peak airway pressure, mean arterial pressure, heart rate, PaCO2, PaO2 and pH values

	ETCO2 (mmHg)	SpO2	Peak airw. P (cmH2O)	Mean ar. P (mmHg)	Heart rate (/min)	PaCO2 (mmHg)	PaO2 (mmHg)	pH
Before CO2 ins.	30.6±0.7	99.4±0.1	14.0±0.8	89.5±2.9	84.4±3	31.1±0.7	175±8.3	7.44±0.1
After CO2 ins.	32.6±1.3	99.5±0.1	18.0±0.9*	100±3.6*	83.3±3	31.7±0.8	161±8.4	7.49±0.1
5. min	36.0±1.3*	99.5±0.1	19.5±0.7	110±3.9	83.9±3			
10. min	39.5±1.4	99.2±0.2	19.5±0.7	112±3.1	86.5±3			
15. min	40.3±1.3	99.2±0.2	19.0±0.8	106±2.8	86.2±2	37.1±0.8*	167±7.8	7.36±0.1*
20. min	40.0±1.3	99.2±0.2	18.6±0.8	106±2.8	89.1±3			
25. min	40.5±1.4	99.2±0.2	19.2±0.7	106±3.1	91.4±4			
30. min	40.8±1.5	99.1±0.2	19.3±0.6	104±2.6	90.1±4	38.2±1.2	155±7.7	7.35±0.1
35. min	40.8±1.5	99.1±0.2	19.1±0.6	105±3.3	89.2±3			
40. min	40.7±1.4	99.0±0.2	19.1±0.6	107±3.0	89.3±3			
45. min	40.2±1.2	99.1±0.2	18.9±0.5	105±2.8	86.9±4	38.6±1.1	161±7.2	7.34±0.1

* $p < 0.05$

DISCUSSION

In recent years laparoscopic cholecystectomy is increasingly preferred to the traditional open technique because of the potential benefits such as reduction in lenght of incision, reduction in postprocedural pain and a prompt return to preoperative activity in patients with symptomatic cholelithiasis (1,2). Besides these benefits, insufflation of the abdominal cavity with CO2 was shown to compromise cardiopulmonary functions. However there were conflicted reports about the changes in cardiopulmonary parameters (3-12).

CO2 insufflation into the peritoneal cavity is known to increase ETCO2 and PaCO2 (4,5,8,10,11). In our study, at the 5th minute of CO2 insufflation a significant increase in ETCO2 and at the 15th minute of CO2 insufflation a significant increase in PaCO2 and a decrease in pH were observed. Seed et al (4), Hodgson et al (5) and Kelman et al (8) increased tidal volume or respiratory rate to maintain respiratory homeostasis during CO2 insufflation whereas Mullet et al (10) and Sasaki et al (11) reported that the increase in ETCO2 and PaCO2 values remained in physiologic limits with a constant tidal volume and respiratory rate. In our study, although the mean values of ETCO2, PaCO2 and pH remained in physiologic limits, the highest ETCO2 value was 54mmHg, the highest PaCO2 was 53mmHg and the lowest pH was 7.27 at the 45th minute of CO2 insufflation whereas seven patients had a PaCO2 higher than 40mmHg and ten patients had a pH lower than 7.35 at the end of the CO2 insufflation.

Anesthesia was maintained with 1% isoflurane in 70% N2O and O2 in our study as the cardiac arryhtmias from increased PaCO2 may be less with isoflurane and none of the patients had cardiac arryhtmias.

Our results are in agreement with the other studies, and it is concluded that the intraperitoneal CO2 insufflation causes a significant increase in peak airway pressure (3,12,13).

We also observed a significant increase in mean arterial pressure immediately after CO2 insufflation whereas the heart rate remained constant. Kelman et al (8) and Verspille et al (9) addressed the issue of cardiac output changes induced by laparoscopy demonstrating that increases in intraabdominal pressure up to 20cmH2O leads first to a redistribution of blood out of the abdominal organs to cenral compartment and thus an increase in cardiac filling and cardiac output. Further increases in intraabdominal pressure cause a pooling of blood upstream of the abdominal cavitiy in the lower limbs leading to a decrease in cardiac output. However Andel et al (13) concluded that as stroke volume and cardiac output decrease after CO2 insufflation, the increase in mean arterial pressure may be the result of an increase in total peripheral resistance. We suggest that further studies will be necessary before recommending this surgical technique for patients with impaired cardiac function. In conclusion; laparoscopic cholecystectomy using intraperitoneal CO2 insufflation results in CO2 diffusion into the body leading an increase in ETCO2, PaCO2 and a decrease in pH. The duration of laparoscopy beyond the first 15 minutes of CO2 insufflation does not influence the rate of CO2 diffusion into the body. Monitoring of cardiopulmonary parameters and larger minute ventilations are essential for the maintenance of respiratory homeostasis during laparoscopic cholecystectomies.

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