A Comparison of $EtCO_2$ and $PaCO_2$ in Laparoscopic Surgery during General Anaesthesia.

Damini S Makwana*, Priyanka N Patil**, Carolin Smita Kerketta**, Dinesh V Ghoghari**, B M Patel***

Abstract

Introduction : Pneumoperitoneum leads to multiple changes in the mechanics of respiration and heart function. We decided to study the changes in arterial blood gas, $EtCO_2$ and pH. We also studied hemodynamic changes due to pneumoperitoneum. **Methodology :** Fifty patients of ASA grade I and II, between the ages of20 to 65 years posted for elective laparoscopic surgery were selected. Arterial blood samples were collected pre-operatively. We also collected arterial blood intra-operatively at 10 min, 60 min and 120 min after insufflation of CO_2 and soon after desufflation. **Result :** There was significant increase in $EtCO_2$ after CO_2 insufflation maximum at 60 minute and return to near baseline value after desufflation. There was significant rise in $PaCO_2$ but within physiological range. There was significant decrease in pH maximum at the time of 120 minute. Blood pressure changes shows significant rise in diastolic blood pressure ($p < 0.05$). **Conclusion :** We concluded that diastolic blood pressure was kept under control by using volatile anesthetic agent. The $EtCO_2$, $PaCO_2$ and pH changes occurred significantly but remains within physiological range and corrected by increasing minute ventilation. Soon after desufflation all value returned to baseline in normal healthy patients. The $EtCO_2$ correlate well with $PaCO_2$, so it is the best parameter to diagnose hypercarbia.

Key Words : Laparoscopic surgery, ABG, $EtCO_2$, CO_2 insufflation

Introduction :

Laparoscopic surgery is now widely established. Benefits include reduced postoperative pain and hospital stay with patient satisfaction and good cosmetic results. The range of surgical techniques is increasing in complexity and now includes major surgeries like cholecystectomy, adrenalectomy, nephrectomy, fundoplication, hernia repair, bowel resection and gynecological procedures. Laparoscopic surgery involves insufflation of a gas (usually carbon dioxide-CO_2) into the peritoneal cavity producing a pneumoperitoneum. This causes an increase in intra-abdominal pressure (IAP). The raised IAP, alteration in the patient's position and effects of carbon dioxide cause changes in physiology, especially cardiovascular and respiratory systems. These changes, as well as direct effects of gas insufflation, may have significant effects on the patient. Carbon dioxide is used as the insufflation gas as it is non-flammable, colorless and has higher blood solubility than air, thus reducing the risk of complications of venous embolism.[1]

Methodology

This prospective study was performed in patients who required elective laparoscopy for major abdominal cancer surgeries after taking permission of the ethical committee. A thorough preanesthetic checkup was done which included history of presenting illness, past illness, surgical, medical and drug history, general and systemic examination and routine and specific investigations depending on the age and complaints of the patients.

Patients between the age group of 20 to 65 years of either sex of ASA grade I and II of average weight were selected. Patients with extreme age group, obesity and history of diabetes and cardiovascular disease were excluded from the study. Duration of surgery ranged from 120-240 minutes. After the selection of patients, they were informed about the aim and methodology of the study and possible complication. Their acceptance and written informed consents were taken. Patients were premeditated with tablet lorazepam 1mg night before surgery and tablet diazepam 5mg at 6:00 A.M on the day of operation. After taking into operation theatre, vital sign monitor was attached to the patient and baseline NIBP, heart rate, SpO_2, $EtCO_2$ and respiratory rate were measured. An intravenous line with 16G intravenous cannula was taken. Radial artery cannulation was done after performance of the allen test to evaluate adequate collateral circulation to the hand via the ulnar artery.

Preoperative sample of arterial blood was collected before induction in a preheparinised 2ml syringe anaerobically, by standard technique and sample tested for arterial blood gases. Preoxygenation was done with 100% O_2 for 3 minutes and all patients were induced with injection glycopyrrolate bromide 0.004mg/kg, injection fentanyl citrate 2mcg/kg followed by injection thiopentone sodium 5mg/kg and intubation performed with appropriate sized portex cuffed endotracheal tube after administration of injection succinylcholine 1.5mg/kg. Ryle's tube was inserted. Anaesthesia was

* Associate Professor
** Resident,
*** Professor & Head, Department of Anaesthesia, GCRI, Civil hospital, Ahmedabad, India
Correspondence : daminisanjay@yahoo.com

maintained with isoflurane in 50% oxygen and 50% nitrous oxide with intermittent bolus doses of injection vecuronium bromide. Intraoperative analgesia was achieved with injection paracetamol 1gm and injection fentanyl citrate 1mcg/kg as required. Intraabdominal pressure was maintained between 12-15mmHg. Arterial blood samples were collected in a similar way as in pre-operative period at 10 min, 60 min and120 min after insufflation of CO_2. Introperative monitoring was done in the form of pulse rate, blood pressure, SpO_2, ECG, $EtCO_2$ and intra-abdominal pressure. Injection ondansetron hydrochloride 4mg was administered intravenously 10 minutes before extubation. Soon after desufflation arterial blood sample was collected and analysed for arterial blood gases. The muscle relaxation was reversed at the end of surgery with injection neostigmine bromide 0.05 mg/kg and injection glycopyrrolate bromide 0.4mg. Postoperative vital parameters were monitored.

Data calculation and p value calculation was done by unpaired t-test using online software from - http:\\ www. graphpad . com \ quickcalcs \ ttest

Results

This prospective study evaluates the cardiorespiratory effects of CO_2 during laparoscopic surgery in healthy patients. Fifty patients (M: F =1:1, average age =54 ± 7.9 years) were monitored with capnography, continuous blood pressure, ECG, pulse oximetry and arterial blood gases. There was significant rise in diastolic pressure (P value <0.001) but systolic pressure had no significant changes (Table 1).

Table 1 : Blood pressure changes

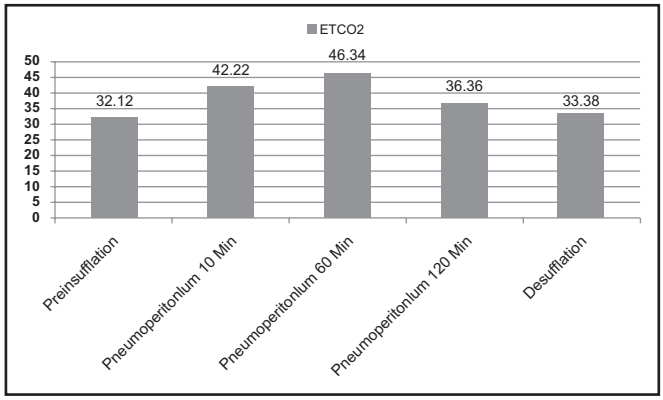
Variable	Preinsufflation	Pneumoperitonium			Desufflation	P Value
		10 Min	60 Min	120 Min		
Systolic Blood Pressure	130.12 ± 5.10 mmHg	141.40 ± 5.14	136.46 ± 3.4	132.2 ± 3.79	128.48 ± 3.99mmHg	0.0765 Not Significant
Diastolic Blood Pressure	79.44 ± 5.8 mmHg	96.42 ± 5.2	91.72 ± 3.06	89.46 ± 2.8	84.7 ± 3.68 mmHg	<0.001 Highly significant

P value <0.05 is considered significant. This table shows that there was significant rise in diastolic blood pressure

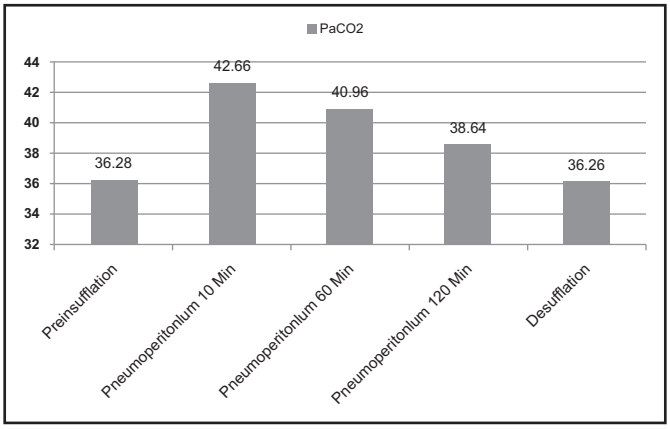
Graph 1 shows there was significant rise in $EtCO_2$ after insufflation, maximum at 60 minutes and return to baseline after desufflation (P value =0.0036). There is significant increase in $EtCO_2$ after insufflation, maximum at 60 minutes and return to baseline after desufflation.

Graph 2 shows $PaCO_2$ changes and suggested that $PaCO_2$increase but within physiological range after insufflations. PH decrease significantly, but bicarbonate remains unchanged (Graph-3). There was significant raise in $PaCO_2$ with in physiological range after insufflations while there was significant decrease in pH at the time of 120 minutes.

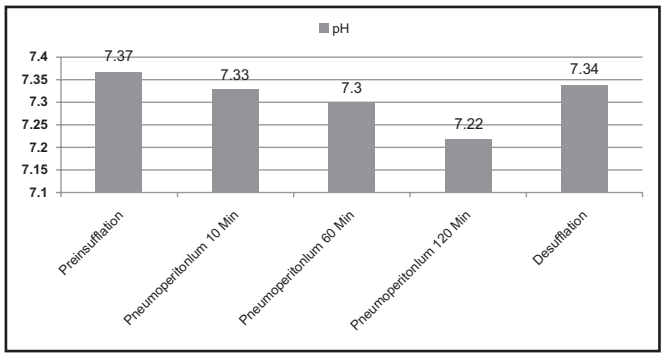
Graph 1 Comparison of $EtCO_2$ before insufflation, after insufflation intraoperatively and after desufflation



Graph 2 Comparison of $PaCO_2$ before insufflation, after insufflation intraoperatively and after desufflation



Graph 3 Comparison of pH before insufflation, after insufflation intraoperatively and after desufflation



Discussion

Laparoscopic surgery compared to conventional surgery has many advantages for the patient including smaller incisions, lesser postoperative pain, earlier oral intake, quicker mobilization, faster discharge and a better cosmetic effect. Because laparoscopy is minimally invasive compared to open surgery, patients may experience less trauma and postoperative discomfort. During laparoscopy, pneumoperitoneum is essential to provide a good surgical field, allowing visibility and performance of surgical maneuvers. Carbon dioxide is the most commonly used gas for pneumoperitoneum. After its insufflation into the peritoneal cavity, CO_2 diffuses throughout the tissues and becomes balanced in all body compartments. Minimally invasive procedure however can cause cardiocirculatory and respiratory alterations.

Hypercarbia may occur due to local CO_2 absorption by the peritoneum and ventilatorycompromise caused by abdominal distension. Pneumoperitoneum leads to cranial dislocation of the diaphragm, reducing lung volume and compliance and increasing airway resistance. This causes reduced alveolar ventilation and ventilation - perfusion mismatch with consequent hypercapnia worsened by the peritoneal absorption of CO_2 and by hypoxemia. The intra-abdominal pressure is of extreme importance to the physiopathology of hypercapnia, as it increases the absorption and reduces the elimination of CO_2. Chronic cardiopulmonary disease patients may require careful intraoperative arterial blood gas monitoring of absorbed carbon dioxide.

Wittgen CM et al [2] studied that patients with preoperative cardiopulmonary disease demonstrated significant increases in arterial carbon dioxide levels and decreases in pH during carbon dioxide insufflation compared with patients without underlying disease. D.T.T. Tran et al [3] studied arterial $PaCO_2$ changes during thoracoscopic surgery with CO_2 insufflation. They said that adult patients undergoing pulmonary resection with pre-existing pulmonary disease and the use of CO_2 insufflation develop significant changes in their arterial blood gases leading to acidosis and hypercarbia. More importantly a significant number of patients (57%) developed moderate hypercarbia defined as a $PaCO_2$>50 mm Hg. So, we included only ASA grade I and II patients.

V. Muralidhar [4] studied, Physiology of Pneumoperitoneum and Anaesthesia in Laparoscopic Surgery . He found that mechanical pressure of CO_2 insufflation causes-

1. Increased systemic vascular resistance (SVR)
2. Increased Mean Arterial pressure (MAP)
3. Minimal change in heart rate (HR)

In the study done by Gupta Shobhana et al [5] 30 patients were included and observed for change in the vital parameters during laparoscopic surgery. The systolic blood pressure varied from 126.56 ± 6.45 mmHg preoperatively to 128.44 ± 5.47 mmHg intraoperatively, and 129.55 ± 8.65mmHg postoperatively, where the p value remained p=0.1345 that is not significant. The diastolic blood pressure was also 77.44 ± 3.44 mmHg preoperatively and 80.08 ± 3.466 mmHg postoperatively where the p value was 0.004 which was statistically highly significant but was in clinically normal range. This result was in accordance with our study where we also found that there was no significant change in systolic blood pressure, however there was a significant increase in diastolic blood pressure with p value <0.001.

Alterations in cardiac rhythm may also be seen during laparoscopy and are related to increased intra-abdominal pressure, hypercarbia, wakefulness and surgical stimulation. Cardiac output was depressed to a maximum of 28% at an insufflations pressure of 15 mmHg but it was maintained at insufflation pressure of 7 mmHg.[4] The cardiac output decreases when intra-abdominal pressure exceeds 20 mmHg. Also inferior vena cava obstruction exaggerates the decrease in cardiac output. Another consistent effect of pneumoperitoneum on the cardiovascular system is an increase in systemic vascular resistance (SVR) as a result of compression of the aorta and increase in splanchnic arteriolar vasoconstriction due to increased IAP. These derangements are more significant in the presence of hypovolaemia.

D. B. Scott and D. G. Julian [6] stated that the incidence of cardiac arrhythmias was more in patients who received carbon dioxide to inflate the abdomen compared to nitrous oxide. In our patients none of them developed intraoperative arrhythmia as we maintained IAP between 12-15 mmHg. In study done by Gupta Shobhana et al [5] tidal volume was kept 10ml/kg and respiratory rate 15/min, thus increasing the minute volume by 25%. The $EtCO_2$ values in their study were maintained between 33.56 ± 3.24mmHg and 36.98 ± 3.54 mmHg preinsufflation and postdesufflation respectively, which was statistically significant (p=0.002). Kazama T et al [7] stated that during carbon dioxide pneumoperitoneum, carbon dioxide output increased by 49% ($P < 0.05$). They also concluded that it was necessary to increase minute ventilation by 1.54 times to maintain $PaCO_2$ during insufflation.

Se-Yuan Liu et al [8] in their study, they increased minute ventilation when $EtCO_2$ exceeded 45 mmHg or rose by more than 12 mmHg from baseline. $EtCO_2$ and $PaCO_2$ increased

from 31.4 ± 0.7 mmHg to 42.1 ± 1.6 mmHg and 33.3 ± 0.7 mmHg to 43.7 ± 1.2 mmHg respectively, during the course of the procedure. Arterial pH decreased from 7.43 ± 0.01 to 7.34 ± 0.01, while bicarbonate concentration remained unchanged. Thirteen of the 16patients required increased minute ventilation due to hypercarbia detected by capnography. Blood pressure increased from 78 ± 2 mmHg (mean) at the start to 98 ± 2 mmHg. This increase was coincidental with the maximal PaCO2. In our study respiratory rate was kept 16/min with tidal volume 10ml/kg. The $EtCO_2$ was preoperatively 36.28 ± 2.22 which came to 42.66±2.08 intraoperatively which was significantly high due to release ofCO2 from the peritoneum and it was corrected by increasing minute volume.

In study done by D.T.T. Tran [3], showed that CO_2 insufflation lowered the pH to 7.31 from 7.40 which was statistically highly significant with p value <0.001. Arterial pH decreased from 7.37 to 7.22 at 120 min which was statistically significant, while bicarbonate remained unchanged.Tanaka T et al [9] studied arterial to end-tidal carbon dioxide tension difference during laparoscopic colorectal surgery. Delta-Et (CO_2) increased significantly during pneumoperitoneum, but did not increase further even if CO_2 insufflation was longer than 60 minutes. According to him in laparoscopic surgery Pa (CO_2) should be checked for at least once in first 60 minutes to confirm adequate ventilation. But in our study $PaCO_2$ was maximum at 10 minutes and remained above baseline values. You SH et al. [10] studied that $PaCO_2$ and P (Et) CO2 were significantly increased during CO_2 insufflation compared with preinsufflation values in different kind of surgeries. But the magnitude of increases of $PaCO_2$ and $PEtCO_2$ was not significantly different among the three groups. This result was accordance of our study too including various kinds of surgeries. Bhavanishankar et al [11] studied laparoscopic surgery in pregnant patient and concluded that capnography is adequate to guide ventilation to maintain $EtCO_2$ at 32 mmHg during carbon dioxide pneumoperitoneum.

Conclusion

There was no significant change in systolic blood pressure but diastolic blood pressure increased significantly which was kept under control by adjusting the concentration of volatile anaesthetic agent. The $EtCO_2$ and $PaCO_2$ significantly remain higher than preinsufflation value but within physiological range. The pH reduced significantly. These changes were corrected by increasing minute ventilation. Soon after desufflation all values returned to baseline. In normal healthy patients the $EtCO_2$ correlated well with $PaCO_2$, so it is best parameter to guide ventilation to maintain$EtCO_2$.

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