

ORIGINAL ARTICLE

Metabolic Effects of Carbon Dioxide Insufflation During Laparoscopic Surgery: Changes in pH, Arterial Partial Pressure of Carbon Dioxide (PaCO₂) And End Tidal Carbon Dioxide (ETCO₂)

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ABSTRACT

Background: Laparoscopy involves inspecting the abdomen and pelvis using an endoscope. Carbon dioxide (CO₂) is the gas that is commonly used to insufflate the abdomen so as to facilitate the surgical view. **Aim:** The present study was undertaken to determine the Metabolic effects of carbon dioxide insufflation during laparoscopic surgery. **Methods:** An observational study on 50 patients above 18 years of age with physical status of American Society of Anaesthesiologists (ASA) Class I and II after obtaining approval from institutional ethical committee and consent of the patient was conducted in the Postgraduate Department of Anaesthesiology and Critical Care, Government Medical College Srinagar. **Results:** There was a progressive decrease in the pH during pneumoperitoneum in keeping with the hypercarbia. An increase towards baseline was observed during recovery but pH was still significantly lower than baseline 15 minutes into recovery ($p < 0.118$). The Pco₂ increased after 15 mins Co₂ insufflation & peaked at 30 mins with mean & SD 42.82, 2.775 & 46.16, 2.909 respectively which was statically significant. Etco₂ also increased after 15 mins of Co₂ insufflation & peaked at 30 mins with mean 41.56 & 44.50 respectively which was statically significant. Similarly, Hco₃ decreased over period of time with peak decrease at 30 mins of Co₂ insufflation with mean 23.70, SD 1.919 & range 19-27. **Conclusion:** Co₂ insufflation does bring metabolic changes in Ph, Pco₂, Etco₂ & HCO₃ but with proper monitoring & management laparoscopic procedure can be safely performed.

Keywords: laparoscopic surgery, Co₂ insufflation, metabolic changes, general anaesthesia

INTRODUCTION:

Over the past two decades the use of laparoscopy has increased due to the advances in video imaging, powerful light-sources, automatic pressure-driven insufflators, and high-flow suction-irrigation technology, making it possible to perform difficult intra-abdominal manoeuvres more easily. [1 2]

Insufflated CO₂ is rapidly absorbed from the peritoneal cavity into the circulation. CO₂ is more rapidly absorbed during extra-peritoneal than intra-peritoneal insufflations and its diffusion is not influenced by the duration of intra-peritoneal pressure. [3 4] Extra-peritoneal insufflation results in higher PaCO₂ values in the post operative period as the maximal absorption rate of CO₂ is reached at a low IAP of 10mmHg. [5,6] The absorbed Insufflated CO₂ is only excreted through the lungs and therefore elimination continues in the postoperative period. Up to 120L CO₂ can be stored in the body with bone as the greatest reservoir. [3] During laparoscopy with CO₂ insufflation, PaCO₂ is expected to progressively increase until a plateau is reached. Mullet et al noted a rapid increase in PaCO₂ and EtCO₂ in the first 8 to 10 minutes of insufflation which reached a plateau at 15 to 40 minutes in patients undergoing mechanical ventilation. [7-10] Within 5 minutes of insufflation the partial pressure of CO₂ in arterial blood (PaCO₂), mixed venous blood (PvCO₂), and alveolar gas (PACO₂) rise by

10 mmHg in young healthy patients. [11] it was noted a decrease in pH, bicarbonate and base excess with the rise in PaCO₂ signifying a metabolic acidosis. This was unrelated to the duration of pneumoperitoneum or amount of carbon dioxide insufflated during laparoscopy and with no significant differences between anaesthetic techniques. They further noted a PaCO₂ increase to a maximum at 60 minutes and a decrease in pH to the lowest level in the recovery room. Twenty seven percent (27%) of the patients had hypercarbia during laparoscopy while fifty six percent (56%) were hypercarbic in the recovery room. [12] Ciofolo et al. performed gynaecological laparoscopy under epidural anaesthesia in which they noted a stable PaCO₂ but there was a significant increase in the minute ventilation.

The change in PaCO₂ is not significantly affected by position whether trendelenberg or head up tilt. IAP is the main determinant of change with continuous rise in PaCO₂ associated with pressure changes from 0-25mmHg but no further changes thereafter. [13] However, it was found that lowering the insufflation pressure from 15 to 10 mmHg does not contribute to the correction of acid-base balance alterations during laparoscopic cholecystectomy. [14] Several factors are involved in the rise in PaCO₂, among them are carbon dioxide absorption from the abdominal cavity, and impaired pulmonary elimination of carbon dioxide due to changes in ventilatory mechanics. Impaired organ perfusion has been suggested as a cause of metabolic acidosis in

laparoscopic surgery. However, the main mechanism of acidosis is the absorption of carbon dioxide. This is further supported by the fact that there is much less increase in PaCO₂ and acidosis with nitrous oxide or helium pneumoperitoneum despite similar conditions. [15,16]

METHODS:

The present observational study was conducted on 50 patients above 18 years of age with physical status of American Society of Anaesthesiologists (ASA) Class I and II after obtaining approval from institutional ethical committee and consent of the patient. This study was conducted in the Postgraduate Department of Anaesthesiology and Critical Care and was performed at SMHS hospital one of the associated hospital of Government Medical College Srinagar.

In the preoperative assessment, the patients were enquired about any comorbid disease, history of drug allergy, previous operations, loose teeth and artificial dentures or prolonged drug treatment. General examination, systemic examinations, and assessment of the airway were done. Preoperative fasting of minimum 8 hours was ensured before operation in all day care cases. All patients were clinically examined in the preoperative period, when whole procedure were explained and written consent obtained. All patients were investigated for CBC, KFT, LFT, coagulogram, ECG and chest X-ray. On entering the patient in the operative room, standard intraoperative monitors like ECG, pulse oximeter, non-invasive blood pressure were attached and baseline parameters were recorded. On the table multi-channel monitor (MCM) was connected and vitals noted; intravenous line secured with 18G cannula thereafter surgery were performed by standard procedure under general anaesthesia Pre-oxygenation with 100% oxygen was done for three minutes with face mask. Induction was done by administering propofol (2mg/kg body weight), muscle relaxation was provided by injection atracurium (0.5mg/kg body weight loading dose and maintenance dose of 0.1mg/kg as per the requirement) and then patient was intubated via endotracheal tube of the appropriate size. Inhalation of isoflurane as per the MAC was used for maintenance of anaesthesia.

Fifty patients undergoing laparoscopic surgery under General Anaesthesia were ventilated with tidal volume of 6 ml/kg and respiratory rate of 12breaths/minute and End tidal CO₂, PaCO₂, pH, bicarbonate and ABE measurement was done before, during and after CO₂ pneumoperitoneum and analyzed. Respiratory adjustments were done for End tidal CO₂ levels above 60mmHg or haemodynamic changes attributable to elevated CO₂. First sample was taken preoperatively, Second sample was taken 15min after CO₂ pneumoperitoneum,third sample after 30 mins and the last/fourth sample was collected in the recovery room fifteen minutes after the patient was extubated and was ascertained to be adequately breathing spontaneously. The EtCO₂ and SPO₂ at the time of sampling were recorded.

RESULTS:

This observational study was conducted at SMHS hospital one of the associate hospital of government medical college Srinagar, The study was conducted over a period of one

year and total number of 50 patients were enrolled of age group 18-60yrs on American Society of Anesthesiologists (ASA) 1 and 2 patients of either gender between 18 and 60 years scheduled for elective procedures of laparoscopic cholecystectomy using CO₂ insufflation& effects on ABG parameters seen.

All patients were comparable with regard to demographic profile (table 1).

Table 1: Demographic profile of the study population.

Parameters	Group A n=50	P value
Age (yrs)	39.4±9.61	0.71*
Sex M/F	28/22	1.0*
Weight	61.50±8.87	0.82
ASA I/II	42/8	0.576*
Height (cm)	166.3±4.61	0.264*
Duration of surgery	84.67±12.15	0.306*

(Mean, SD= standard deviation,* = level of significance)

Table 2: Changes in pH over time

Time Interval	Mean	SD	Range	P-value
Preop	7.41	0.024	7.35-7.45	-
15 Min	7.33	0.017	7.31-7.38	<0.001*
30 Min	7.27	0.018	7.24-7.33	<0.001*
Postop	7.40	0.017	7.34-7.43	0.118

*Statistically Significant Difference from Baseline (P-value<0.05)

In pre operative period the pH was within normal range, after 15 mins of CO₂ insufflation pH decreased and there was a peak drop in ph at 30 mins, with mean of 7.33 & 7.27 respectively(p value<0.01) (Table 2).

Pco₂ changes after Co₂ insufflation which increased at 15 mins& peak at 30 mins with mean & SD 42.82, 2.775 & 46.16, 2.909 respectively (p value<0.01) (Fig 1).

Etco₂ increases after insufflation of Co₂ at 15 mins& peak rise at 30 mins with mean 41.56 & 44.50 respectively (p value<0.01) (Fig 2).

Changes in Hco₃ which decreases over period of time with peak decrease at 30 mins with mean 23.70,SD 1.919 & range 19-27 (Fig 3).

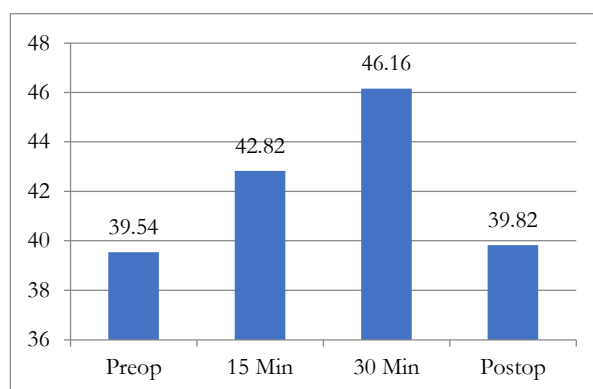


Fig 1: Pco₂ changes after Co₂ insufflation

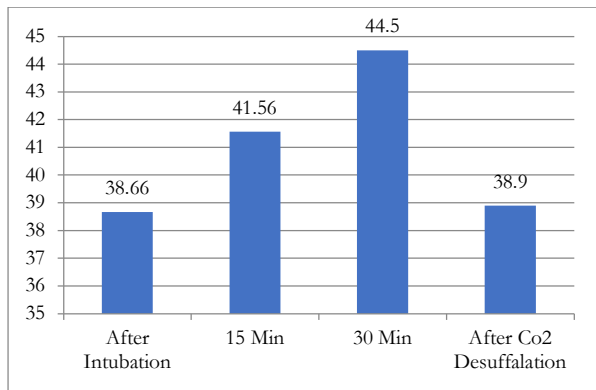


Fig 2: Etco2 changes after Co2 insufflation

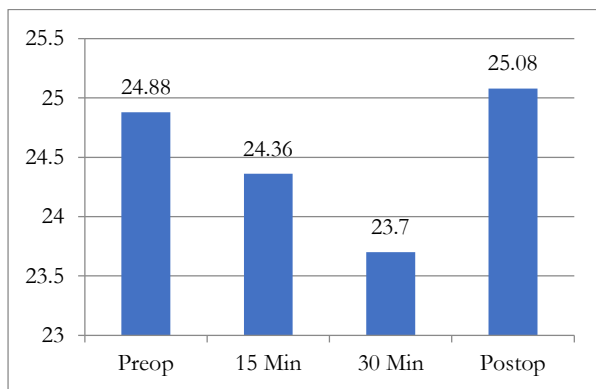


Fig 3 HCo3 changes after Co2 insufflation

DISCUSSION:

The recent advent of laparoscopic surgeries has marked a new milestone in surgical practice, as it introduced a new era of surgical treatment. Minimal invasive techniques are designed to minimize the trauma of access without compromising the well-established principles of operative surgical treatment. Although laparoscopic surgeries result in less pain than open surgeries it is not a pain free procedure.

The findings of our study had many similarities with other studies of a similar design. There were rises in the PaCO₂ and EtCO₂ and a fall in pH signifying hypercarbia and hypercapnia with a resultant respiratory acidosis. There was an initial rise in PaCO₂ of approximately 10 mmHg in the first 15 minutes (p value < 0.001) similar to the findings by Ishikawa et al and reviewed by Doyle et al. [17,18] Similar to the findings of Mullet et al, Meininger et al, Ishikawa et al and Monagle et al, there was a progressive increase in EtCO₂ and PaCO₂ during carbon dioxide insufflation in this study. The maximum rate of increase in this study occurred at 30 minutes of insufflation. The rapid rise from the initial carbon dioxide load may be due to the delayed equilibration of the carbon dioxide between the blood and other tissues considering that the bone which is the biggest buffer has relatively poor blood supply. However the decreasing number of subjects going beyond 30 minutes of pneumoperitoneum could be the limiting factor in determining a reliable PaCO₂ trend in this study. The trend and gradual rise of the EtCO₂ was similar to that observed by Baraka et al. [19] However the change in the EtCO₂ from 15 to 30 minutes

was statistically significant. There was a progressive decrease in the pH during pneumoperitoneum in keeping with the hypercarbia. An increase towards baseline was observed during recovery but pH was still significantly lower than baseline 15 minutes into recovery (p < 0.118). The pH was consistently above the 7.20 which was proposed by Bidani et al as the lower limit of safety in most patients where permissive hypercapnia is instituted [20]. A significant degree of metabolic acidosis was also observed during pneumoperitoneum defined by a decrease in both the bicarbonate and the base excess. There was a significant decrease in bicarbonate in the first 15 minutes (p value = 0.164) and a progressive decrease in base excess throughout the duration of pneumoperitoneum. Bicarbonate concentrations as low as 19 mmol/L. Gandara et al, Hirnoven et al and Shuto et al reported similar findings. [19,20] The cause of the metabolic acidosis however could not be elucidated in this study as several components of the metabolic profile necessary to fully characterize the metabolic acidosis like the lactate levels, electrolytes, albumin and other anions were not measured. However it has been postulated that the metabolic acidosis is secondary to organ hypo-perfusion during pneumoperitoneum.

Conclusion:

We concluded that Co₂ insufflation does bring metabolic changes in Ph, Pco₂, Etco₂ & HCO₃ but with proper monitoring & management laparoscopic procedure can be safely performed.

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