EFFECTS OF CO₂ PNEUMOPERITONEUM ON ARTERIAL PARTIAL PRESSURE OF CARBON DIOXIDE PH, END TIDAL CARBON DIOXIDE AND BICARBONATE IN PATIENTS DURING LAPAROSCOPIC CHOLECYSTECTOMY

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ABSTRACT

AIMS

Laparoscopically performed surgeries have increased manifold as they have provided many advantages when compared to traditional way of performing surgeries. But laparoscopic technique has its own disadvantages, which may be in form of metabolic effects of CO₂ pneumoperitoneum. Current observation study was designed for observing metabolic changes in form of PaCO₂, EtCO₂ pH and bicarbonate levels in patients undergoing laparoscopic cholecystectomy and their effects on patient if any. Role of lung protective ventilation in managing PaCO₂ and to ascertain the need of arterial blood gas monitoring in presence of EtCO₂ monitoring in laparoscopic procedures like cholecystectomy.

METHODS

50 ASA 1 and ASA 11 patients undergoing laparoscopic cholecystectomy were selected for this study. Each of them was anaesthetised by standard protocol for general anaesthesia with endotracheal intubation. Surgical technique was uniform in all the cases. Arterial blood gas sampling was done prior to CO₂ pneumoperitoneum and at intervals of 15 minutes and 30 minutes and then in recovery post reversal of pneumoperitoneum and extubation once patient was stable. Variables like PaCO₂, EtCO₂, pH and bicarbonate were recorded and analysed statistically for results.

RESULTS

There were significant changes in PaCO₂, EtCO₂, pH and bicarbonate at 15 min and 30 min intervals with return to baseline in early post-operative period. Changes in variables were in normal range for these variables without any significant effect on patient. Furthermore, it was noted that EtCO₂ varied in accordance to PaCO₂, thus could be used as surrogate marker of PaCO₂ in case of arterial blood gas measurement is not available.

CONCLUSION

Laparoscopic cholecystectomy with CO₂ pneumoperitoneum results in changes in PaCO₂, EtCO₂, pH and bicarbonate, but the changes return to baseline in early post-operative period on reversal of CO₂ pneumoperitoneum. EtCO₂ monitoring can be used as surrogate marker in short laparoscopic procedures in most cases in case arterial blood gas monitoring is not available. Lung protective ventilation could be used to manage PaCO₂ intra-operatively.

KEYWORDS

Laparoscopic, Pneumoperitoneum, Arterial Blood Gas, Cholecystectomy, End Tidal CO₂, Surrogate.
after approval by Institutional Ethical Committee.

**Inclusion Criteria**
1. Patients above age of consent (18 years) undergoing laparoscopic elective cholecystectomy surgery.
2. ASA I and II patients.

**Exclusion Criteria**
1. Patient’s refusal.
2. Patients for emergency laparoscopy.
3. Obese patients BMI >30.
4. Patients who are converted to an open procedure.
5. Patients with cardiac disease and COPD.

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 physical examination, systemic examinations and assessment of the airway were done. Preoperative fasting of minimum 8 hours was ensured before operation in all cases. All patients were investigated for CBC, KFT, LFT, ECG and chest X-ray.

On entering in the operative room, standard monitors like ECG, pulse oximeter, non-invasive blood pressure was attached and baseline parameters were recorded. Intravenous access was secured with 18G cannula. Preoxygenation was done for three minutes with 100% oxygen. Induction was done by administering propofol (2 mg/kg body weight), muscle relaxation was provided by injection atracurium (0.5 mg/kg body weight loading dose and maintenance dose of 0.1 mg/kg as per the requirement) and then patient was intubated via endotracheal tube of the appropriate size.

Anaesthesia was maintained with 50% nitrous oxide, 50% oxygen and isoflurane. Injection tramadol 1-2 mg/kg along injection paracetamol 1 gm/100 mL was used for analgesia. Pneumoperitoneum was created with CO₂ gas through Veress needle initially at a slow flow (1 L/min) and then faster flow (Maximum 20 L/min) to avoid a vasovagal reaction. A target IAP (Intra-abdominal Pressure) 10-12 mmHg once attained with pneumoperitoneum, was maintained with a constant flow of 200 mL- 400 mL/min for all patients throughout the procedure. Surgical technique was uniform in all patients. Patients were ventilated with tidal volume of 8-10 mL/kg and respiratory rate of 14 breaths/minute and PO₂. End tidal CO₂, PaCO₂, pH, bicarbonate measurement were done before during and after CO2 pneumoperitoneum. Most of the cholecystectomies in the study group were completed in 30 min and very few extended to 45 min period, hence the duration of exposure to CO₂ was same in most patients.

Ventilatory adjustments were done for end tidal CO₂ levels above 55 mmHg or haemodynamic changes attributable to elevated CO₂. Arterial blood samples were taken puncturing the left radial artery for arterial blood gas measurements. First sample was taken preoperatively. Second sample at 15 min 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 ascertained to be breathing spontaneously and adequately.

**AIMS AND OBJECTIVE**
1. To determine the metabolic changes in EtCO₂, PaCO₂, HCO₃, pH intraoperatively and early post-operative period, after CO₂ pneumoperitoneum. Pathological effects if any due to such changes in patient undergoing laparoscopic cholecystectomy.
2. To observe any influence of high altitude on effects of CO₂ pneumoperitoneum during laparoscopic cholecystectomy.
3. Role of EtCO₂ as surrogate marker in place arterial blood gas monitoring is not available.

**RESULTS AND OBSERVATIONS**
This observational study was conducted at SMHS Hospital of Government Medical College, Srinagar. The study was conducted over a period of one year 50 patients in age group 18-60 yrs. of ASA (American Society of Anaesthesiologists) status 1 and 2 of either gender, scheduled for elective laparoscopic cholecystectomy were enrolled for the study. The results and observations obtained are depicted in the following Tables and graphs.

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>No. of Patients</th>
<th>Percentage</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-29</td>
<td>10</td>
<td>20</td>
<td>39.4±9.6</td>
</tr>
<tr>
<td>30-39</td>
<td>14</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>40-49</td>
<td>22</td>
<td>44</td>
<td></td>
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<tr>
<td>≥ 50</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Age Distribution of Studied Patients

Majority of patients belonged to the age group of 40-49 years (44%) with mean and SD 39.4±9.61.

**Fig. 1:** The above Figure shows Gender Distribution of Studied Patients with 28 Male (56%) and 22 Female (44%)

**Fig. 2:** The above Figure 2 shows ASA Status Majority of Studied Patients had ASA I 42 (84%) and ASA II 8 (16%)
Although, hypercarbia has direct and indirect sympathoadrenal stimulating effects on cardiovascular functions also.

These effects are not pronounced with mild hypercarbia (PaCO₂ 45-50 mmHg), whereas moderate-to-severe hypercarbia affects cardiac function.² Since it is then a myocardial depressant and has direct vasodilator effect. In the study performed, no undue haemodynamic changes directly attributable to hypercarbia or acidosis were recorded and none of the patients required blood transfusion perioperatively. Dexter et al³ studied two groups of patients, one with pneumoperitoneum with intra-abdominal pressure (IAP) of 7 mmHg and the other with IAP of 15 mmHg during laparoscopic procedure. It was observed by them that cardiac output and stroke volume were more considerable depressed in the 15 mmHg IAP group. We in our study maintained IAP of 12 mmHg, which may be the reason there were no significant haemodynamic changes in our study.

In the study performed, metabolic effects of pneumoperitoneum created with CO₂ were noted in form of rise in the PaCO₂, EtCO₂ and a fall in pH signifying hypercarbia and hypercapnia with a resultant respiratory acidosis. PaCO₂ (Table 3) increased from base line values to 42.86 mmHg ±2.775 at 15 min to 46.16 mmHg ±2.909 at 30, EtCO₂ (Table 4) from 41.56 mmHg at 15 min to 44.50 mmHg at 30 min respectively and pH (Table 2) dropped from 7.33 at 15 minutes to 7.27 at 30 minutes intervals from baseline. But the values of PaCO₂, EtCO₂ and pH returned to preoperative values in immediate post-operative period. There appears correlation in change in PaCO₂ and EtCO₂ levels, thus EtCO₂ may be used as marker of PaCO₂ change in case arterial blood gas analyser is not available in majority of patients. Although, ABG may be required for calculating gradient between PaCO₂ and EtCO₂ in many patients.

Some researchers suggest that CO₂ absorption increases proportionately with the operation time and increase IAP (Intra-abdominal pressure). However, other reports suggest no proportional relationship between IAP and peritoneal absorption of CO₂.⁴,⁵ In our study most of surgeries were completed in 30 minutes and very few extended to 40 minutes and IAP was targeted around 10-12 mmHg. Several studies have shown the effect of CO₂ pneumoperitoneum on the arterial partial pressure of CO₂ (PaCO₂) and end-tidal CO₂ (EtCO₂). Octavio Hypolito⁶ et al noted statistically significant differences in MAP (Mean Arterial Pressure), pH, HCO₃ and base excess using IAP of 20 mmHg during creation of pneumoperitoneum, they concluded that high and transient intra-abdominal pressure causes changes in MAP, pH, HCO₃ and BE, but without any clinical impact on the patient. Our results were in accordance their study, although in our study there was fall in pH from normal values which was not the case in the study mentioned above.

Nihat Aksakal et al⁷ evaluated either low (8 mmHg) or high (14 mmHg) IAP pneumoperitoneum pressures in laparoscopic cholecystectomy and noted that respiratory acidosis may occur due to decreased compliance and pneumoperitoneum, especially during high intra-abdominal pressures. Results showed that performing laparoscopy with lower pneumoperitoneum pressures decreases these adverse effects, especially in patients with cardiopulmonary comorbid disease. Wittgen et al⁸ found that patients with normal cardiorespiratory system had increased EtCO₂ and PaCO₂.
with decreased pH values in a study comparing ventilatory effects of laparoscopic cholecystectomy.

The maximum rate of increase in this study occurred at 30 minutes of insufflations same was the case in our study.

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. CO₂ elimination occurs directly from lungs by ventilation. Elimination is directly proportional with cardiac output and ventilation rate. Insufficient ventilation may cause hypercapnia and acidosis. Persistent hypercapnia induces renal response including H⁺ secretion from renal tubule and bicarbonate passage into the extracellular zone.

As almost all CO₂ is eliminated during laparoscopy, compensatory hyperventilation is required in order to prevent hypercapnia and acidosis. There was a significant decrease in bicarbonate intra-operatively with peak drop at 30 minute interval (Table 5). Bicarbonate concentrations as low as 19mmol/L was observed. Some experimental and clinical studies suggest that abdominal pressure formed by CO₂ changes ABG towards acidosis and hypercapnia. Although the mechanisms causing these changes are still unclear, predominant opinions suggest acidosis associated with trans-peritoneal CO₂ absorption rather than negative effects of increased IAP on ventilation.

CONCLUSION AND RECOMMENDATIONS
This study was carried in genetically and geographically different set of population living comparatively higher altitude (5500 ft above sea level). Their response to CO₂ pneumoperitoneum was similar to studies performed at other altitude. EtCO₂ monitoring can be safely used as a surrogate monitoring of PaCO₂ if ABGs (Arterial Blood Gas) measurement are not available; however, ABG if available should be done to ascertain the PaCO₂-EtCO₂ gradient during CO₂ pneumoperitoneum. This study emphasised that PaCO₂ levels could be controlled by increasing respiratory rate rather than increasing tidal volume, due to proven benefits of low volume lung protective ventilation during CO₂ pneumoperitoneum within the limits of permissive hypercapnia.

Limitations of the Study
1. We could not measure the influence of duration of surgery, thus varied amount of CO₂ exposure, a study including different laparoscopic procedure would need to be performed in order to analyse this effect.
2. Measurements of lactate, urea, other electrolytes and albumin and calculation of the anion and osmolar gaps would be recommended to access their influence.
3. Longer term follow-up of the patients after the surgery may be needed to review the pulmonary and metabolic consequences of CO₂ pneumoperitoneum along with effect of low tidal volume ventilation during laparoscopic procedures.

REFERENCES