EFFECTS OF CO_2 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 CO_2 pneumoperitoneum. Current observation study was designed for observing metabolic changes in form of $PaCO_2$, $EtCO_2$, pH and bicarbonate levels in patients undergoing laparoscopic cholecystectomy and their effects on patient if any. Role of lung protective ventilation in managing $PaCO_2$ and to ascertain the need of arterial blood gas monitoring in presence of $EtCO_2$ 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 CO_2 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 $PaCO_2$, $EtCO_2$, pH and bicarbonate were recorded and analysed statistically for results.

RESULTS

There were significant changes in $PaCO_2$, $EtCO_2$, 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 $EtCO_2$ varied in accordance to $PaCO_2$, thus could be used as surrogate marker of $PaCO_2$ in case of arterial blood gas measurement is not available.

CONCLUSION

Laparoscopic cholecystectomy with CO_2 pneumoperitoneum results in changes in PaCO2, $EtCO_2$, pH and bicarbonate, but the changes return to baseline in early post-operative period on reversal of CO_2 pneumoperitoneum. $EtCO_2$ 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 CO_2, Surrogate.

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INTRODUCTION

Laparoscopically conducted surgeries have increased manifold in recent years, due to many advantages as compared to surgeries performed by traditional technique. But this technique comes with problems of its own. Complications could be surgical, patient positioning and metabolic due to pneumoperitoneum created during laparoscopic technique.[1]

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Carbon Dioxide (CO2) is the gas that is commonly used to insufflate the abdomen so as to facilitate the surgical view during laparoscopic procedures. Arterial Blood Gas (ABG) monitoring to ascertain $PaCO_2$ levels is not routinely done due to non-availability of ABG analysers and the related costs in developing world hospitals. End tidal CO_2 measurement may also be not available at times. There is limited data available related to metabolic effects of pneumoperitoneum with CO_2 on $PaCO_2$, $EtCO_2$, pH and HCO_3 and the reliability of $EtCO_2$ monitoring as a surrogate to $PaCO_2$ in the local population. Hence, current observational study was carried out to know about metabolic effect of CO_2 pneumoperitoneum in laparoscopic cholecystectomy and the effect of these changes on the patient.

MATERIAL AND METHODS

The present observational study was conducted in Postgraduate Department of Anaesthesiology and Critical Care at SMHS hospital Government Medical College, Srinagar,

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. Pre-oxygenation 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 CO_2 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 PO_2, End tidal $C0_2$, $PaC0_2$, pH, bicarbonate measurement were done before during and after C02 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 CO_2 was same in most patients.

Ventilatory adjustments were done for end tidal CO_2 levels above 55 mmHg or haemodynamic changes attributable to elevated CO_2. 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 $C0_2$ 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 $EtCO_2$, $PaCO_2$, HCO_3, pH intraoperatively and early post-operative period, after CO_2 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 CO_2 pneumoperitoneum during laparoscopic cholecystectomy.
3. Role of $EtCO_2$ 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.

Age (Years)	No. of. Patients	Percentage	Mean±SD
18-29	10	20	39.4±9.61
30-39	14	28	
40-49	22	44	
≥ 50	4	8	
Total	50	100	

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.

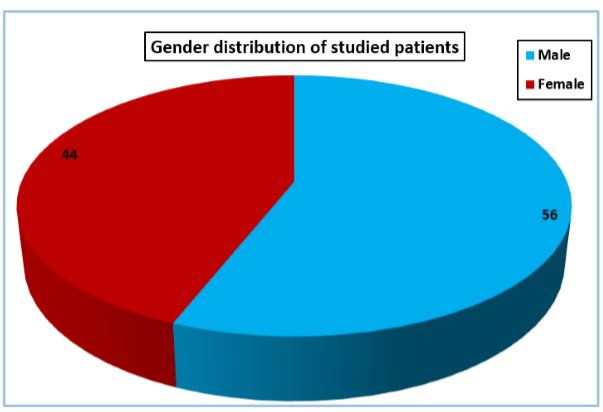

Fig. 1: The above Figure shows Gender Distribution of Studied Patients with 28 Male (56%) and 22 Female (44%)

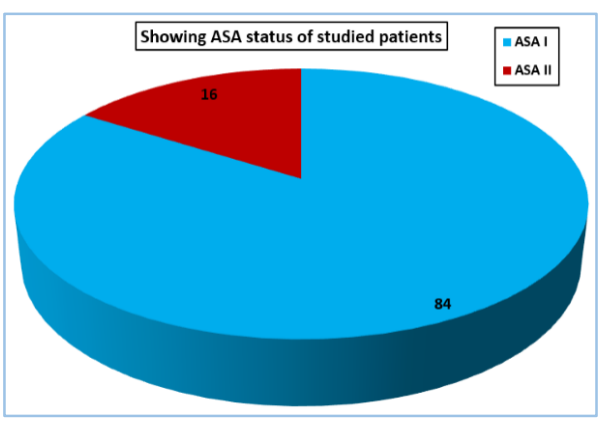

Fig. 2: The above Figure 2 shows ASA Status Majority of Studied Patients had ASA I 42 (84%) and ASA II 8 (16%)

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

Table 2: Showing Changes in pH Over Time

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

Table 2 shows changes in pH from preoperative to post-operative. In pre-operative period the pH was within normal range, after 15 mins of CO_2 insufflations pH decreased and there was a peak drop in pH at 30 mins with mean of 7.33 and 7.27 respectively, p was statistically significant.

Time Interval	Mean	SD	Range	P-value
Preoperative	39.54	3.065	35-45	-
15 min intraoperative	42.82	2.775	37-47	<0.001*
30 min intraoperative	46.16	2.909	39-51	<0.001*
Postoperative	39.82	2.716	35-45	0.093

Table 3: Showing Changes in PCO_2 Over Time

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

Table 3 showing changes in PCO_2 after CO_2 insufflations, which increased at 15 mins and peak at 30 mins with mean and SD 42.82, 2.775 and 46.16, 2.909 respectively was statistically significant.

Time Interval	Mean	SD	Range	P-value
After intubation	38.66	2.818	35-45	-
15 Min intraoperative	41.56	2.287	37-46	<0.001*
30 Min intraoperative	44.50	2.452	40-51	<0.001*
After CO_2 desufflation	38.90	2.468	34-44	0.103

Table 4: Showing Changes in $EtCO_2$ Over Time

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

Table 4 shows increase in $EtCO_2$, which is seen after insufflations of CO_2 at 15 mins and peak rise at 30 mins with mean 41.56 and 44.50 respectively value was statistically significant.

Time Interval	Mean	SD	Range	P-value
Preoperative	24.88	1.891	22-28	-
15 min intraoperative	24.36	1.699	20-27	0.164
30 min intraoperative	23.70	1.919	19-27	0.135
Postoperative	25.08	1.589	22-28	0.199

Table 5: Showing Changes in HCO_3 Over Time

Table 5 shows changes in HCO_3, which decreases over period of time with peak decrease at 30 mins intraoperatively with mean 23.70, SD 1.919 and range 19-27.

DISCUSSION

The mean age of patient was 39 years with 28 males and 22 females out of total 50 patients. Patients with euvolemic status prior to start of surgery have reduced haemodynamic variability due to reduced preload caused by the pneumoperitoneum in laparoscopic abdominal surgeries.

Although, hypercarbia has direct and indirect sympathoadrenal stimulating effects on cardiovascular functions also.

These effects are not pronounced with mild hypercarbia ($PaCO_2$ 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 al[3] 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 CO_2 were noted in form of rise in the $PaCO_2$, $EtCO_2$ and a fall in pH signifying hypercarbia and hypercapnia with a resultant respiratory acidosis. $PaCO_2$ (Table 3) increased from base line values to 42.86 mmHg ±2.775 at 15 min to 46.16 mmHg ±2.909 at 30, $EtCO_2$ (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 $PaCO_2$, $EtCO_2$ and pH returned to preoperative values in immediate post-operative period. There appears correlation in change in $PaCO_2$ and $EtCO_2$ levels, thus $EtCO_2$ may be used as marker of $PaCO_2$ change in case arterial blood gas analyser is not available in majority of patients. Although, ABG may be required for calculating gradient between $PaCO_2$ and $EtCO_2$ in many patients.

Some researchers suggest that CO_2 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 CO_2.[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 CO_2 pneumoperitoneum on the arterial partial pressure of CO_2 ($PaCO_2$) and end-tidal CO_2 ($EtCO_2$). Octavio Hypolito.[6] et al noted statistically significant differences in MAP (Mean Arterial Pressure), pH, HCO_3 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, HCO_3 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 al[7] 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 al[8] found that patients with normal cardiorespiratory system had increased $EtCO_2$ and $PaCO_2$

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. CO_2 elimination occurs directly from lungs by ventilation. Elimination is directly proportional with cardiac output and ventilation rate.[7] insufficient ventilation may cause hypercapnia and acidosis.[9] Persistent hypercapnia induces renal response including H^+ secretion from renal tubule and bicarbonate passage into the extracellular zone.

As almost all CO_2 is eliminated during laparoscopy, compensatory hyperventilation is required in order to prevent hypercapnia and acidosis.[7] 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 CO_2 changes ABG towards acidosis and hypercapnia.[10,11,12,13] Although the mechanisms causing these changes are still unclear, predominant opinions suggest acidosis associated with trans-peritoneal CO_2 absorption rather than negative effects of increased IAP on ventilation.[14,15]

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 CO_2 pneumoperitoneum was similar to studies performed at other altitude. $EtCO_2$ monitoring can be safely used as a surrogate monitoring of $PaCO_2$, if ABGs (Arterial Blood Gas) measurement are not available; however, ABG if available should be done to ascertain the $PaCO_2$-$EtCO_2$ gradient during C02 pneumoperitoneum. This study emphasised that $PaCO_2$ levels could be controlled by increasing respiratory rate rather than increasing tidal volume, due to proven benefits of low volume lung protective ventilation during CO_2 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 CO_2 exposure, a study including different laparoscopical procedure would need to be performed in order to analyse these effect.
2. Measurements of lactate, urea, other electrolytes and albumin and calculation of the anion and osmolal 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 CO_2 pneumoperitoneum along with effect of low tidal volume ventilation during laparoscopic procedures.

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