Original Research Paper

Volume - 14 | Issue - 01 | January - 2024 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Anaesthesiology

A STUDY OF HEMODYNAMIC CHANGES DURING CARBON DIOXIDE PNEUMOPERITONEUM IN LAPAROSCOPIC CHOLECYSTECTOMY

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ABSTRACT **Background:** Peritoneal insufflation with CO2 for creating a pneumoperitoneum is necessary to visualise the intra – abdominal organs separately as it separates the intra – abdominal organs from anterior abdominal wall. Hemodynamic changes observed during laparoscopy result from the combined effects of pneumoperitoneum, patient position, anaesthesia and hypercarbia from the absorbed CO2 1. **Methods:** After obtaining the Institutional Ethics Committee approval and written informed consent from the patients, this study was carried out in 50 patients undergoing elective laparoscopic cholecystectomy under general anaesthesia. **Results:** Blood pressure increased during pneumoperitoneum. The end – tidal carbon dioxide was significantly increased during the pneumoperitoneum. **Conclusion:** This descriptive study documents significant systemic hemodynamic parameters that are directly associated with carbon dioxide insufflation during pneumoperitoneum.

KEYWORDS : Laparoscopic surgeries, pneumoperitoneum, end – tidal carbon dioxide, partial pressure of carbon dioxide.

INTRODUCTION

Although laparoscopy was introduced in 20th century and developed in 1970s for gynaecological procedures, its recent extension to gastrointestinal surgical procedure has created new interest and consideration in anaesthetic management. Peritoneal insufflation with CO2 for creating a pneumoperitoneum necessary for laparoscopy to visualise the intraabdominal organs separately as it separates the intra – abdominal organs from anterior abdominal wall[2]. Artificial pneumoperitoneum with CO2 high pressure over a prolonged period of time can cause haemodynamic, ventilatory changes and structural changes in the host, directly related to the magnitude of gas tension levels and detectable by monitoring haemodynamic and blood gas analysis parameters. Under moderate intraperitoneal pressure (12 – 14 mm Hg) haemodynamic changes which occurs include mainly, decrease in the cardiac output and venous return, increase in mean arterial pressure and systemic vascular resistance[3]. In the present study, we aimed at documenting hemodynamic changes in patients under going elective laparoscopic cholecystectomy in our institution.

Methods:

The present study was carried out in the Department of Anaesthesiology of a Tertiary Care Hospital, after approval by the institutional ethics committee. Patients posted for elective laparoscopic cholecystectomy were included in this study.

Inclusion Criteria

- Age from 18 – 60 years
- Patients of either sex.
- ASA physical status I and II.

Exclusion Criteria

- Significant cardiovascular morbidity (ASA III and IV).
- Patients with respiratory disorders e.g., asthma, chronic obstructive pulmonary disorder, pulmonary tuberculosis, history of pulmonary resection.
- Coagulopathy or patients on anti – coagulant therapy.
- Chronic smokers
- Obese patients with BMI > 25 Kg/m^2
- Patient refusal

Sample Size:

Based on a previous study, a sample size of 50 patients was calculated using values of confidence level = 90%, level of significance = 5% and relative precision = 5%.

$$n = Z^2 p(1 – p)/m^2$$

Where,

- *n is the sample size,*
- *Z is the z-value,*
- *p is the proportion of population (generally taken as 0.5),*
- *m is the margin of error.*

METHODOLOGY:

A detailed preanaesthetic evaluation including history of present illness, general examination, systemic examination, airway assessment was carried out in each patient. Appropriate laboratory tests and radiological investigations were carried out and results noted. Patients were premedicated with i.v. Ranitidine 50mg and i.v. Glycopyrrolate 0.004mg/kg. Subjects were sedated with i.v. Midazolam 0.02 mg/kg and i.v. Fentanyl 2g/kg. Baseline vital parameters were noted after premedication and sedation, but before induction. Patients were preoxygenated with 100% oxygen on mask for 3 minutes. Induction of general anaesthesia was done with i.v. Propofol 2mg/kg and i.v. Atracurium 0.15mg/kg and the patient was ventilated for 3 min on mask on O_2 + N_2O + Sevoflurane / Isoflurane. Intubation was done, controlled mechanical ventilation was started and anaesthesia was maintained on O_2 and N2O in ratio of 50:50 along with inhalational anaesthetic agent (2% Sevoflurane or 1.2% Isoflurane) on semiclosed circle system with CO_2 absorber and flow rate of 4 lit/min. Mechanical ventilation was adjusted by changing respiratory rate to maintain etCO2 between 30 to 40 mmHg while tidal volume was kept constant at 10 ml/kg. Intraoperatively, all patients received i.v. Paracetamol infusion 1 gram after insufflation. Baseline arterial blood gas sample was taken.

During the procedure all the patients were followed up through the following parameters; HR, SPO2, EtCO2, SBP, DBP, MAP and Arterial blood gas parameters using blood gas analyser before creation of pneumoperitoneum, after CO_2 insufflation intraperitoneally and finally after the deflation of CO_2 observed. At the end of surgery, Neuromuscular blockade was reversed with Inj. Neostigmine 0.05 mg/kg and Inj. Glycopyrrolate 0.008 mg/kg i.v. After thorough oropharyngeal suction, patient was extubated when he had established protective reflexes with adequate tidal volume and hemodynamic stability and adequate muscle tone power. Parameters observed in post – operative room after extubation were Heart rate, Systolic BP, Diastolic BP, Mean BP, SpO_2, $EtCO_2$.

Statistical Analysis:

Non – Invasive blood pressure measurements, heart rate, end tidal CO_2 respiratory rate, and pulse oximetry were recorded at each stage. The standardized anaesthesia monitoring protocol parameters were used to monitor homeostasis during laparoscopic surgery.

Demographics and data with parametric values are presented as mean + SD. From the sample size calculation, it was determined that at least 50 patients would be required for the present study. Parametric data were analysed by ANOVA and t–test for multiple comparisons with baseline values. The dependent physiological variables were analysed at four different points in time, namely before insufflation, during the first 10 minutes of pneumoperitoneum (measurements obtained every 2 minutes) for the remaining laparoscopic part of the procedure (measurements obtained every 5 minutes), and after evacuation of the carbon dioxide. A p – value of less than 0.05 was accepted for statistically significant.

RESULTS:

Prospective observational clinical study of comparing hemodynamic and blood gas changes during CO2 insufflation and post deflation was done among 50 patients of either sex undergoing laparoscopic cholecystectomy under general anaesthesia. The following observation and results were recorded from our study. Patient data were analysed using student t test, P value of <0.05 was considered significant.

Out of 50 patients included in our study, average age of the patient was 37.76±8.31 years, average duration of surgery was 109.56±12.2 mins and the average weight of my patients is 66.32±9.41 kg. ***(Table 1)*** In our study both ASA grade I and ASA grade II patients were included.

Table 1: Age, Duration of Surgery and Weight of the patients

Variable	Mean ± SD
Age(years)	37.76 ± 8.31
Duration of Surgery(minutes)	109.56 ± 12.2
Weight(kg)	66.32 ± 9.41

Table 2: Number of patients in either sex

Sex	Number of patients	Percentage
Male	35	70%
Female	15	30%
Total	50	100%

In our study out of 50 patients 35 are male patients which corresponds to 70% of total and 15 are female patients which corresponds to 30% of the total ***(Table 2)***.

Table 3: Changes in mean heart rate

Time Interval (Minutes)	Mean Heart Rate
Baseline	89.40 ± 11.75
At Insufflation	87.68 ± 11.08(↓0.39%)
2	89.16 ± 10.24(↓0.27%)
5	90.86 ± 9.10 (↑1.63%)
10	92.24 ± 9.64(↑3.17%)
20	100.16 ± 10.19(↑12.03%)
30	95.16 ± 10.52(↑6.93%)
At Desufflation	92.98 ± 9.03(↑4.00%)
2	90.94 ± 8.34(↑1.72%)
5	88.26 ± 8.38(↓1.28%)
10	85 ± 9.33(↓4.93%)
20	83.84 ± 7.63(↓6.22%)
30	82.7 ± 6.21(↓7.5%)

The above table describes the changes in the heart rate at different time intervals during the laparoscopic procedure. In Our study, the average basal rate of the patient is 89.40 ± 11.75. There is maximum rise in heart rate 100.16 ± 10.19mmHg (↑12.03%) at 20 mins after CO2 insufflation and maximum fall in heart rate 82.7 ± 6.21mmHg (↓7.5%) at 30 minutes after desufflation ***(Table 3)***.

Table 4: Changes in SBP, DBP and MAP

Time Interval (Minutes)	Mean Systolic BP (mmHg)	Mean Diastolic BP (mmHg)	Mean Arterial BP (mmHg)
Baseline	123.26+_5.66	81.18±5.68	92.1±5.85
Insufflation	117.76±11.74(↓4.47%)	79.68±8.74(↓1.85%)	88.96±9.55(↓3.49%)
2	124.10±4.45(↑0.68%)	79.76±12.49(↓1.75%)	95.44±7.48(↑3.62%)
5	131.76±5.10(↑6.89%)	85.1±4.61(↑4.82%)	98.32±7.25(↑6.75%)
10	133.04±6.12(↑7.95%)	85.74±6.24(↑5.61%)	98.04±9.41(↑6.4%)
20	145.06±7.79(↑17.68%)	92±8.38(↑13.32%)	105.38±8.02(↑14.4%)
30	134.22±9.59(↑8.89%)	88.0±9.54(↑8.42%)	92.98±7.11(↑0.95%)
Desufflation	130.38±7.55(↑5.77%)	85.28±8.46(↑5.05%)	91.08±5.24(↓1.11%)
2	127.58±5.69(↑3.50%)	83.76±7.96(↑3.17%)	88.38±4.63(↓4.04%)
5	124.54±5.61(↑1.03%)	81.66±7.81(↑0.59%)	86.84±4.61(↓5.72%)
10	118.72±7.69(↓3.69%)	79.46±8.48(↓2.12%)	87.7±6.24(↓4.78%)
20	118.86±7.48(↓3.6%)	78.98±7.78(↓2.72%)	85.14±4.94(↓7.56%)
30	118.72±7.69(↓3.69%)	77.3±6.12(↓4.78%)	83±4.22(↓9.89%)

The above table describes the changes in the systolic blood pressure at different time intervals during the laparoscopic procedure. The average baseline systolic blood pressure was 123.2 ± 65.66 mmHg. After CO_2 insufflation there was a gradual increase in SBP, which reached a maximum up to 145.06+_7.79 mmHg (↑17.68%) at 20 minutes. 30 minutes after desufflation of CO_2, average SBP fell up to 118.72±7.69 mmHg (↓3.69%). The average baseline DBP was 81.18 ± 5.68mmHg. There was maximum increase of DBP 92 ± 8.38 mmHg (↑13.32%) at 20 minutes after insufflation of CO_2, while there was a maximum fall up to 77.3 ± 6.12 mmHg (↓4.78%) at 30 minutes after CO_2 desufflation. The average baseline mean arterial pressure is 92.1 ± 5.85mmHg. It rises maximum up to 105.38 ± 8.02 mmHg (↑14.4%) after 20 mins of CO2 insufflation and fall maximum up to 83 ± 4.22 mmHg (↓9.89%) at 30 minutes after desufflation of CO_2 ***(Table 4)***.

Table 5: Changes in end – tidal carbon dioxide concentration

Pre – Insufflation	30.7±2.5mmHg
Pneumoperitoneum	35.04±2.34mmHg
Desufflation	30.48±2.29mmHg

The above table describes the changes in the end tidal CO2 concentration during pneumoperitoneum. There was increase in the end tidal CO2 from the baseline 30.7**±**2.5 mmHg to 35.04 ± 2.34 mmHg (↑14.1%) after creation of pneumoperitoneum, and it returned near normal 30.48 ± 2.29 mmHg (↓0.8%) after desufflation ***(Table 5)***.

There was no significant change in SPO_2 readings throughout the procedure. There is no significant disturbance in urine output of the patient during the procedure.

Table 6: Changes in PaO2, PaCO2 and pH

Variable	PaO2	PacO2	pH
Pre – Insufflation	298.01±95.94mmHg	34.26±4.84mmHg	7.44±0.06
Pneumoperitoneum	404.07±68.95mmHg	40.68±4.85mmHg	7.40±0.02
Desufflation	368.91±75.59mmHg	37.77±5.68mmHg	7.41±0.03

All the three readings of PaO_2 in arterial blood gas analysis shows a higher PaO2 denoting severe respiratory alkalosis due to the fact the sample was taken after induction of anaesthesia but prior to CO_2 insufflation.

The above table also describes the changes in the arterial CO_2 concentration during laparoscopy. Pre – Insufflation $PaCO_2$ was 34.26 ± 4.84mmHg. $PaCO_2$ after CO_2 pneumoperitoneum was 40.68 ± 4.85mmHg (↑18.73%) and post desufflation it was 37.77 ± 5.68 mmHg (↑10.24%). There were no significant changes in arterial pH related to changes in arterial $PaCO_2$ during laparoscopic pneumoperitoneum in our study (***Table 6)***.

DISCUSSION:

Biliary diseases known since ages constitute a major portion of gastrointestinal tract disorders. Cholelithiasis being the leader among these, causing ill health and eventually requiring a surgical intervention. Carbon dioxide insufflation is, one of the basic features of laparoscopic surgery, provides the space needed for best view and optimal working in the surgical field[4]. Since laparoscopic surgery needs smaller incisions and less dissections when compared to open surgery, patients have less postoperative pain and less complications including wound infection, respiratory and gastrointestinal complications[5]. Additionally, it is preferred by surgeons and patients as it provides better cosmetic outcomes reducing hospitalization time and shortening the time needed to return to daily activities[6]. Carbon dioxide pneumoperitoneum has been shown to produce respiratory and hemodynamic changes due to both CO_2 absorption and the effects of increased intraperitoneal pressure. Pneumothorax and subcutaneous emphysema were confounding factors that can affect the rate of CO_2 elimination, which will affect measuring parameters. CO_2 insufflation caused decreasing of cardiac output and affected the cardiovascular system[7].

Conclusion: Laparoscopic cholecystectomy promotes significant hemodynamic changes intraoperatively. The majority of these changes are directly related to carbon dioxide insufflation. High intra – abdominal pressure is associated with increased absorption of CO_2 and more hemodynamic fluctuations. Low – pressure pneumoperitoneum is ideal alternative to overcome many of the adverse hemodynamic changes in laparoscopic cholecystectomy[8].

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