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ORIGINAL RESEARCH

A comparative study of hemodynamic and end-tidal carbon dioxide changes during laparoscopic and open cholecystectomy

[1]Jayanta Padun, [2]Kannauj Swargiri, [3]Arnav Das, [4]Hilan Chakrabarty, [5]Saravanan Palani, [6]Chandana Deka

[1,2]Associate Professor, [3]Assistant Professor, [5,6]Post Graduate Student, Department of Anaesthesiology, Jorhat Medical College and Hospital, Jorhat, Assam, India
[4]Senior Resident, Department of Anaesthesiology, Tezpur Medical College and Hospital, Tezpur, Assam, India

Corresponding Author
Arnav Das
Assistant Professor, Department of Anaesthesiology, Jorhat Medical College and Hospital, Jorhat, Assam

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ABSTRACT

Keywords: Cholelithiasis, End Tidal Carbon Dioxide (ETCO2), Hemodynamic, Laparoscopic Cholecystectomy, Saturated Pressure of Oxygen (SpO2)

INTRODUCTION

Cholelithiasis is one of the most common biliary diseases requiring cholecystectomy. The Greek origin word Laparoscopy means looking into the flanks. It is achieved through the abdominal wall after the creation of the pneumoperitoneum.[1]

Early in the 20th century, the first endoscopic examinations of the peritoneal cavity were accomplished. Initially, in 1982, liver biopsies were the first laparoscopic procedures attempted by general surgeons.[2] In 1987, Mouret performed the first human laparoscopic cholecystectomy in France.[3]

Among laparoscopic surgery, cholecystectomy is one of the most commonly performed operations worldwide. Laparoscopic cholecystectomy requires small, limited incisions and short hospital stays and shows faster recovery times, less postoperative pain and less postoperative ileus because the laparoscopic approach reduces manipulation of the bowel and peritoneum. Therefore, oral food intake can be resumed earlier than with open surgical techniques.

Laparoscopic Cholecystectomy: Comparison with Traditional Open Cholecystectomy Minimises the abdominal incision, Preserves diaphragmatic function, Reduced adverse events, Less postoperative ileus, Early ambulation, Shorter hospital stay, Laparoscopic surgery is helpful in obese patients in whom usually open procedures would be very challenging and those who are particularly susceptible to wound infections after operation.[4]

Laparoscopic cholecystectomy also has complications due to an increase in intra-abdominal pressure, carbon dioxide absorption from the peritoneal cavity, and frequent changes in patient position. These complications are associated with severe hemodynamic, pulmonary, and acid-base disorders.[5]

This study was performed to To compare End Tidal Carbon Dioxide (ETCO2) changes during laparoscopic, to compare Saturated Pressure of Oxygen (SpO2) and electrocardiogram changes during laparoscopic and open cholecystectomy and to evaluate any additional effects of the insufflated carbon dioxide during laparoscopic cholecystectomy under general anesthesia.

MATERIALS AND METHODS

This was a Hospital-Based Observational Study performed at Department of Anaesthesiology, Jorhat Medical College and Hospital, Jorhat, Assam from July 2020 To June 2021. Sample Size was measured from the last 3 year hospital record, with a proportion of laparoscopic cholecystectomy & open cholecystectomy with N=3115, the sample size can be determined as 70 (35 in each group) under 95% CI, 80% power, 10% absolute precision using Epi-info software. Sample selection was done consecutively. Adult patients of either sex, between 18-60 years of age, belonging to ASA grade I and II, and scheduled for elective cholecystectomy, were selected. The patients were divided into two groups.

Group I (N=35): - Patients scheduled for open cholecystectomy.
Group II (N=35): - Patients scheduled for laparoscopic cholecystectomy.
Adult patients of either sex, between 18-60 years, who gave written informed consent, American Society of Anaesthesiology (ASA) Physical status I and II, and patients with Mallampati score class I/II were included for elective cholecystectomy. ASA grades III and higher, baseline heart rate <60 beats per minute, baseline blood pressure <100/50 mm Hg, bleeding diathesis, any hypersensitivity or contraindication to drugs used for anaesthesia. Patients with history of significant neurological, psychiatric, or neuromuscular disorders, Pregnant or lactating mothers, Laparoscopic cholecystectomy patients who had been converted to open cholecystectomy were excluded from the analysis.
A written and informed consent was taken from all the patients after explaining the procedure involved, its benefits and possible adverse effects in their own language.
Study Variables were heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, ETCO2, continuous ECG monitoring, SpO2, any side effects.

Pre-operative preparation of the patient:

- On the day prior to the scheduled date of proposed surgery, a thorough history was taken and clinical examination of all the patients was done. All patients were explained about the anaesthesia technique & written informed consent was taken. Patients were kept nil per oral for at least 6 hours prior to surgery. Preoperative blood and urine laboratory investigations, Chest X-ray, standard 12- lead ECG and Echocardiography was performed.

On the day of surgery upon arrival to the preoperative room all patients were divided into 2 groups and each group contains 35 patients.

- Group I- Open Cholecystectomy.
- Group II- Laparoscopic Cholecystectomy.

Anaesthesia machine, circuits were checked for proper functioning, and resuscitation drugs and equipment were made ready. The baseline heart rate, systolic, diastolic, and mean arterial blood pressure, SpO2 and ECG were recorded. Continuous monitoring of the vital parameters was done thereafter. An intravenous line was secured with an appropriately sized cannula and intravenous fluids were started with 5ml/kg Ringer lactate. Patients were pre-medicated with Injection palonosetron 0.075mg i.v stat, Injection pantoprazole 40 mg i.v stat, Injection glycopyrolate 0.2 mg i.v stat, Injection fentanyl 2µg/kg i.v stat.
Then, the patients were pre-oxygenated with 100% oxygen for 3 minutes with a facemask of appropriate size. For induction, both group patients received injection propofol till the loss of verbal command. Endotracheal intubation was done with an appropriate size endotracheal tube that was facilitated with an injection of cisatracurium besylate in the dose of 0.2 mg/kg in a single attempt of less than 20 seconds. A side stream ETCO2 monitor was connected, and proper placement of the endotracheal tube was confirmed by capnography and 5-point auscultation of the chest. Following the successful placement of the endotracheal tube, controlled ventilation was maintained with 33% oxygen in 66% nitrous oxide and sevoflurane inhalation in titrated dose. Tidal Volume was fixed at 8ml/kg body weight. The respiratory rate was fixed to 14 breaths/min. Muscle relaxation was maintained by intermittent i.v. cisatracurium besylate [dose of 0.03 mg/kg]. The skin incision was allowed 2 minutes after intubation, and CO2 pneumoperitoneum was established with IAP 12 mmhg100 by the surgeon in Group II patients. Intravenous fluid was given as Ringer‘s lactate and Normal Saline 0.9% at a rate of 4-6ml/kg/hr. Study parameters including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, ECG, ETCO2 and SpO2 were at 10 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes, 60 minutes and 70 minutes after intubation. At the completion of surgery residual neuromuscular blockade was antagonized by neostigmine 0.05mg/kg and glycopyrolate 0.01mg/kg intravenously. The patients were extubated after completion of surgery. After extubation, all patients were transferred to the post-operative ward. Hemodynamic management: Hemodynamic end point of the anaesthetic management was maintenance of heart rate and blood pressure within 25% of baseline values. In such a case it was planned to increase the sevoflurane concentration by 0.2% every 3 minutes and to supplement injection fentanyl 1mcg/kg if sevoflurane concentration exceeded 1%.
Statistical analysis: The statistical analysis of data was performed using the computer program, Statistical Package for Social Sciences (SPSS for Windows, version 20.0. Chicago, SPSS Inc.) and Microsoft Excel 2010. Results on continuous measurements will be presented as mean ± standard deviation they were compared using student‘s t-test (intergroup and intragroup). Discrete data are expressed as number (%) and are analyzed using Chi square test and Fischer‘s exact test. p value > 0.05 not significant, p value ≤ 0.05 significant and p value < 0.001 is highly significant. Any cost incurred during this study was beared by researcher.

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RESULT

Table 1: Comparison of HR between Group I and Group II

HR (Mean)	Group I	Group II	P value
Base line	80.456±5.868	80.6±5.822	0.9352
10 min	83.8±4.975	83.371±5.698	0.7385
20 min	82.349±5.641	85.257±5.452	0.0317
30 min	81.857±4.647	88.714±5.182	<0.001
40 min	80.943±4.517	90.714±4.661	<0.001
50 min	81.857±4.551	92.514±5.008	<0.001
60 min	81.514±5.457	84.714±4.554	0.0096
70 min	81.743±4.865	82.8±4.549	0.3511
End of surgery	82.029±3.690	80±4.982	0.0570

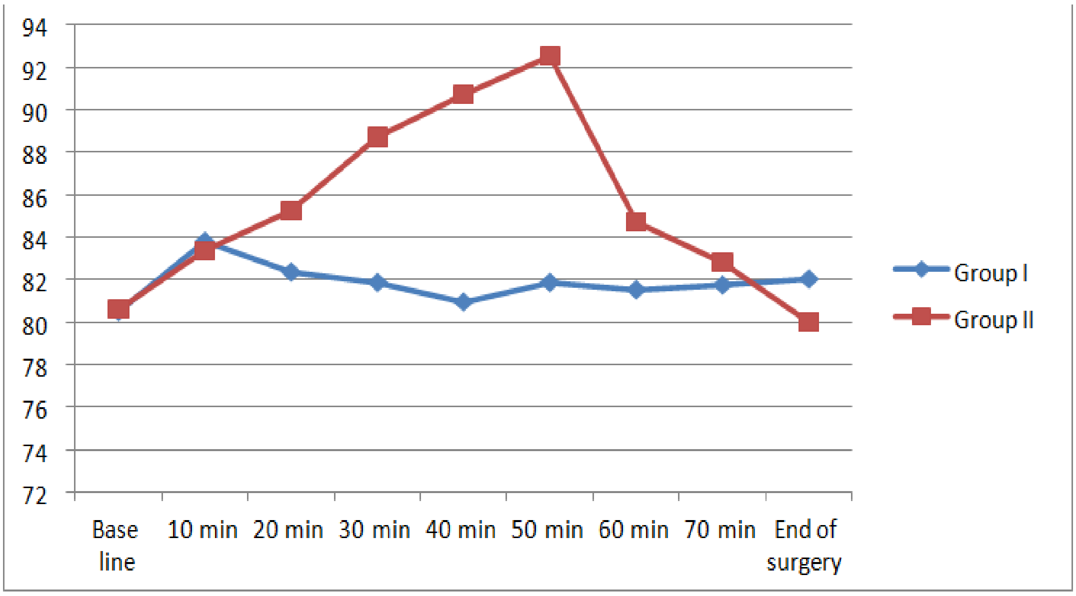

Figure1: The variation of HR between two groups.

From Table 1, we can note that in Group II, there is a gradual rise in HR in the patients when compared to the baseline. There is a significant rise at 10 minutes, 20 minutes, and 60 minutes; a highly significant rise at 30 minutes, 40 minutes, and 50 minutes. Heart rate gradually becomes comparable to baseline.

Table 2: Comparison of mean SBP between Group I and Group II

SBP (Mean)	Group I	Group II	p-value
Base line	118.571 ± 7.175	118.343 ± 6.889	0.8925
10 min	122.943 ± 6.646	122.686 ± 6.520	0.8708
20 min	121 ± 6.235	125.028 ± 6.070	0.0079
30 min	120.686 ± 6.443	130.285 ± 5.415	< 0.0001
40 min	120.486 ± 6.496	133.257 ± 5.287	< 0.0001
50 min	120.371 ± 6.467	130.914 ± 4.494	< 0.0001
60 min	119.743 ± 6.455	124.086 ± 5.365	0.0032
70 min	118.743 ± 6.604	120.971 ± 5.575	0.1318
End of surgery	119.514 ± 6.128	119.771 ± 5.347	0.8520

From Table 2, on comparison of Group I to Group II, systolic blood pressure was increased significantly at 20 and 60 minutes; highly significant at 30 minutes, 40 minutes and 50 minutes; insignificant in other time intervals in Group II.

Table 3: Comparison of mean DBP between Group I and Group II

DBP (Mean)	Group I	Group II	p-value
Base line	68.428 ± 5.237	67.886 ± 5.301	0.6944
10 min	71.343 ± 5.396	70.514 ± 5.209	0.5155
20 min	70.943 ± 5.069	73.343 ± 4.976	0.0496

30 min	70.371 ± 5.589	75.285 ± 4.991	< 0.001
40 min	70.171 ± 4.611	77.286 ± 4.854	< 0.001
50 min	69.971 ± 4.618	75.257 ± 4.610	< 0.001
60 min	70.086 ± 4.520	70.628 ± 5.168	0.6416
70 min	69.8 ± 5.455	68.771 ± 5.128	0.4190
End of surgery	70.2 ± 4.006	69.8 ± 5.128	0.7172

From Table 3, we can observe that in Group II, diastolic blood pressure increased significantly at 20 minutes, highly significant at 30 minutes, 40 minutes, and 50 minutes, and not significant in other time intervals compared to Group I.

Table 4: Comparison of mean MAP between Group I and Group II

MAP (Mean)	Group I	Group II	p-value
Base line	85.143 ± 5.035	84.705 ± 5.582	0.8057
10 min	88.543 ± 4.974	87.905 ± 5.430	5.430
20 min	87.628 ± 4.609	90.571 ± 5.108	0.0137
30 min	87.143 ± 4.951	93.619 ± 4.688	< 0.001
40 min	86.943 ± 4.111	95.943 ± 4.695	< 0.001
50 min	86.771 ± 4.314	93.809 ± 4.148	< 0.001
60 min	86.638 ± 4.404	88.448 ± 4.732	0.1023
70 min	86.114 ± 5.013	86.171± 5.019	0.9622
End of surgery	86.638 ± 3.585	86.457 ± 4.529	0.8536

We observe from Table 4 when both groups are compared, in Group II, MAP was increased significantly at 20 minutes; highly significant at 30 minutes, 40 minutes and 50 minutes; not statistically significant in other time interval

Table 5: Comparison of mean $ETCO_2$ between Group I and Group II

ET CO_2 (Mean)	Group I	Group II	p-value
10 min	35.143 ± 1.833	36.057 ± 2.209	0.0638
20 min	35.743 ± 1.930	36.742 ± 1.945	0.0344
30 min	35.657 ± 1.765	43.343 ± 1.282	< 0.0001
40 min	35.743 ± 1.884	45.029 ± 1.317	< 0.0001
50 min	35.343 ± 1.327	45.428 ± 1.119	< 0.0001
60 min	35.514 ± 1.314	40 ± 1.372	< 0.0001
70 min	35.4 ± 1.499	39.2 ± 2.045	< 0.0001
End of surgery	35.486 ± 1.422	35.914 ± 1.314	0.1948

From Table 5, when we compare both groups, in Group II, EtCO2 mmHg increased significantly at 20 minutes and remained highly significant at 30 minutes, 40 minutes, 50 minutes, 60 minutes and 70 minutes.

Table 6: Comparison of mean SpO_2 between Group I and Group II

SpO2 (Mean)	Group I	Group II	p-value
Base line	98.686 ± 1.105	98.971 ± 0.706	0.2019
10 min	98.971 ± 0.954	98.943 ± 0.872	0.8964
20 min	98.943 ± 0.873	98.686 ± 1.105	0.2838
30 min	99 ± 0.874	98.971 ± 0.954	0.8965
40 min	98.714 ± 0.859	98.886 ± 0.832	0.3997
50 min	98.971 ± 0.706	99 ± 0.874	0.8809
60 min	99.029 ± 0.822	98.829 ± 0.954	0.3509
70 min	99 ± 0.840	98.714 ± 0.859	0.1643
End of surgery	98.943 ± 0.937	98.971 ± 0.706	0.8859

Table 6 clearly shows that SpO2 remained normal and comparable in both groups throughout the surgery period.
No ECG changes were recorded in any of the patients in either Group I or Group II throughout the surgery.
There were no adverse effects in patients of either group intraoperative during the study.

DISCUSSION

Laparoscopic cholecystectomy is now increasingly preferred over open cholecystectomy. Studies are being undertaken to know and compare the hemodynamic, cardiovascular and pulmonary changes associated with the procedure for better patient care.
We carried out this prospective study on 70 patients who were planning to undergo elective

cholecystectomy. The patients were divided equally into two groups of the surgeon's choice, each consisting of 35 patients who underwent open cholecystectomy (Group I) and laparoscopic cholecystectomy (Group II), respectively.

It was observed that the demographic profiles (age, sex, weight, height), ASA status, baseline parameters, and duration of surgery were comparable and statistically insignificant.

When we compare the two groups, in Group II, the difference in mean HR between the groups was significant at 20 minutes and 60 minutes; it was highly significant at 30 minutes, 40 minutes, and 50 minutes. The difference gradually became insignificant by the end of surgery.

Studies have demonstrated that Hypercarbia induces the release of catecholamines, which causes tachycardia. In laparoscopic surgery, there is a rise in intra-abdominal pressure along with a decrease in venous return, which may cause a compensatory increase in heart rate.

When we compared the mean arterial pressure between the two groups, we found the difference to be significantly increased at 20 minutes and highly significant at 30 minutes, 40 minutes, and 50 minutes. The findings of our study were similar to those of an earlier study by Kelman GR et al.[6] done in 1972.

Harris MNE et al. 7, in 1984, observed a similar increase in the heart rate from the baseline (75 ± 1.83) after 30 minutes (99 ± 2.61) which was statistically significant. There was also a significant difference in the increase in systolic blood pressure from baseline (115 ± 2.01) at 30 minutes (123 ± 3.13).

Rishimani AS et al[8] in 1996 in a study detected MAP was increased significantly while HR remained constant during laparoscopic cholecystectomy in their study subjects.

In 2008, Meininger D et al[9] did not detect much change in systolic blood pressure, diastolic blood pressure and heart during the course of their study on laparoscopic surgery. They concluded that hemodynamic parameters generally remain within normal ranges during laparoscopic procedures.

Makwana DS et al[10] in 2014, in their study found significant increase in diastolic blood pressure at 10 minutes, 60 minutes and 120 minutes, which is in accordance to our study. The SBP in their study was increased but not significantly may be because they used volatile agents to keep the SBP under check.

IAP above 20mmHg may cause the emptying of abdominal capacitance vessels, which in turn causes a fall in central venous reserve and a decrease in cardiac output and Blood Pressure.[11] In this study, the IAP was kept strictly at 12 mmHg, so hypotension was not observed in any of our patients. On comparing the two groups, we observed a significant increase in $ETCO_2$ in patients undergoing laparoscopic cholecystectomy than open cholecystectomy, similar as in the study conducted by Fox et al., in 1993.[12]

No major changes in the electrocardiogram were recorded. The electrocardiogram displayed sinus rhythm in both groups throughout the surgical period. The saturation pressure of oxygen (SPO2) was within the normal range and comparable in both groups throughout the surgery.

Conflict of interest: Nil

CONCLUSION

Thus, we conclude that there are significant hemodynamic changes and significant $ETCO_2$ changes even in ASA grade I and II patients during laparoscopic cholecystectomy when compared to open cholecystectomy. However, most of these changes are transient and within the normal range, and they become comparable by the end of the surgery. SpO_2 and ECG also showed no significant changes between the two groups.

Since this study is a hospital-based observational study, it has the potential risk of containing confounding biases. Due to the availability of limited resources, intermittent recording of the hemodynamics and $ETCO_2$ was used in this study. This could mean that some of the variations in the hemodynamics and ETCO2, which occurred in between the fixed record intervals, may have been missed. Parameters such as central venous pressure, cardiac output, invasive arterial blood pressure, cardiac index, systemic vascular resistance and pulmonary capillary wedge pressure and PaCO2 etc., could not be measured due to the limited resources.

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