Original Research Article

Evaluation of hemodynamic changes during laparoscopic cholecystectomy in patients with moderate to severe left ventricular dysfunction: A prospective observational controlled study

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Abstract

Background: Laparoscopic cholecystectomy is a widely accepted surgical procedure for treatment of gall bladder stones. Intensive intraoperative monitoring and vigilance in the anesthetic management is of utmost importance for a smooth perioperative course in patients with cardiac dysfunction. Present study was designed to evaluate the effect on hemodynamics in response to pneumoperitoneum in patients with moderate to severe left ventricular dysfunction during laparoscopic cholecystectomy. **Material and Methods:** Present study was Single center, open label, prospective, observational controlled study, with study group as patients aged 18-65 years, moderate to severe left ventricular systolic dysfunction, planned for laparoscopic cholecystectomy, willing to participate in study. Consecutive ASA I patients with no documented echocardiographic finding suggestive of LV dysfunction were eligible for participation into the control group. **Results:** In present study, 7 patients with moderate to severe LV dysfunction (study group) and 7 patient with normal LV function (control group) undergoing laparoscopic cholecystectomy were considered. On intragroup statistical analysis, no significant change in mean heart rate, of mean arterial pressure was seen at T2, T3, T4 or T5 from T1 in the study group, whereas in the control group a statistically significant fall in was noticed at T2 and T4 from T1.On intragroup statistical analysis, significant increase in mean CVP was seen at T3, T4 from T1 in the both the groups. The mean SVR values at T5 return to the approximately the T1 levels after CO2 exsufflation in both the groups. The cardiac output does return to similar pre-induction T1 values at T5 in both the groups. The mean EtCO2, PaCO2 values are comparable between the 2 groups at the predefined time points in the study. **Conclusion:** Present study showed that laparoscopic cholecystectomy may be safely done in cardiac patients with moderate to severe left ventricular systolic dysfunction patients under the supervision of an experienced consultant anaesthesiologist.

Keywords: laparoscopic cholecystectomy, left ventricular systolic dysfunction, balanced anaesthesia, pneumoperitoneum

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INTRODUCTION

Laparoscopic cholecystectomy is a widely accepted surgical procedure for treatment of gall bladder stones. Over the years surgical skills have been improved and also there is better understanding of pneumoperitoneum so now laparoscopic cholecystectomy is done by most of the surgeons.[1] The superior cosmesis ,early return to daily activities, appeal of diminished pain and fatigue are responsible for its popularity in surgery field.[2] Laparoscopic surgeries using carbon dioxide for inflating the abdomen have serious impacts on various systems including cardiovascular system. So earlier in patients with

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cardiac abnormality, laparoscopic cholecystectomy was avoided.[3,4] On the opposite hand, patients with laparoscopic cholecystectomy, experience less physiological stress as compared to those who underwent open surgery[5].So this makes us think whether the laparoscopic cholecystectomy be beneficial in patients having cardiac dysfunction as the advantage will be less physiological stress and disadvantage of pneumoperitoneum will be there. Intensive intraoperative monitoring and vigilance in the anesthetic management is of utmost importance for a smooth perioperative course in patients with cardiac dysfunction. Present study was designed to evaluate the effect on hemodynamics in response to pneumoperitoneum in patients with moderate to severe left ventricular dysfunction during laparoscopic cholecystectomy.

MATERIAL AND METHODS

Present study was Single center, open label, prospective, observational controlled study, conducted in department of anaestesthesiology at PGIMER, India. Study duration was of 1 year (April 2019 to March 2020). Study was approved by institutional ethical committee.

Inclusion criteria: Patients aged 18-65 years, moderate to severe left ventricular systolic dysfunction, planned for laparoscopic cholecystectomy, willing to participate in study

Exclusion criteria: BMI > 35 kg/m^2. Coexisting stenotic valve lesions or right ventricular dysfunction. Presence of electrocardiographic findings of arrhythmia. NYHA IV physical status. End stage hepatic/renal/pulmonary disease.

Consecutive ASA I patients with no documented echocardiographic finding suggestive of LV dysfunction were eligible for participation into the control group. Details such as demographic variables, history of cardiac medications and prior history of admission to the ER or cardiac adverse events was noted. As per echocardiography findings, LV systolic dysfunction would be graded as mild (LVEF 41–45%), moderate (LVEF 36–40%), or severe (LVEF (35%)[18].

Patients were informed on the day prior to the surgery about the study and a written informed consent was taken. Pre-operative fasting of 8 hours for solid food intake was followed. All study parameters were recorded at the following time points. Pre-induction(T_{1}), 10 minute after induction(T_2), when pneumoperitoneum with intra-abdominal(IAP) pressure of 12mm Hg is achieved (T_3), 10 minute after reverse Trendelenburg position(T_4), 10 minute after deflation of pneumoperitoneum(T_5). On arrival in the OR, standard ASA monitors including 5 lead ECG, pulse oximeter and NIBP were attached and baseline echocardiography was done and measurements were noted. Central venous pressure(CVP) measurement was done by central line. An arterial cannula was used to measure continuous cardiac output, SVV monitoring. A baseline ABG sample was taken at T1 for measurement of baseline $PaCO_2$. Following this the patient was induced with and anaesthesia was maintained using oxygen, nitrous oxide and isoflurane. Rescue fentanyl 0.5-1.5 µg/kg when HR as well as MAP increased to ≥ 20% of base line and composite MAC of nitrous oxide and isoflurane was maintained in the range of 1-1.2. After surgery, patient was shifted to PACU after fulfilling the criteria that patient was able to respond to verbal stimuli and ensuring that pain was adequately managed. Any post procedure nausea and vomiting were addressed and anti-emetics were prescribed. All cardiac patients were followed till hospital discharge and any in hospital morbidity were noted. Any patients with symptoms suggestive of failure or ischemic event in the postoperative period were subjected to quantitative analysis of cardiac biomarkers. 30-day morbidity and mortality were for telephonic communication with the patients. Data was collected and statistical analysis was conducted using IBM SPSS STATISTICS (version 22.0). Group comparisons of values of data were made with Mann-Whitney test for 2 groups. For Normally distributed data Student t-test was applied to compare 2 groups. P value less than 0.5 was considered as statistically significant.

RESULTS

In present study, 7 patients with moderate to severe LV dysfunction (study group) and 7 patient with normal LV function (control group) undergoing laparoscopic cholecystectomy were considered. The mean age of patients was 55.6 years and 36.6 years in study and control group, respectively and difference was statistically significant. Gender, weight, height, BMI, BSA and duration of pneumoperitoneum was comparable in both groups and difference was not statistically significant.

Table 1: Demographic characteristics of both groups

Parameter	Study group (N=7)	Control group (N=7)	P value
Age in years	55.57±7.52	36.57±9.55	0.001*
Sex (male/ female)	1/6	¾	0.559
Weight in kg	64.43±14.62	56.29±8.18	0.229

Height in cm	164.29±11.15	155.43±2.07	0.061
BMI in kg/m^2	23.66±2.77	26.23±4.45	0.218
BSA in m^2	1.7±0.25	1.55±0.13	0.196
Duration of pneumoperitoneum (min)	29.71±9.36	27.43±4.54	0.572

The mean HR values in both the groups were comparable at the predefined time points during the study. On intragroup statistical analysis, no significant change in mean HR was seen at T2, T3, T4 or T5 from T1 in the study group, whereas in the control group a statistically significant fall in HR was noticed at T2 and T4 from T1.

Table 2: Heart rate in the two groups

Parameter	Study group (N=7)		Control group (N=7)		P value
	Mean ± SD (beats/min)	P value from T1	Mean ± SD (beats/min)	P value from T1	
HR at T1	81±10.82	-	83.71±9.91	-	0.633
HR at T2	75.71±12.84	.411	76±9.95	.000*	0.964
HR at T3	74.29±14.16	.338	80.29±6.65	.185	0.330
HR at T4	75.43±15.21	.464	76.43±5.03	.033	0.872
HR at T5	71.86±13.31	.106	77.71±7.09	.124	0.324

The mean values of mean arterial pressure in both the groups were comparable at the predefined time points during the study except at T5. On intragroup statistical analysis, no significant change in mean MAP was seen at T2,T3,T4 or T5 from T1 in the study group, whereas in the control group a statistically significant fall in MAP was noticed at T2 and T5 from.

Table 3: Mean arterial pressure in the two groups at defined time points of the study

Parameter	Study group (N=7)		Control group (N=7)		P value
	Mean ± SD	P value from T1	Mean ± SD	P value from T1	
MAP at T1	92±12.81	-	93.57±2.23	-	0.755
MAP at T2	83±13.18	.316	72.71±9.16	.002	0.116
MAP at T3	102.43±16.46	.083	96.43±14.54	.617	0.484
MAP at T4	97.57±13.15	.368	92.29±10.66	.751	0.425
MAP at T5	97.29±13.95	.472	82.71±5.82	.001	0.025*

The mean central venous pressure in the two groups was comparable at the predefined time points during the study. On intragroup statistical analysis, significant increase in mean CVP was seen at T3, T4 from T1 in the both the groups.

Table 4: Mean CVP in the two groups at the defined time points of the study.

Parameter	Study group (N=7)		Control group (N=7)		P value Between Groups
	Mean ± SD	P value from T1	Mean ± SD	P value from T1	
CVP at T1	7.86±2.41	-	7.43±1.27	-	0.685
CVP at T2	10.14±4.71	.121	7.29±2.5	.864	0.181
CVP at T3	12.86±3.24	.006	10.14±2.41	.059	0.100
CVP at T4	12.57±3.26	.008	11.14±1.22	.004	0.298
CVP at T5	8.57±3.21	.593	9.14±2.91	.212	0.733

The mean SVR in both the groups was comparable at the predefined time points during the study except at T2. The mean SVR values at T5 return to the approximately the T1 levels after CO2 exsufflation in both the groups.

Table 5: Mean SVR in the two groups at the defined time points of the study.

Parameter	Study group (N=7)		Control group (N=7)		P value Between Groups
	Mean ± SD	P value from T1	Mean ± SD	P value from T1	
SVR at T1	1503.71±674.3	-	1157.43±203.77	-	0.234
SVR at T2	1505±463.33	.995	1074.57±194.17	.100	0.043*
SVR at T3	1988.86±755.96	.041	1409.14±281.44	.063	0.096
SVR at T4	1970.57±629.86	.058	1470.57±153.49	.015	0.082
SVR at T5	1702.86±849.44	.387	1224.57±292.46	.692	0.184

The mean cardiac output in both the groups was comparable at the predefined time points during the study except at T3. The cardiac output does return to similar pre-induction T1 values at T5 in both the groups .

Table 6: Mean cardiac output in the two groups

Parameter	Study group (N=7)		Control group (N=7)		P value Between Groups
	Mean ± SD	P value from T1	Mean ± SD	P value from T1	
CO at T1	4.98±1.46	-	6.14±1.22	-	0.131
CO at T2	4.19±1.33	.180	4.93±0.54	.007	0.198
CO at T3	3.78±1.12	.092	5.07±0.93	.021	0.036*
CO at T4	3.71±1.13	.067	4.47±0.63	.005	0.146
CO at T5	4.66±1.3	.507	5.36±0.86	.029	0.259

The mean EtCO2 values are comparable between the 2 groups at the predefined time points in the study.

Table 7: Mean EtCO2 in the two groups at the defined time points of the study.

Parameter	Study group (N=7)		Control group (N=7)		P value Between Groups
	Mean ± SD	P value from T1	Mean ± SD	P value from T1	
EtCO2 at T1	29.86±2.34	-	31.29±1.25	-	0.180
EtCO2 at T2	35.43±5.32	.011	33.71±2.06	.024	0.442
EtCO2 at T3	34.71±5.94	.045	33.14±2.55	.102	0.532
EtCO2 at T4	37.29±4.57	.006	36.57±1.72	.000	0.706
EtCO2 at T5	37.57±5.86	.012	36.71±1.8	.000	0.722

The PaCO2 is comparable between the 2 groups at the predefined time points in the study.

Table 8: Mean PaCO2 in the two groups at the defined time points of the study.

Parameter	Study group (N=7)		Control group (N=7)		P value Between Groups
	Mean ± SD	P value from T1	Mean ± SD	P value from T1	
PaCO2 at T1	36.19±6.75	-	32.86±1.46	-	0.246
PaCO2 at T4	39.86±4.95	.249	39.14±3.18	.001	0.754
PaCO2 at T5	39.69±6.71	.354	40.84±2.73	.000	0.680

Out of the 7 patients in the study group, 4 patients had episodes of hypotension requiring intervention. Only 1 patient in the study group had an episode of bradycardia at T2 requiring intervention. The patient in the control group had no intraoperative adverse event during the study. There were no episodes of clinically significant hypertension, tachycardia and arrhythmias requiring intervention in both the groups. No significant complications occurred during immediate postoperative period as well as during the hospital stay. All control groups patients were discharged from hospital on the evening of surgery. Amongst the study group patients, 5 were discharged on the POD 1 and two were discharged on POD2 of surgery. On 3 month follow up of these patient (telephonically), no mortality or morbidity has been recorded.

DISCUSSION

Laparoscopic cholecystectomy minimizes abdominal incision and therefore pulmonary function and diaphragmatic function remain preserved. Laparoscopic cholecystectomy decreases the incidence of postoperative ileus, helps early ambulation, has economic benefits, helps early ambulation with shorter hospital stay , early return to work and normal daily activities. According to the demographic data, the patients in the study group belong to a significantly older age group (55± 7 years) as compared to those in the control group (36 ± 10 years). This difference can be very well explained by the fact that incidence of LV systolic dysfunction and hypertension increases significantly with age.[6] Patients in the study per se are predominantly females (72%). A population based study done in the north Indian population confirms a greater prevalence of cholecystitis in females as compared to males.[7] Ten minutes post-induction of anesthesia, there is a decrease in sympathetic tone of the vasculature and negative chronotropic effects of anesthetic drugs. The effect of the sympathetic response to laryngoscopy and tracheal intubation on hemodynamic parameters wear off within the first 5 min of laryngoscopy.[8] As the control group is younger than the study group population, the dose of propofol required for induction of anesthesia (induction dose of propofol is titrated to effect i.e. loss to verbal command) would also depend on the preoperative anxiety of the patient which in turn is higher in patients with age 30-45 years as compared to >45 years.[9] Dhoste et al.,[10] in a similar study concluded that the main cardiovascular depression was noted after induction of anesthesia. In their study the CI dropped by 41%, MAP by 27% while the HR by 20% from the baseline value. The fall in these hemodynamic parameters is greater as compared to observations in our study. This difference in results could be because of titrated and graded induction of anesthesia, along with rescue pharmacological interventions done to maintain the hemodynamic parameters. In the study by Dhoste et al.,[10] surgery and pneumoperitoneum resulted in increase in the CI (1.6 to 1.9 ml/min/m^{-2}), improvement of heart rate (+21%) and MAP (+19%) during peritoneal insufflations from baseline values. Changes in MAP and

HR similar to the control group of the present study. In another study done by Hein et al.,[11] 17 patients with ASA III and ASA IV noted significant decrease in CI ($p<0.05$) following insufflations and remained low until exsufflation. The effects of pneumoperitoneum on arterial CO_2 and end tidal CO_2 were also comparable in patients with normal as well as impaired left ventricular systolic function removing any confounding effects of respiratory acidosis on cardiac functions. There are no episodes of tachycardia and arrhythmia seen during the surgery. No morbidity or mortality is seen in any of the patients during their hospital stay and till 3 months follow up. A tailored anaesthetic technique keeping in mind the physiological changes of pneumoperitoneum, limited pneumoperitoneum time, and anesthetic as well as surgical expertise play a very important role in achieving stable hemodynamics perioperatively. The expertise of surgeon (same surgeon performing all the procedures) and an average time of pneumo-peritoneum of 29 minutes significantly reduce the duration of exposure of the patients with impaired left ventricular systolic function to the deleterious effects of pneumoperitoneum. Strengths of the study was use of less invasive technique for cardiac parameters. Limitations of present study were, no randomization, sample size was quite small. Flow track was not available for all patients due to resources limitation. The other cardiac output measurement technique which is lesser invasive to the standard techniques (eg.thermodilution method through pulmonary artery catheters) is pulse contour analysis of arterial waveform. Flo Trac is one such moniter which uses the above principle to obtain continuous cardiac output measurements. Its calculations are based on arterial waveform characteristics after adjustment for vascular compliance. It does not require frequent calibration unlike the PiCCO techniques.[12,13]

CONCLUSION

resent study showed that laparoscopic cholecystectomy may be safely done in cardiac patients with moderate to severe left ventricular systolic dysfunction patients under the supervision of an experienced consultant anaesthesiologist. Optimization of cardiac status, administered of balanced anaesthesia and 10-12 mmHg pressure pneumoperitoneum are essential steps for patients' safety.

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