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Original Research Article

Comparative evaluation of hemodynamic and capnographic changes in low pressure versus normal pressure pneumoperitoneum in laparoscopic cholecystectomy

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ABSTRACT

Background: In laparoscopic cholecystectomy (LC), the extent of hemodynamic changes associated with creation of pneumoperitoneum depends on the intra-abdominal pressure attained, volume of CO2 absorbed, and patient's intravascular volume. In our study, we attempted to compare the hemodynamic and capnographic changes in the low pressure (<8mm Hg) and standard pressure (12-14mm Hg) LC.
Methods: In this randomized case control study, Group A included patients undergoing Low pressure LC (<8mm Hg). In group B, Standard pressure LC (12-14mmHg) was performed. Both groups were evaluated for the hemodynamic and capnographic changes and other parameters.
Results: Difference in mean heart rate of Group A and Group B was found to be statistically significant at 10 min after induction. After 30 minutes of surgery, systolic blood pressure of Group B was found to be higher than that of Group A ($p < 0.05$). Differences in diastolic blood pressure among patients of Group A and Group B were found to be statistically significant only at 30 min and 40 min after induction. Except at 30 min after induction, differences in EtCO2 levels of patients of Group A and Group B were found to be statistically significant.
Conclusions: It appears that low pressure pneumoperitoneum appears to be having fewer effects on blood pressure-both systolic and diastolic, as compared to standard pressure pneumoperitoneum in patients undergoing LC. It also appears to be causing fewer derangements in ETCO2. This may help in smooth recovery and less post-operative problems.

Keywords: Capnography, Laparoscopic cholecystectomy, Low pressure, Pneumoperitoneum

INTRODUCTION

Gallstone disease remains one of the major causes of abdominal morbidity and mortality through the world.[1] Laparoscopic cholecystectomy (LC) is the most common laparoscopic procedure performed in general surgical units worldwide. Despite definite advantages of LC, there are certain problems associated due to the physiological effect of pneumoperitoneum and the positioning of the patient.

Pneumoperitoneum is most often created by insufflating carbon dioxide gas into peritoneal cavity. However, absorption of carbon dioxide from peritoneal cavity is the potential mechanism for rise in end tidal carbon dioxide

and severe hypercarbia exerts a negative ionotropic effect on the heart and reduces left ventricular function.[2,3]

The extent of hemodynamic changes associated with the creation of pneumoperitoneum depends on the intra-abdominal pressure attained, volume of carbon-dioxide absorbed, and patient's intravascular volume. Frequent complications associated with pneumoperitoneum includes subcutaneous or mediastinal emphysema, pneumothorax, hypoxemia, hypotension carbon dioxide embolism cardiovascular collapse, and cardiac arrhythmias.[4] There are studies, which have concluded that these adverse effects can be minimized by use of low pressure for pneumoperitoneum instead of the standard or high-pressure pneumoperitoneum.[5,6]

In our study, we attempted to compare the hemodynamic and capnographic changes in the low pressure (<8 mm Hg) and standard pressure (12-14mm Hg) LC. We also compared the difficulty in surgery by evaluating adequate exposure of operating field, operating time, incidence of intraoperative complications, and frequency of conversion to standard pressure laparoscopic cholecystectomy or open cholecystectomy. Finally, evaluation of post-operative pain by using visual analogue scale (VAS) was also analysed.

METHODS

This was a randomized case control study conducted in the Department of Surgery of the Medical University from January 2015 to July 2016. It was approved by the hospital ethical committee.

After informed consent, selected patients were randomized into 2 groups- group A and group B by sealed envelope method on the day before the surgery. Group A included patients undergoing Low pressure laparoscopic cholecystectomy (<8mm Hg). In group B, Standard pressure laparoscopic cholecystectomy (12-14mm Hg) was performed. Inclusion criteria included all patients of age between 18 to 60 years with uncomplicated symptomatic gallstone disease and ASA I and II.

Cuschieri scale of difficulty for cholecystectomy was used for intra-operative gall bladder difficulty assessment. Standard four port LC was performed in both the groups under strict aseptic precautions. Postoperatively, the patients were examined in ward for pain, vomiting, abdominal distention, fever and incidence of wound sepsis i.e. port site infection. After discharge, the patients were followed in out-patients department (OPD).

During the procedure, following base line parameters will be monitored:

- Heart rate
- Respiratory rate
- Non-invasive blood pressure (systolic, diastolic and mean)
- End tidal carbon dioxide

All the above-mentioned parameters will be monitored in both groups at various intervals, that is:

- Before induction of anaesthesia,
- Every 10 min after Carbon dioxide insufflation,
- Ten min after Carbon dioxide exsufflation,
- Twelve hours after procedure.

The degree of postoperative pain will be assessed by means of visual analogue scale at 3,6,12 and 24 hr postoperatively.

- Requirement of analgesic administration in postoperative period.

In addition, following parameters will be noted in each case:

- Operating time,
- Conversion to standard pressure/open cholecystectomy,
- Intraoperative /post-operative complications.

Statistical analysis

The statistical analysis was performed using Statistical Package for Social Sciences (SPSS) Version 15.0 for Windows (Chicago, IL). The values were represented in Number (%) and Mean±SD. P value less than 0.05 was taken as significant.

RESULTS

Table 1: Between group comparison of demographic variables.

Variables	Group I (n=40)		Group II (n=40)		Total (N=80)	
	No.	%	No.	%	No.	%
Age Group (years)						
Upto 20	7	17.50	2	5.00	9	11.25
21-30	13	32.50	17	42.50	30	37.50
31-40	15	37.50	9	22.50	24	30.00
41-50	5	12.50	10	25.00	15	18.75
>50	0	0.00	2	5.00	2	2.50
	χ^2=8.478 (df=4); p=0.076					
Min-Max (Median)	18-45 (30.50)		18-63 (32.50)		18-63 (31.50)	
Mean±SD	30.18±8.91		34.75±10.86		32.46±10.13	
Gender						
Female	36	90.00	38	95.00	74	92.50
Male	4	10.00	2	5.00	6	7.50
	χ^2=0.721(df=1); p=0.396					

The duration of this study was 1½ years. The total number of patients was 40 in both groups. Mean age of overall, Group A and Group B patients were 32.46±10.13 years, 30.18±8.91 years and 34.75±10.86 years respectively. Mean duration of hospital stay in Group I (2.33±0.47 days) was found to be higher than that of Group II (2.10±0.78 days), but difference was not statistically significant (Table 1).

At baseline, the difference in mean heart rate among patients of both groups was not found to be statistically significant. Difference in mean heart rate of patients of Group A and Group B were found to be statistically significant at 10 min after induction (89.75±12.04 vs. 84.05±12.99 beats/min), 20min after induction (90.18±11.60 beats/min vs. 82.95±11.65 beats/min) and at 2 hours after induction (91.25±10.55 vs. 83.60±11.76 beats/min). As regard to respiratory rate, difference in respiratory rate of patients of Group A and Group B was found to be statistically significant only at 50 min (Group A 12.50±0.90 vs. Group A 12.00±0.00 per min) (Table 2).

Table 2: Between group comparison of heart rate at different time intervals (independent 't' test).

Time Interval	Group I			Group II			Statistical significance	
	N	Mean	SD	N	Mean	SD	't'	'P'
BI	40	87.50	11.76	40	82.50	12.32	1.857	0.067
10 m	40	89.75	12.04	40	84.05	12.99	2.035	0.045
20 m	40	90.18	11.60	40	82.95	11.65	2.779	0.007
30 m	40	90.73	11.10	40	89.63	13.44	0.399	0.691
40 m	40	91.83	12.08	39	89.90	12.94	0.685	0.496
50 m	12	88.58	10.40	14	90.64	11.08	-0.486	0.631
60 m	4	88.50	13.23	4	83.75	8.02	0.614	0.562
2 h	40	91.25	10.55	40	83.60	11.76	3.063	0.003

BI= before induction

Table 3: Between group comparison of systolic BP at different time intervals (independent 't' test).

Time interval	Group I			Group II			Statistical significance	
	N	Mean	SD	N	Mean	SD	't'	'P'
BI	40	115.90	9.18	40	124.30	10.39	-3.831	<0.001
10 m	40	117.18	8.83	40	124.03	9.84	-3.278	0.002
20 m	40	116.50	8.12	40	123.70	9.12	-3.729	<0.001
30 m	40	117.33	7.57	40	130.95	10.89	-6.496	<0.001
40 m	40	116.40	7.89	39	130.77	10.54	-6.873	<0.001
50 m	12	114.58	5.84	14	128.71	12.12	-3.681	0.001
60 m	4	120.25	3.77	4	130.25	9.11	-2.029	0.089
2 h	40	116.90	8.51	40	124.58	10.24	-3.645	<0.001

Table 4: Between group comparison of diastolic BP at different time intervals (independent 't' test).

Time interval	Group I			Group II			Statistical significance	
	N	Mean	SD	N	Mean	SD	't'	'P'
BI	40	78.93	6.72	40	78.93	6.91	0.000	1.000
10 m	40	80.50	6.05	40	80.10	12.89	0.178	0.859
20 m	40	80.78	6.09	40	78.40	6.57	1.676	0.098
30 m	40	80.50	6.70	40	85.90	7.42	-3.416	0.001
40 m	40	80.35	6.44	39	85.82	6.85	-3.657	<0.001
50 m	12	82.58	5.28	14	85.86	8.02	-1.206	0.240
60 m	4	87.00	2.71	4	84.25	8.88	0.592	0.575
2 h	40	79.93	6.24	40	78.70	6.65	0.850	0.398

Before induction systolic blood pressure of Group B (124.30±10.39 mm Hg) was found to be higher than that of Group A (115.90±9.18 mm Hg) and difference in systolic blood pressure of above two groups was found to

be statistically significant. Before induction Diastolic blood pressure of patients of Group A (78.93±6.72mm Hg) and Group B (78.93±6.91mm Hg) were found to be almost similar. Diastolic blood pressure of patients of Group B was found to be higher than that of Group A at 30 min, 40 min and 50 min after induction while at rest of the periods of observation diastolic blood pressure of Group A was found to be higher than that of Group B. Differences in diastolic blood pressure among patients of Group A and Group B were found to be statistically significant only at 30 min (p=0.001) and 40 min (p<0.001) after induction. At rest of the periods of observation systolic blood pressure of Group B was found to be higher than that of Group A and differences in systolic blood pressure among the patients of Group A and Group B were found to be statistically significant at all the periods of observation except at 60 min after induction (p=0.089) (Table 3 and Table 4).

Out of 80 patients included in the study, requirement of analgesia was observed in only 4 (5.00%) patients. Though proportion of patients with requirement of analgesia during surgery was higher in Group II (7.50%) as compared to Group I (2.50%) but this difference was not found to be statistically significant (p=0.305).

Before induction $EtCO_2$ of patients of Group B (33.75±1.45mm Hg) was found to be higher than that of Group A (33.58±0.84mm Hg), difference in $EtCO_2$ levels of patients of Group A and Group B was not found to be statistically significant (p=0.510). Mean $EtCO_2$ of patients of Group B was found to be higher than that of Group A at all the periods of observation except at 30 min after induction, differences in $EtCO_2$ levels of patients of Group A and Group B were found to be statistically significant at all the periods of observation at and after 30 min of induction (i.e. 30 min, 40 min, 50 min, 60 min and at 2 hr after induction) (Table 5).

Table 5: Between group comparison of $EtCO_2$ at different time intervals (independent 't' test).

Time interval	Group I			Group II			Statistical significance	
	N	Mean	SD	N	Mean	SD	't'	'P'
BI	40	33.58	0.84	40	33.75	1.45	-0.661	0.510
10 m	40	33.75	0.67	40	33.80	1.79	-0.166	0.869
20 m	40	33.75	0.67	40	34.33	1.86	-1.840	0.070
30 m	40	39.50	2.47	40	36.45	1.43	6.756	<0.001
40 m	40	36.40	1.37	39	38.31	1.79	-5.315	<0.001
50 m	12	36.00	0.74	14	38.64	1.08	-7.146	<0.001
60 m	4	35.00	0.82	4	38.75	1.26	-5.000	0.002
2 h	40	33.68	0.97	40	35.55	1.71	-6.033	<0.001

DISCUSSION

LC induces significant hemodynamic changes intraoperatively. There are changes in mean heart rate immediately during insufflations, which decrease at exsufflation. The majority of pathophysiological changes is related to cardiovascular system and is caused by CO2 insufflation.[7] Because of the possibility of hemodynamic derangements during CO_2 insufflation, workers tried to evaluate the possibility of low pressure pneumoperitoneum for LC.

In a recent randomized controlled trial between low pressure and standard pressure pneumoperitoneum, the mean operative time in both groups was statistically same.[8] The mean pain in low pressure pneumoperitoneum group was statistically less. It has also been found to be true by others.[9] The duration of stay is not affected by low pressure.[10,11] In a study comparing standard pressure pneumoperitoneum to low pressure pneumoperitoneum, average change in heart rate was not statistically significant in between the groups.[12]

We had noticed changes in heart rate in between the groups after 10 minutes of surgery. The difference was statistically significant. Besides this, there were changes in systolic and diastolic pressures after about 30 minutes of surgery, which were statistically significant. This has also been observed by others.[7] However, a study by Kanwer et al, consisting of 60 patients did not find any statistical difference in systolic or diastolic BP.[12]

In current study, differences in $EtCO_2$ levels of patients of Group A and Group B were found to be statistically significant at all the periods of observation at and after 30 min of induction (i.e. 30 min, 40 min, 50 min, 60 min and at 2 hr after induction). In a study of 80 patients, randomized trial of low pressure carbon dioxide elicited pneumoperitoneum versus abdominal wall lifting for laparoscopic cholecystectomy was evaluated.[13] The mean values of $PetCO_2$, $PaCO_2$ and peak airway pressure during surgery did not change significantly from the baseline values (p >0.05) for members from the abdominal wall lifting group. Conversely, for individuals from the low pressure group, a significant and sustained increase in the level of all 3 parameters was observed (p

<0.001 for all comparisons); also, a substantial decrease in pH (p <0.001) was noted following CO_2 insufflation, a decrease that remained so until desufflation was completed. Rise of end-tidal CO_2 has also been observed by others.[7] The rise is immediately after insufflation and the rise in $EtCO_2$ continues with the increasing period of CO_2 insufflation and even at 10 min after exsufflation the mean values were higher than the base line (Figure 1).

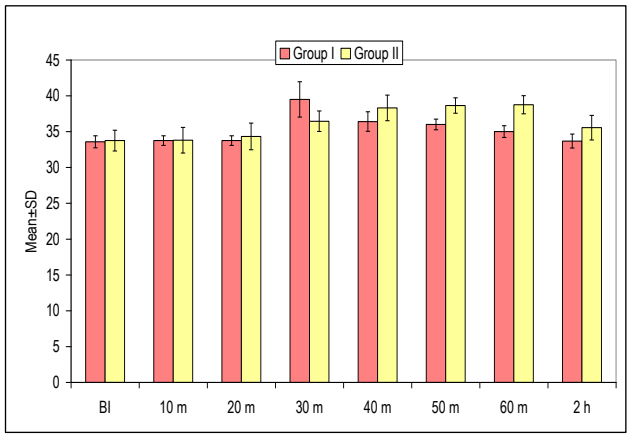

Figure 1: Serial capnographic changes in Group A and Group B patients.

Before induction $EtCO_2$ of patients of Group II (33.75±1.45 mm Hg) was found to be higher than that of Group I (33.58±0.84 mm Hg), difference in $EtCO_2$ levels of patients of Group I and Group II was not found to be statistically significant (p=0.510). Mean $EtCO_2$ of patients of Group II was found to be higher than that of Group I at all the periods of observation except at 30 min after induction, differences in $EtCO_2$ levels of patients of Group A and Group B were found to be statistically significant at all the periods of observation at and after 30 min of induction (i.e. 30 min, 40 min, 50 min, 60 min and at 2 hr after induction).

Out of 80 patients included in the study, requirement of analgesia was observed in only 4 (5.00%) patients. Though proportion of patients with requirement of analgesia during surgery was higher in Group B (7.50%) as compared to Group A (2.50%), but this difference was not found to be statistically significant (p=0.305). Kum et al, conducted a prospective trial to compare the level of pain in laparoscopic (n=28) versus conventional (n=11) cholecystectomy.[14]

Visual analogue scale (VAS) was used to assess the level of pain. Intramuscular pethidine or oral naproxen was given intermittently on demand. They found that patients undergoing laparoscopic procedure had significantly less pain on the day of surgery (VAS score of 3.8 versus 7.7), and the first post-operative day (VAS score of 2.8 versus 6.2). The proportion of patients requiring pethidine was also correspondingly less in the laparoscopic group. Therefore, the authors concluded that pain reduction was an important advantage of laparoscopic cholecystectomy.

In other prospective randomized trial on comparison in low pressure and standard pressure pneumoperitoneum for LC, post-operative pain was assessed by the VAS including the incidence of shoulder tip pain, post-operative hospital stay, recovery time, and the quality of life (QOL) within 7 days of operation.[11] The shoulder pain was lower in low pressure group. The study concluded that LP peumoperitoneum is superior to SP pneumoperitoneum in terms of lower postoperative pain, a lower incidence of shoulder tip pain, and a better QOL within 5 days following the operation.

CONCLUSION

It appears that low pressure pneumoperitoneum appears to be having less effects on blood pressure- both systolic and diastolic, as compared to standard pressure pneumoperitoneum in patients undergoing LC. It also appears to be causing fewer derangements in $ETCO_2$. This may help in smooth recovery and less post-operative problems. Further prospective studies may throw additional light on these observations.

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Ethical approval: The study was approved by the institutional ethics committee

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