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A Comparative Study between the Low Pressure Versus Standard Pressure Pneumoperitoneum In Laparoscopic Cholecystectomy

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Abstract:
Background: *The introduction of laparoscopic cholecystectomy have profoundly changed the way for the management of patients with gall bladder diseases. Since then, efforts have been made to reduce various adverse effects of pneumoperitoneum without compromising the efficacy, feasibility and safety of the operation. Many studies have shown that using a low-pressure pneumoperitoneum decreases the cardiac changes, shoulder tip pain, intensity of pain and the analgesic requirement. This study proposes to compare the use of low pressure versus standard pressure pneumoperitoneum in laparoscopic cholecystectomy.*
Materials and methods: *This prospective randomized clinical trial was done over a period of 24 months in the department of surgery where the patients were divided into 2 groups with 39 patients in each group. Group A patients underwent laparoscopic cholecystectomy with low pressure pneumoperitoneum of 10 mmHg while group B patients underwentlaparoscopic cholecystectomy with standard pressure pneumoperitoneum of 14 mmHg.*
Results: *In the present study, both studies were comparable in respect to conversion to open cholecystectomy and operating time. The hemodynamic changes were found to be minimal in low pressure pneumoperitoneum. This study also demonstrates a better outcome in terms of postoperative pain score and hospital stay with low pressure pneumoperitoneum. The systemic analgesic requirement was significantly reduced in low pressure group (mean = 1.14±1.11) in comparison to the standard pressure group (mean = 3.23±1.84). Thedifference in the systemic analgesic requirement was statistically significant ($p < 0.001$).*
Conclusion: *Low pressure pneumoperitoneum has less hemodynamic effect than the standard pressure pneumoperitoneum and is a safer option in the hemodynamically compromised patients for laparoscopic cholecystectomy.*

Keywords: *Laparoscopic cholecystectomy, low pressure pneumoperitoneum, standard pressure pneumoperitoneum.*

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I. Introduction

Improvement in video technology and surgical instrumentation has resulted in the current preferences for minimally invasive technique over conventional technique for many surgical procedures.[1]The introduction of laparoscopic surgery has profoundly changed the way for the management of patients with gallbladder diseases and common bile duct stones.[2] One of the first steps in the laparoscopic cholecystectomy is the creation of pneumoperitoneum using gas through Veress needle or through a port hole in the abdominal wall. Currently, laparoscopy implies the use of Carbon dioxide (CO_2) pneumoperitoneum.Solubility, diffusibility, combustibility, and minimal or less possible pharmacological side effects (for example, on lung and heart function, infections, as well as tumor growth) are the parameters of choice for use in human. Carbon dioxide is a common product of metabolism. It dissolves very well in the blood fluid physically and chemically. Therefore, the danger of gas embolism is very low. CO_2 doesn't support combustion. So, this gas is commonly used for pneumoperitoneum. Adverse pharmacologic effects are of concern. Besides hypercarbia, which is well tolerated in most patients, a positive effect on tumor cell growth and on bacterial infections seems to have been

experimentally proven. Recently the use of 32°C heated CO_2 for insufflation became possible. The use of warm CO_2 produced a significant reduction in postoperative shoulder and diaphragm pain.[3]

Traditional closed method of pneumoperitoneum involves initial blind entry into abdomen, and more than half of such injuries are related to this primary blind access and occur before the start of actual anatomic dissection. To prevent these complications other methods were introduced in practice like open technique as devised by Harrith Hasson, direct trocar insertion, optical trocars, radically expending trocars and use of disposable shielded trocars. However, the Veress needle technique and Hasson's technique with their different modifications are the two widely used methods today.[4]

Pressure pneumoperitoneum of less than 12 mmHg is considered as low pressure and more than 16mmHg as high-pressure pneumoperitoneum.[5] Higher the pressure better the view used to be the axiom invoked by Surgeon who needed adequate exposure for laparoscopic procedure. However, it is probable that intra-abdominal pressure (IAP) of more than 12 mmHg hardly lead to an effective enlargement of the gas filled abdominal cavity.[6] The pressure of more than or equal to 15 mmHg reduces cardiac output and stroke volume (SV) and also causes venous distension in the lower limbs and stasis. High pressure pneumoperitoneum also splints the diaphragm resulting in reduced functional capacity of the lungs, the need for increased ventilation and a higher probability of pulmonary complications.[7]

Laparoscopic cholecystectomy in patients with severe cardiac dysfunction has been reported to result in significant hemodynamic changes, including a significant decrease in cardiac index (CI) following insufflations that remained low until exsufflations. Mean arterial pressure (MAP), systemic venous resistance (SVR), and pulmonary artery occlusion pressure (PAOP) increased significantly after CO_2 insufflations. Thus, careful fluid management, maintaining low abdominal pressure, and use of the reverse Trendelenburg position are favoured to prevent the occurrence of adverse hemodynamic effects in the course of laparoscopic surgery.[8]

Therefore,to minimize the harmful effects of pressure pneumoperitoneum during laparoscopic cholecystectomy it may be needed to select the minimal intraabdominal pressure (IAP) value that will ensure sufficient visualization of the area to be operated on. This study proposes to compare the use of low pressure versus standard pressure pneumoperitoneum in laparoscopic cholecystectomy.

II. Materials And Methods

This prospective randomized clinical trial was conducted on patients admitted in surgical wards of RIMS, Imphal for elective laparoscopic cholecystectomy from August 2017 to July 2019 after obtaining clearance from the Research Ethics Board of the institute. 78 patients were allotted into two groups with 39 in each, group A (low pressure) and group B (standard pressure)using block randomization method.

Inclusion criteria: All the patients admitted in surgical ward with diagnosis of cholelithiasis, in the age range of 18 to 60 years for laparoscopic cholecystectomy.

Exclusion criteria:

1. Acute cholecystitis
2. Age <18 and >60 years
3. Pregnancy
4. Patients with comorbid condition like Diabetes Mellitus (DM), Chronic Obstructive Pulmonary Disease (COPD), cardiac comorbidities
5. Suspicious of malignancy, Mirrizzi's syndrome, features suggestive of xanthogranulomatous cholecystitis, dense adhesion, choledocholithiasis.

Study variables:

1. Independent variable: age, sex, weight, height, body mass index, socioeconomic status, occupation.
2. Dependent variable:

   To achieve the objectives of this study the following parameters were divided into a) primary outcome:

   a_1: conversion to open cholecystectomy,

   a_2: abdominal and shoulder tip pain score at 4, 8, 12, 24, and 48 hours post-operative by visual analog scale (VAS) and systemic analgesic requirement (SAR).

   b) secondary outcome:

   b_1: operating time in minutes and

   b_2: hospital stay in hours.

   c) Intra-operative parameters like heart rate (HR), blood pressure (BP), Mean Arterial Blood Pressure (MABP) end tidal CO_2 ($etCO_2$).

Working Definition:

1. Low pressure pneumoperitoneum: intraperitoneal pressure at 10 mmHg.
2. Standard pressure pneumoperitoneum: intraperitoneal pressure at 14 mmHg
3. Operating time (in minutes): Time duration between creation of pneumoperitoneum to release of pneumoperitoneum.

Study Tools:

Pre-prepared proforma for:

1. History and clinical examination
2. Investigation
3. Visual Analog Scale (VAS) for pain score

Surgical technique:

Standard Laparoscopic procedure was performed in both groups. In the group A patients, thepressure pneumoperitoneum was pre-set at 10 mmHg to 12 mmHg and reduced to 10 mmHg after the insertion of the fourth port till the completion of the procedure.In the group B patients with the standard pressure pneumoperitoneum, the pressure was pre-set at 14 mmHg from the beginning till the end of the procedure. Closure of the rectus sheath was done at 10 mm ports at the umbilicus and epigastric site using absorbable suture. Skin was approximated using 3-0 vicryl rapide suture. Pre and post-operative protocols were same in both groups. Post-operative pain was measured at 4,8,12, 24 and 48 hours post-operatively usingvisual analog scale (VAS) and systemic analgesic requirement (SAR).

Data Management and Statistical Analysis:

After thorough checking of the data obtained, statistical analysis was performed using SPSS version 21.0 IBM for WINDOWS. For categorical (qualitative) data, frequency and percentage were calculated and χ^2-test (chi-square test) was advocated for significance test between the case and control groups whilst for quantitative data, mean and standard deviation were calculated and independent sample t-test was applied to test the difference between the groups. Besides, non -parametric test like Friedman Test is applied in order to test the difference of means within each group. The P-value < 0.05 and < 0.001 were adopted as the cut off values for statistical significance and highly significance respectively.

III. Results And Observations

For demographic and socio-economic profile of the study, age in years, sex, height, weight, body mass index, religion and occupation of the patients are considered. To achieve the objectives of the present study the following parameters have been compared between laparoscopic cholecystectomy under standard pressure pneumoperitoneum (14mmHg) and laparoscopic cholecystectomy under low pressure pneumoperitoneum (10 mmHg). The parameters are divided into 1) primary outcome and 2) secondary outcome.

In the primary outcome, the parameters compared between the two groups were 1) conversion to open cholecystectomy, 2) abdominal pain and shoulder tip pain score at 4, 8, 12, 24, and 48 hrs post-operatively by Visual Analog Scale (VAS), and Systemic Analgesic Requirement (SAR).

In the secondary outcome: 1) operating time in minutes and 2) hospital stay in hours were the parameters compared between the two groups. Detailed information on socio-demographic profile, intra-operative parameters like Heart Rate (HR),Blood Pressure (BP), end tidal Carbon dioxide (etCO2), ECG and post-operative primary and secondary out-comes like conversion to open cholecystectomy (CTOC), Shoulder Tip Pain (STP), Abdominal Pain (AP),Systemic Analgesic Requirement (SAR), Operating Time (OPT) and Hospital Stay (HS) were elicited on the predesigned proforma designed for the study.

Table-1: Group wise comparison of cases with respect to sociodemographic profile

Parameter	Group			P-value
	Low Pressure n(%)	Standard Pressure n(%)	Total (78)	
Sex				
Male	16(40)	16(40)	32(40)	
Female	23(60)	23(60)	46(60)	
Religion				0.527
Hindu	22(57.1)	20(51.4)	42(54.3)	
Muslim	9(22.9)	7(17.1)	16(20)	
Christian	8(20)	12(31.4)	20(25.7)	
Occupation				0.507
Employee	11(28.6)	11(28.6)	22(28.6)	

Farmer	8(20)	3(8.5)	11(14.3)	
Housewife	14(37.1)	16(40)	30(38.6)	
Student	6(14.3)	9(22.9)	15(18.6)	
BMI				0.873
Normal (18.5-24.5)	24(60)	26(65.7)	50(62.9)	
Overweight (24.6-29.9)	13(34.3)	11(28.6)	24(31.4)	
Obese (30-40)	2(5.71)	2(5.71)	4(5.71)	

It may be observed that two groups have same composition of sex and therefore test is not required. However, females were more (60%) in the study sample, considered. This is true in both the groups. Again, in both the groups Hindu has higher percentage than other religions, although religion composition in one group is almost akin to the other group. This statement is supported by the insignificant P-value (0.527). The same insignificant pattern between the groups is also persisted in case of occupation (P=0.507), but in both the groups housewife constitute highest and employee maintains next to highest. Nonetheless, the difference is not significant even at 5% probability level. Around 60% and above of the sample have normal BMI which is followed by overweight around (30%) and least percentage (around 6%) pertains to obese.

From these interpretative findings it may be concluded that sex, religion, occupation and BMI are matched in the present study and therefore confounding effects of these factors on the main findings is control.

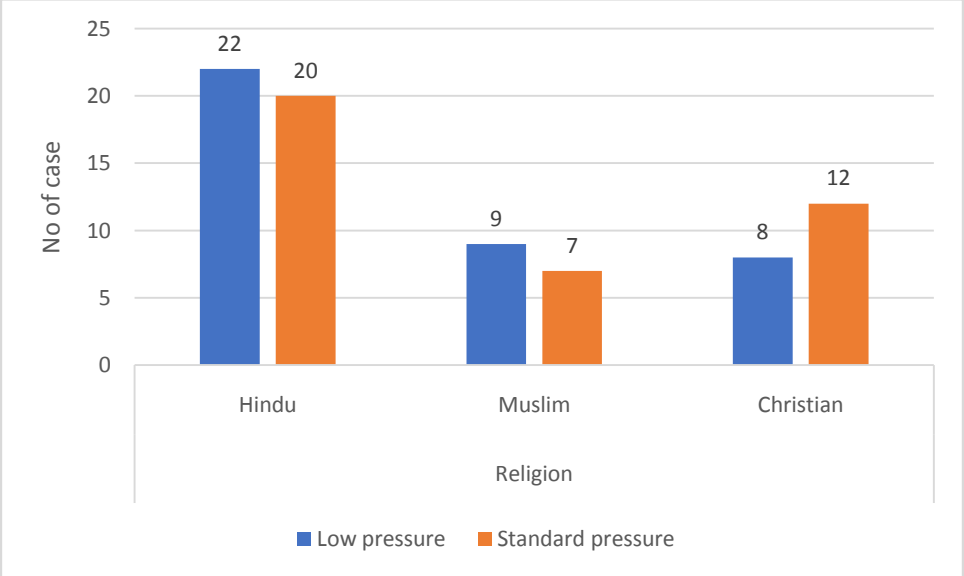

Fig-1: Showing group-wise comparison of cases according to religion

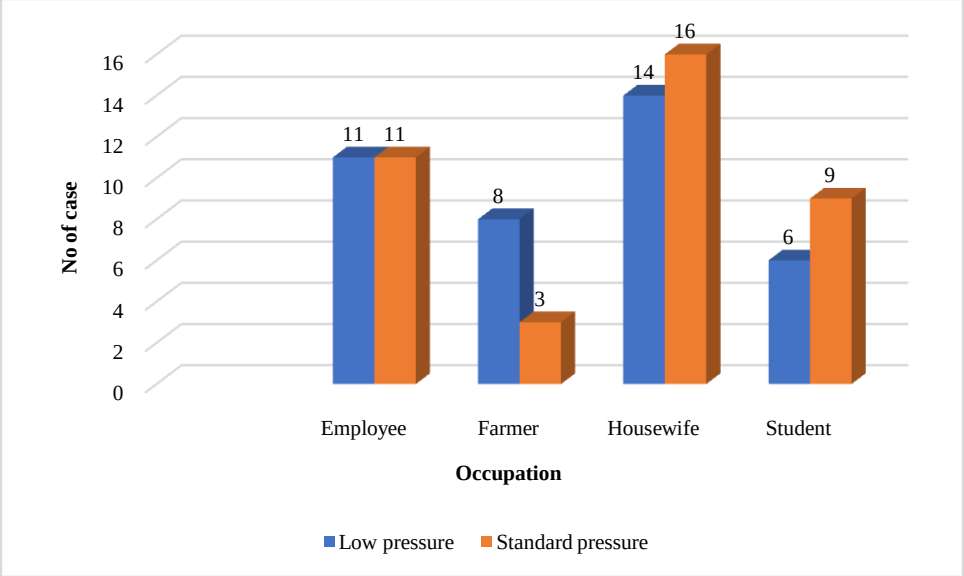

Fig: 2 Showing group-wise comparison of cases according to occupation

Table -2 :Group wise comparison of mean ± SD of age, height and weight

Parameters	Mean ± SD		P-value
	Low pressure (n=39)	Standard pressure (n=39)	
Age	49.89±17.58	39.86±14.23	.011
Height	1.56±.07	1.56±.06	.970
Weight	62.17±6.56	61.23±7.30	.572

Average age for the patient underwent operation through low pressure is 49.89 years as against 39.86 years for the patient through standard pressure and the difference is found to be significant (P = 0.011). It means that the patients under the former group are significantly older than the patient under latter group. Nevertheless, the height and weight of the patients in both the groups are almost alike as evident by corresponding insignificant P-values, shown at the last column of the table.

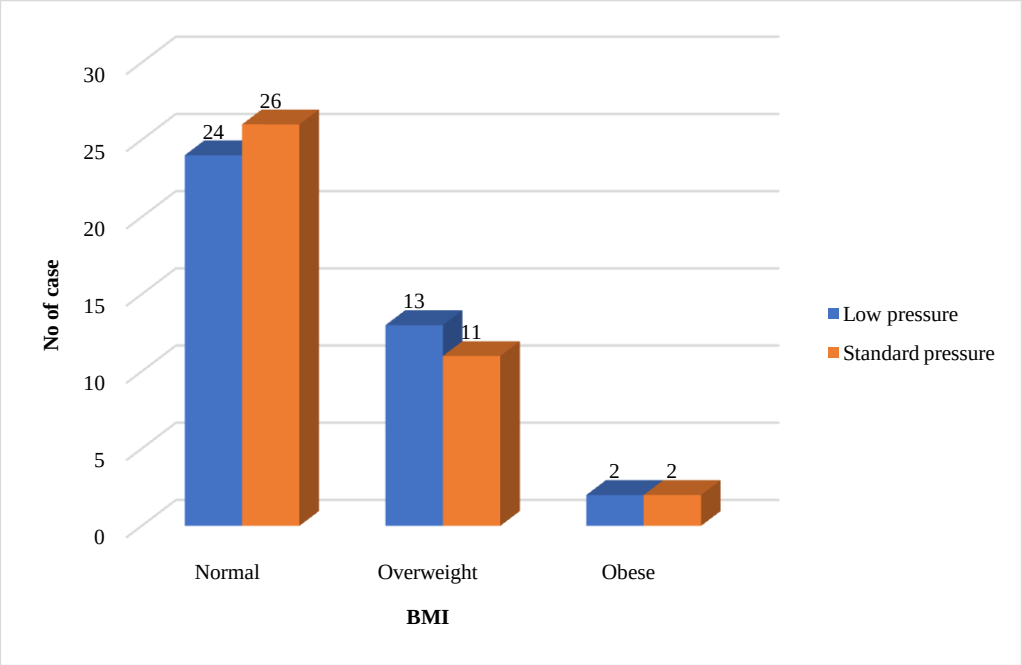

Fig-3: Showing group-wise comparison of cases according to BMI

Table -3 : Group-wise comparison of mean ± SD of Heart Rate (HR) as well as within group comparison at various intraoperative stages

Parameters	Mean± SD		t-value	P-Value
	Low pressure (n=39)	Standard pressure (n =39)		
HR before insufflation	76.06±11.73	79.17±13.52	1.029	0.307
HR at 5 minutes after insufflation	89.40±16.89	94.43±14.91	1.320	0.191
HR at 5 minutes after exsufflation	80.80±11.36	84.57±15.53	1.159	0.251
Friedman Test	46.978	60.057		
P-value	< 0.001	< 0.001		

Here in table-3, intra-operative HR is compared between the groups as well as the variation of values for all stages within the group also is compared. For the test of significance, in the former situation, independent sample t-test (simply t-test) is advocated while in the latter situation, Friedman test is used. In all the stages, the heart test for standard pressure group have higher but not significant level than that of low-pressure group as evident by the corresponding t-values and P-values.

On the contrary, highly significant Friedman test (P < 0.001) indicates that heart rate fluctuates significantly, within the group, over the stages. This is true in both the groups. Further, it highlights that HR rises from 1st stage to 2nd stage then tapering upto 3rd stage.

Table – 4 : Group-wise comparison of Mean ± SD of Systolic blood pressure as well as within group comparison at various intra-operative stages

Parameters	**Mean ± SD**		**t-value**	**P-value**
	Low pressure(n=39)	**Standard pressure(n=39)**		
Systolic BP before insufflation	122.34±12.39	118.46±9.00	1.5000	0.138
Systolic BP at 5 minutes after insufflations	130.89±11.50	131.77±12.87	0.304	0.762
Systolic BP at 5 minutes after exsufflation	126.03±12.43	124.43±8.80	0.621	0.537
Friedman Test	47.260	56.833		
P-value	< 0.001	< 0.001		

The tables-4, 5, and 6 deal mean and standard deviation of blood pressure viz., the first relates to systolic while second and third, diastolic and mean arterial blood pressure (MABP). From the table-4, highly significant Friedman test (P< 0.001) for both groups indicates that systolic fluctuates significantly, within the group, over the stages. This is true in both the groups. Further, it highlights that systolic rises from 1st stage to 2nd stage then tapering up to 3rd stage. However, insignificant t-values for all the stages prove that there is no variation of systolic level between the groups, which is implied in three stages considered.

Table – 5 : Group-wise comparison of Mean ± SD of Diastolic blood pressure as well as within group comparison at various intra-operative stages

Parameters	**Mean ± SD**		**t- value**	**P-value**
	Low pressure (n=39)	**Standard pressure (n=39)**		
Diastolic BP before insufflation	80.63±10.53	76.80±8.79	1.651	0.103
Diastolic BP at 5 minutes after insufflation	86.94±9.04	87.63±7.63	0.343	0.733
Diastolic BP at 5 minutes after exsufflation	81.97±8.80	80.57±8.06	0.694	0.490
Friedman test	52.635	55.435		
P-value	< 0.001	< 0.001		

Exactly same pattern of systolic blood pressure is also keeping it up here in diastolic BP level. For instance, highly significant Chi square test (< 0.001) for both groups indicates that diastolic BP oscillates significantly, within the group, over the stages, which is true in both the groups. Further, it highlights those diastolic upsurges from 1st stage to 2nd stage then tapering up to 3rd stage. However, insignificant t- values for all the stages ascertain that there is no variation of diastolic level between the groups.

Table-6 : Group-wise comparison of Mean ± SD of Mean arterial blood pressure (MABP) as well as within group comparison at various intra-operative stages

Parameters	**Mean ± SD**		**t-value**	**P-value**
	Low pressure(n=39)	**Standard pressure(n-39)**		
MABP before insufflations	94.49±10.12	90.56±7.79	1.820	0.073
MABP at 5 minutes after insufflations	101.50±8.91	102.28±8.48	0.374	0.79
MABP at 5 minutes after exsufflation	96.57±8.93	95.11±7.35	0.745	0.459
Friedman Test	52.471	58.350		
P-value	< 0.001	< 0.001		

The table-6 depicts group-wise comparison of mean and standard deviation of MABP as well as comparison of its values of each stage within group. Insignificant t-values for all the stages prove that there is no variation of MABP level between the groups. This is found true in three stages considered. At the same time, highly significant Friedman test (P < 0.001) for both groups indicates that MABP differs significantly, within the group, over the stages, which is true in both the groups. Further, it highlights those MABP increases from 1st stage to 2nd stage.

Table – 7: Group-wise comparison of Mean ± SD of end tidal Carbon Dioxide(etCO2) as well as within group comparison at various intra-operative stages

Parameters	Mean ± SD		P-value
	Low pressure (39)	Standard pressure (39)	
etCO2 before insufflation	32.03±4.40	32.63±3.42	0.527
etCO2 at 5 minutes after insufflation	39.94±4.88	42.11±4.69	0.062
etCO2 at 5 minutes after exsufflation	36.11±3.96	36.20±3.70	0.926
Friedman Test	60.745	63.522	
P-Value	< 0.001	< 0.001	

Mean etCO2 before insufflations, at 5 minutes after insufflations and at 5 minutes after exsufflation for low pressure group are 32.03, 39.94 and 36.11 respectively and corresponding figures for standard pressure are 32.63, 42.11 and 36.20 respectively. The deviation so far observed within each group is highly significant (P <0.001). In contrast, no significant variation in all the stages is noticed between the groups as P- value are insignificant even at 5% probabilitylevel. Although it is seen in all the stages considered the latter group possesses higher etCO2 than that of former group.

Table – 8 : Group-wise comparison of cases with respect to intra-operative ECG changes at various stages and conversion to open cholecystectomy (CTOC)

Parameter	Group		Total (78)
	Low pressure (39)	Standard pressure (39)	
ECG before insufflation			
Within normal limits	39(100)	39(100)	78(100)
ECG at 5 minutes after insufflation			
Within normal limits	39(100)	39(100)	78(100)
ECG at 5 minutes after exsufflation			
Within normal limits	39(100)	39(100)	78(100)
CTOC			
No conversion to open cholecystectomy	39(100)	39(100)	78(100)

The intra-operative ECG changes before insufflations, 5 minutes after insufflations and 5 minutes after exsufflation of the patients who underwent laparoscopic cholecystectomy are found to be within normal limits. This is true in both the groups. There was no conversion to open cholecystectomy in both the group.

Table – 9 : Group-wise comparison of cases with respect to Shoulder Tip Pain (STP) at various post-operative stages

Parameter	Group		Total (78)	P-value
	Low pressure (39)	Standard pressure (39)		
STP at 4 hr post-op				0.020
No pain(VAS)	39(100)	31(80)	70(90)	
Mild Annoying pain	-	6(14)	6(7.1)	
Moderate pain	-	2(5.7)	2(2.9)	
STP at 8 hr post-op				0.029
No pain(VAS)	39(100)	30(77)	69(89)	
Mild pain(VAS)	-	3(8.6)	3(4.3)	
Mild Annoying pain	-	4(11)	4(5.7)	
Moderate pain	-	2(2.9)	2(1.4)	
STP at 12th hr post-op				0.038
No pain(VAS)	39(100)	32(83)	71(91)	
Mild pain(VAS)	-	5(14)	5(7.1)	
Mild annoying pain		2(2.9)	2(1.4)	
STP at 24 hr post-op				0.151
No pain(VAS)	39(100)	37(94)	76(97)	
Mild pain(VAS)	-	2(5.7)	2(2.9)	
STP at 48 hr post-op				
No pain (VAS)	39(100)	39(100)	78(100)	

It may be observed from the above table that in all the five stages considered after operation, cent percent no pain (VAS) is noticed in low pressure group while in the case of standard pressure, variation pattern is found persisted over the types of pain. For instance, at the first stage i.e., at 4 hours after operation, highest percentage (80.0) pertains to no pain and next to it is mild annoying pain, and moderate pain, the least. Similar pattern is existed at second stage i.e., at 8 hours too with an induction of mild pain having the rank third. Almost akin pattern is happened to occur in other remaining stages with little variation. Nevertheless, at 5th stage (at 48

hours), cent percent no pain is also witnessed in standard pressure as similar to the low-pressure group. Further test values suggest that all the stages except the late ones i.e.,4th and 5th are found differ significantly between the groups.

Table – 10 : Group-wise comparison of Mean ± SD of Abdominal Pain (AP) as well as within group comparison at various post-operative stages

Parameters	Mean ± SD		P-value
	Low pressure (n=39)	Standard pressure (n=39)	
AP at 4hr post-op.	2.23±0.64	2.71±0.57	0.001
AP at 8hr post-op.	1.66±0.68	1.89±0.63	0.151
AP at 12hr post-op.	0.97±0.45	1.34±0.63	0.007
AP at 24hr post-op.	0.26±0.44	0.80±0.53	<0.001
AP at 48hr post-op.	0.11±0.53	0.29±0.45	0.152

Abdominal pain was recorded for separate group at five stages after operation. They are AP at 4hr, AP at 8hr, AP at 12hr, AP at 24hr and AP at 48hr post-operative periods. It is worthwhile to mention that in all the stages, mean AP for standard pressure group is found to be higher than that of low pressure group. Besides, the test values suggest out of the five, three stages viz., AP at 4hr, AP at 12hr and AP at 24hr post-operative times have significant different AP values between the groups while the remaining two viz., AP at 8hr and AP at 48hr don't have significant difference statistically.

Table – 10(A) : Comparison of Mean ± SD of Abdominal Pain (AP) at various stages within group

Parameters	AP at 4hr Mean ± SD	AP at 8hr Mean ± SD	AP at 12hr Mean ± SD	AP at 24hr Mean ± SD	AP at 48hr Mean ± SD	P-value
Low pressure (n=39)	2.23±0.64	1.66±0.68	0.97±0.45	0.26±0.44	0.11±0.53	<0.001
Standard pressure (n=39)	2.71±0.57	1.89±0.63	1.34±0.63	0.80±0.53	0.29±0.45	<0.001

Here in table- 10(A), mean comparison is made within each group and findings proclaim that abdominal pain decreases as post-operative stage advances and their decreasing trend is found to be highly significant as indicated by $P < 0.001$. This is true in both the groups.

Table – 11 : Group-wise comparison of Mean ± SD of Systemic Analgesic Requirement (SAR), Operating time (OPT) and Hospital Stay (HS)

Parameters	Mean ± SD		P-value
	Low pressure(n=39)	Standard pressure(n=39)	
SAR	1.14±1.11	3.23±1.84	<0.001
OPT	48.94±9.40	48.74±8.71	0.927
HS	51.74±7.18	63.43±9.86	<0.001

It is observed from the table – 11 that mean SAR for low pressure group is found to be 1.14 while the corresponding figure for standard pressure group is 3.23 which is very much significantly higher than that for the former group. However, the operating time is not vary between the groups ($P = 0.927$) as each group needs around 48 minutes. An interesting finding is coming up in the present study that low pressure entails significantly less hospital stay (51.74 hours) in comparison with the number of hospital stay in hours for those patients who received standard pressure (63.43) as evident by $P < 0.001$.

IV. Discussion

One of the most important technical aspects of laparoscopic surgery is the creation of pneumoperitoneum pressure and the type of gas used. Various studies have demonstrated that high intra-abdominal pressure along with types of gas used, duration of surgery and type of anaesthesia have all deleterious effects on the normal physiology and outcome of laparoscopic surgery. Intra-abdominal pressure of 15 mmHg during laparoscopic cholecystectomy may reduce the cardiac output by as much as 30%, it may also increase the blood pressure and central venous pressure.[9] Additionally, other hemodynamic changes such as increase heart rate, increase systemic vascular resistance, and reduction of stroke volume have been demonstrated.[10]This study demonstrated increase in the heart rate, blood pressure, and mean arterial pressure after insufflations of CO2 pressure pneumoperitoneum in both the group. The increase in the heart rate in standard pressure group is higher than that in the low-pressure group but the difference was statistically not significant between the groups. The increase in the blood pressure and MAP seen after 5 minutes of insufflations did not show any inter group variability. A decrease in all the above three parameters was seen after exsufflation in both the groups. Though there are no significant variation in the groups these intra-operative

hemodynamic changes indicate a cardiovascular effect either by increased intra-abdominal pressure or due to direct pharmacological action of CO2. Although healthy individuals may well tolerate these changes, they may increase physiological stress in patients with pre-existing condition, placing them at increased risk of perioperative complications. In both the groups the intra-operative ECG was within normal limits.

Pain after laparoscopic surgery is multifactorial. The etiology of post laparoscopic surgery pain can be classified in three aspects: visceral, incision, and shoulder tip pain.[11] The origin of shoulder tip pain is commonly assumed to be due to overstretching of the diaphragmatic muscle fibres owing to the high the rate of insufflations. Degree of stretching in the intra-abdominal cavity is a significant source of the post-operative pain and it has been observed that a low insufflations rate significantly reduces shoulder tip pain.[12] The shape and size of the access of devices, temperature of the insufflations gas and duration of surgery may have major bearing on the etiology of the post-operative abdominal pain.[13] Since the low pressure pneumoperitoneum is associated with reduced severity of pain, there is also reduction of analgesic requirement in this group.

Shoulder tip pain and abdominal pain were recorded at 4 hr, 8 hr, 12 hr, 24 hr and 48 hr post-operatively and visual analog scale was used to quantify the degree of post-operative pain. This study demonstrates a cent percent no shoulder tip pain in low pressure group while in standard pressure group 8 patients' complaint of shoulder tip pain. In all stages mean abdominal pain in standard pressure group is found to be greater than that of low-pressure group. The difference in the pain score between the group was statistically significant. The systemic analgesic requirement was significantly reduced in low pressure group (mean = 1.14 ± 1.11) in comparison to standard pressure group (mean = 3.23 ± 1.84). The difference in the systemic analgesic requirement was statistically highly significant ($P < 0.001$).

Carbon dioxide pressure pneumoperitoneum causes hypercapnia and respiratory acidosis. During laparoscopy, monitoring of end tidal CO_2 level is mandatory and minute volume of ventilation should be increased in order to maintain normocapnia. Hypercarbia and acidosis occurs due to absorption via huge peritoneal cavity, decreased lung compliance and insufficient ventilation.[14] It has been demonstrated that the $etCO_2$ and $PaCO_2$ measurement showed linear increase from before insufflations and still increasing to higher normal level after exsufflation in the high pressure group. Whereas in low pressure group there was no increase in $etCO_2$ and $PaCO_2$ during insufflations time and was in normal level after exsufflation as well.[15]

In the present study intra-operative $etCO_2$ level was measured with anaesthesia Dragger work-station device. The level of $PaCO_2$ was automatically controlled with the device. The $etCO_2$ level tends to increase after CO_2 insufflation in both the groups. The increase in the $etCO_2$ was greater in the standard pressure group but the variation was statistically not significant. The level of $etCO_2$ tapered after exsufflation.

In the present study both the groups were comparable in respect to conversion to open cholecystectomy and operating time. In the study there was no instances of conversion to open cholecystectomy or from low pressure to standard pressure pneumoperitoneum. The operating time was comparable as each group required around 48 minutes in average. This indicates that surgical field exposure was adequate with low pressure as with standard pressure pneumoperitoneum and the surgeons could maintain the same operative freedom.

Post-operative hospital stay was significantly less (51.74 hrs) in low pressure group in comparison with standard pressure group (63.43 hrs).

V. Conclusion

In conclusion, low pressure pneumoperitoneum has least hemodynamic and physiologic effects than standard pressure pneumoperitoneum. It is particularly better tolerated in patients with cardiovascular and pulmonary insufficiencies and other pre-existing comorbid conditions. This study shows that low pressure pneumoperitoneum is safe and feasible in most of the laparoscopic surgeries and can be used in routine basis in laparoscopic cholecystectomy.

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