Effects of Low and Standard Intra-Abdominal Pressure on Postoperative Pain in Laparoscopic Cholecystectomy

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ABSTRACT

Objective: To analyze the effects of low and standard intra-abdominal pressure on post-operative pain in laparoscopic cholecystectomy.

Study Design: Comparative prospective study.

Place and Duration of the Study: Department of General Surgery, Pak Emirates Military Hospital Rawalpindi, from Nov 2019 to Feb 2020.

Methodology: The study comprised 53 patients who underwent Laparoscopic Cholecystectomy and were selected for the study. They were randomly divided into two groups by third-party randomization. The first group was operated on under low pneumatic pressure, i.e. 8-12 mmHg and the second group was operated on under high pneumatic pressure, i.e. (≥15 mmHg). The complaint of post-operative pain was evaluated using a visual analogue scale (VAS) in the next 12 hours.

Results: The group that was operated under high pneumatic pressure showed a higher occurrence of post-operative pain (50.9%) than the group that operated under low pneumatic pressure. On the Visual Analogue Scale, 80.0% of patients with high pneumatic pressure showed a pain of score four or more which is very high compared to the other group (p<0.05).

***Conclusion*:** The patients operated for laparoscopic cholecystectomy under low-pressure pneumoperitoneum would suffer from less post-operative abdominal pain, which needs less analgesia and leads to early hospital discharge.

Keywords: cholecystectomies, laparoscopic, Laparoscopic cholecystectomy, Post-cholecystectomy syndrome, Pneumatic Pressure, Post-operative pain.

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INTRODUCTION

Since the late 1980s, laparoscopic cholecystectomy (LC) has replaced the open technique worldwide. In LC, the peritoneal cavity is visualized by using an endoscope assisted by creating a pneumoperitoneum that distends the abdomen and separates the abdominal wall from intra-abdominal contents. Artificially created pneumoperitoneum provides sufficient space to perform diagnostic and therapeutic procedures and visual clarity for safe and effective surgery. To perform laparoscopic procedures, the abdominal cavity is usually inflated with carbon dioxide to create the pneumoperitoneum at a rate of 4-6 litres/min to a pressure of 10-20 mmHg, and it is maintained by a constant gas flow at 200-400 ml/min, creating raised intra-abdominal pressure (IAP) of up to 20mmHg.[1,2] It is important to note that post-operative pain assessment in patients is a complex phenomenon, and it usually depends on the patient's perception. A visual analogue scale (VAS) is commonly used in hospitals, particularly in pain management, to assess the severity of pain, e.g., post-operative abdominal pain. Like numerical VAS, Wong-Baker FACES pain rating score is also a VAS to endorse the intensity of pain in the patients. It ranges from a score of "0", which is no hurt, to "10", which hurt worst, and it is applicable in the assessment of post-operative pain.[3,4]

LC has many benefits over open cholecystectomy. It is associated with lesser complications, viz. less invasive, fewer cosmetics problems, fast recovery, shorter hospital stays and hence, early return to normal daily activities. In LC, carbon dioxide (CO2) increases IAP and produces pneumoperitoneum. The abdominal cavity is usually inflated with CO2 to create the pneumoperitoneum at a rate of 4–6 litres/min to a pressure of 10-20 mm Hg, and it is maintained by a constant gas flow of 200-400 ml/min, creating raised intra-abdominal pressure (IAP) of up to 20 mmHg.[1] CO2 is a low cost, non-flammable, chemically stable gas that provides high diffusion capacity with subsequent rapid absorption and excretion. The systemic absorption of carbon dioxide may cause hypercapnia and acidosis. Besides, it may cause post-operative pain due to peri-

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toneal irritation, and its use is associated with immunological impairment.[5,6] The increased intra-abdominal pressure (IAP) is associated with cardiopulmonary complications such as tachycardia, cardiac arrhythmias, pulmonary oedema, and reduced hepatic and renal blood flow. Decrease hepatic blood flow can cause hepatic injury and raised liver enzymes level, while decreased renal blood flow can lead to kidney injury and oliguria. These hemodynamic changes may result in considerable side effects for the patients, especially if they are aged or have other associated comorbidity.[5] In surgical practice, a pressure of 8-12 mmHg is considered low, while a pressure of 15 mmHg or above is considered high pneumatic pressure.[7] Though in LC, post-operative pain is usually less severe than open cholecystectomy during the first 6–12 hours, it is still one of the major problems patients face. The aetiology of pain after laparoscopy can be summarized in three ways, referred shoulder pain, surgical site pain, and deep intra-abdominal pain. Pain to the shoulder tip (C4 dermatome) occurs due to CO2-induced diaphragmatic irritation, stretching or residual gas pockets in the abdomen. Deep intra-abdominal pain is primarily due to bowel traction, the abdominal wall stretching and compression of intraabdominal organs due to raised IAP.[8]

Numerous trials have been conducted comparing low- versus standard-pressure pneumoperitoneum to reduce adverse effects. Nevertheless, intra-abdominal organ injury increases due to inadequate working space in low pressure as there is a significant decrease in visibility, especially during suctioning. Maintaining optimum intra-abdominal pressure while allowing safe surgery, at acceptable cardiorespiratory physiology, and reduced post-operative pain is tricky. However, some researchers conclude that intra-abdominal pressure does not affect post-operative visceral pain. Instead, it has a more significant effect on the duration of anaesthesia and operation. On this proposition, some randomized control trials are underway.[9,10]

The relief of post-operative pain has significant physiological benefits. Hence, monitoring of pain relief is increasingly becoming an essential post-operative quality measure. Still, the ability of low-pressure pneumoperitoneum to reduce post-operative pain remains controversial among many surgeons. The drive of this study was to observe the effects of low and standard intra-abdominal pressure on post-operative pain in LC. This study aims to estimate the importance of using low-pressure pneumoperitoneum in LC to prevent the post-op complication of abdominal peri-toneum and achieve early recovery of the patients in our hospital. Unfortunately, no such study has been conducted in our hospital so far.

METHODOLOGY

This prospective comparative study was conducted in the Department of General Surgery, Pak Emirates Military Hospital, Rawalpindi. For this study, after the approval of the ethical committee (Letter no. A/28/EC/42/19 dated 20 November 2019), data was collected from 20th November 2019 to 29th February 2020. To estimate a difference between the two groups having mean pain VAS values of 1.42 and 7.88, with a power of 99% and a significance level of 5% as estimated by Singla *et al*,[11] a sample of 21 participants was calculated using the WHO sample size calculator version 2.021 (release 2). In addition, total pain values from table 3 of their study were used for sample size estimation.

Inclusion Criteria: Patients of age 18 and 60 years, with ASA class I and II, suffering from cholelithiasis and booked for elective LC were included in the study.

Exclusion Criteria: Patients who were suffering from any co-morbidity like diabetes mellitus, hypertension, ischemic heart disease or any other chronic ailment were excluded fro the study.

Initially, 65 patients were enrolled, patients were randomly divided into two groups by third-party randomization. The distribution of patients was blinded, and each participant was randomly assigned to the surgical team by the third person. One group was operated on under low pneumatic pressure, i.e. 8-12 mmHg and the patients in the other group were operated on under high pneumatic pressure, i.e. (≥15 mm Hg). Out of these 65 patients, 12 were dropped from the list post-operatively as they suffered from intra-operative complications like an injury to the bile duct, bile leakage, or haemorrhage. Finally, 53 patients were included in the study and evaluated for post-operative pain. Post-operatively the complaints of pain among the patients were documented after being evaluated with VAS by the on-duty doctor. 27 (50.9%) patients in the first group were given high pneumatic pressure equal to or more than 15 mmHg, while 26 (49.1%) in the second group patients were given low pneumatic pressure of 8-12 mmHg.

Data was entered and analyzed using Statistical Package for Social Sciences (SPSS) version 26.0. Mean and the standard deviation were described for mean

pain VAS values of both groups and the age of the patients. In addition, frequencies and percentages were described for categorical variables such as gender and BMI. Since pain is an ordinal variable, the Mann-Whitney U test analysed any difference in the post-operative pain between the two groups.

RESULTS

Our results showed that the mean age of our patients was 41.49 ± 12.44 years, with a minimum age of 18 years and a maximum age of 60 years, with a majority of patients from the fifth and sixth decade of their life. 41 (77.36%) were females, and 12 (22.64%) were male. The mean body mass index was 27.14 ± 4.60 kg/m^2. It was seen that only 32.1% of the total study population lay in the normal weight group. In addition, 17 (32.08%) patients were ASA-I, and 36 (67.92%) were ASA-II. Patients were assessed post-operatively for 12 hours, and pain complaints, if the present, were assessed and documented by the medical officers on duty using VAS and Wong-Baker FACES pain rating scores. 25 (47.2%) patients experienced post-op pain, and it was moderateintensity, between the score of 4-6 according to VAS and Wong-Baker Faces pain rating scores. Out of these, 20 (37.7%) patients were from the high-pressure group and 5 (9.4%) in the low-pressure group.

The majority of the patients in both pressure groups had a pain score of 4. While discussing separately, in the low pneumatic group, the maximum pain score of patients was four, while in the high-pressure group, it was 6. According to VAS and Wong-Baker FACES pain rating score in the low-pressure group, all 5 (9.4%) patients had a pain of score 4. While in the high-pressure group, 12 (48.0%) patients had a pain of score 4, 6 (24.0%) patients had a pain of score 5, and 2 (8.0%) had pain of score 6. The Chi-square test revealed a strong association between post-operative pain and high pneumatic pressure (p<0.05).

In the low-pressure group, males and females were 2 (7.41%) and 25 (92.59%). Among them, 3 (11.11%) females and 2 (100%) males experienced abdominal pain (Mean VAS=4.2). The patients in the low pneumatic group who experienced pain with BMI are shown below in (Table-I).

In the high-pressure group, males and females were 10 (38.46%) and 16 (61.54%). Among them, 19 (73.08%) females and 1 (10%) males experienced abdominal pain (Mean VAS=4.5) (Table-II).

Table-I: Low-Pressure pneumoperitoneum.

Low-Pressure Pneumoperitoneum		
Gender	BMI	Visual Analogue Scale
		4 or above n (%)
Female	Over Weight	1 (20%)
	Class I Obesity	2 (40%)
Male	Normal Weight	1 (20%)
	Class I Obesity	1 (20%)

Table-II: High-pressure pneumoperitoneum.

High-Pressure Pneumoperitoneum				
Gender	**BMI**	**Visual Analogue Scale, n (%)**		
		4	**5**	**6**
Female	Normal Weight	5 (19.23%)	4 (15.38%)	-
	Overweight	3 (11.54%)	1 (3.85%)	1 (3.85%)
	Class I Obesity	4 (15.38%)	1 (3.85%)	-
Male	Class I Obesity	-	-	1 (3.85%)

Another finding was that age was not a factor affecting our patients, and patients of all age groups were equally affected by pain. Similarly, pain intensity was directly proportional to the VAS, and Wong-Baker FACES pain rating score. All the patients who had complained of abdominal pain of score 6.00 had a mean BMI >24 kg/m2 (Table-III). However, in general, the pain was more common in normal and overweight patients as compared to obese.

Table-III: Post-op pain as compared to BMI.

BMI Group	Visual Analogue Scale n (%)		
	4.00	**5.00**	**6.00**
Normal Weight	6 (24%)	4 (16%)	0
Overweight	4 (16%)	1 (4%)	1 (4%)
Class I Obesity	7 (28%)	1 (4%)	1 (4%)

DISCUSSION

The success of any surgical procedure is subjected to a pain-free post-operative period, early recovery and shorter hospital stay and the same are expected after laparoscopic procedures. Therefore, it is believed by some surgeons that low-pressure pneumoperitoneum causes less pain as compared to high pressure, so there is less need for analgesics and subsequent achievement of the goals mentioned earlier. However, to others, whether low-pressure pneumoperitoneum is beneficial or not; is still a controversial topic and needs to be evaluated. For this reason, we performed this study to evaluate this hypothesis in our setup. Our research was based on the hypothesis that low pressure will produce less stretching of the abdominal wall and result in less pain. Many studies were accessed in which low pneumatic pressure was used for different surgical procedures in the abdomen and pelvis. In our study, the patients were included from both genders,

and VAS (Wong-Baker FACES pain rating score) was used as an assessment tool for abdominal pain. VAS is a widespread and useful tool used by physicians to assess the severity of pain, particularly in pain management. It is also a helpful tool to assess post-operative pain in patients having complaints of abdominal pain or having undergone LC.[3,12] The Acute Abdominal Pain Study group also used this tool to assess the acute abdomen and found it a helpful diagnostic aide.[3]

Like any other surgical phenomenon and preposition, many authors in the past believed that pressure is not a factor that causes post-operative pain. Hence, creating a low-pressure pneumoperitoneum has no role in the management and prophylaxis. Özdemirvan Brunschot *et al,*[13] concluded in their systemic review of pain scores post-operatively that the overall pain has been lower in the low-pressure group. However, the efficacy and practicality need to be assessed, and they have proposed that more studies must be conducted to evaluate this.

However, many studies conducted all over the world have advocated the benefits of using low-pressure pneumoperitoneum. For example, a prospective randomized trial comparing standard pressure versus low-pressure LC was done in a tertiary care hospital in Kolkata, India, in which Ghosh, Gangopadhyay,[14] have accessed post-operative pain by VAS score at 6 hours, 12 hours and 24 hours post-operatively and concluded that there was a significant difference in pain at 6, 12 and 24 hours in low-pressure pneumoperitoneum as compared to high-pressure pneumoperitoneum. Similarly, it was concluded by Mahajan *et al,*[5] five that low pressure (less than 10 mmHg) pneumoperitoneum is not only a safe approach with similar outcomes when compared to high pressure (more than 14 mmHg), but it is also associated with lesser post-operative pain. Likewise, in the studies mentioned earlier, in our study, more patients who were operated on under high pneumatic pressure (>15 mmHg) had complaints of abdominal pain as compared to the low-pressure group (8-12 mmHg). Similar hypotheses are under study to evaluate the benefits of low-pressure pneumoperitoneum, and their results are awaited.[10,15]

Like the studies mentioned earlier, our study has also revealed a strong association between high pneumatic pressure and post-operative pain. Recently a study was done by Mohammadzade, Esmaili *et al,*[16], also concluded that the incidence of pain in shoulder-tip and abdomen was significantly higher in the high-pressure LC, and low pressure could replace high-pressure in LC as it has good results and low side effects as compared to those of high-pressure.

It has been proved in many RCTs worldwide that post-operative pain can be reduced significantly using low-pressure pneumoperitoneum, and this technique of laparoscopy must be practised by the laparoscopic surgeons, which ensures almost the same exposure to the peritoneal cavity as seen in standard pressure.[9,17,18] Not-ably, the use of laparoscopy is not limited only to general surgery. In many other specialities like gynaecology, gastroenterology, and urology, surgeons also use this technique for several operations. For example, Akkoc *et al,*[19] researched the field of urology and concluded that low peritoneal pressure is associated with less post-operative pain results in the early post-operative period.

As we have mentioned, LC can be started at lower pressure, and then the pressure can be increased according to the surgeons' needs. The same strategy has been applied in a clinical trial by Diaz-Cambronero *et al*.[20] Its results are still awaited and can be compared to our results once their study is complete. Though the study included both genders, the participants were not equal. We also ensured that the study should be double-blinded. Though we included that group of patients that were not suffering from any chronic disease and were ASA-I and II, the spectrum of the study may be broadened. More groups of the patient population can be included.

Nowadays, researchers are also paying attention to the combination of pain killers and low-pressure pneumoperitoneum to manage pain after LC and moderate and deep neuromuscular blocks for low-pressure pneumoperitoneum during LC. Nevertheless, Neogi *et al,*[18] have suggested that the surgeon's comfort in laparoscopy is more important than the pressure used for pneumoperitoneum. Nevertheless, the benefits of the low-pressure cannot be negated. For this, they have proposed that the surgery be started with low pressure and then, according to the surgeon's preference, the pressure can be raised to avoid post-operative pain. We also suggest that the surgery must be started at a lower pressure, and then the pressure may be increased gradually for the surgeon's comfort.

CONCLUSION

To make laparoscopic cholecystectomy less painful and more effective than open cholecystectomy, surgeons can create pneumoperitoneum using a minimum carbon dioxide pressure. The patients operated under low-pres-

sure pneumo-peritoneum suffer from less post-operative abdominal pain, which needs less analgesia and leads to early hospital discharge.

Conflict of Interest: None.

Authors' Contribution

AA: ZH:, AJ:, Conception, design, interpretation, analysis of data, writing, FR:, TM:, SI: Interpretation and analysis of data, writing.

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