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Research Paper

# Comparison of Right Shoulder Pain in Patients Undergoing Laparoscopic Cholecystectomy in Single and Multiple Use of CO2 Filters

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**Key words:**
Cholecystectomy,
Co2 filter,
Laparoscopy
Shoulder pain

## ABSTRACT

**Aims** Laparoscopic cholecystectomy is a popular surgery which, despite its numerous advantages, causes some complications. One of the common complications of laparoscopy is postoperative pain in the shoulders. Several factors have been found to be effective in the occurrence and reduction of this complication. The present study aimed to determine the relationship between the number of times the CO2 filter is used and the patient's shoulder pain.

**Materials & Methods** This quasi-experimental study was conducted on 45 candidates for laparoscopic cholecystectomy surgery who met the inclusion criteria from 2020-2021. Study subjects were assigned to three groups by three permutation block randomization. In one group, the filter was used for the first time, in the second group, the filter was used twice, and in the third group, the filter was used three times. Thereafter, patients' shoulder pain after the surgery was assessed using a visual analog pain scale. The data were analyzed in SPSS software (version 20).

**Findings** The majority of research subjects were female (66.6%). The mean age of participants was 41.95±14.38 and their mean weight was 68.71±8.66 kg. The results demonstrated that there was a statistically significant difference in right shoulder pain in 1, 3, 6, 12 hours after the surgery in three groups. The subjects who received a reusable filter experienced more shoulder pain than those who received a disposable filter (P<0.05).

**Conclusion** As evidenced by the findings of the study, the use of a disposable filter is recommended to reduce the pain of patients.

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## مقاله پژوهشی

# مقایسه درد شانه راست در بیماران تحت کله سیستکتومی به روش لاپاراسکوپی در استفاده یکباره و چندباره فیلتر CO۲

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## چکیده

**هدف** کله سیستکتومی لاپاراسکوپی یک عمل جراحی پرطرفدار بوده که باوجود مزایای زیاد عوارضی را نیز به دنبال دارد . یکی از عوارض شایع لاپاراسکوپی، درد پس از عمل در شانه هاست. عوامل متعددی بر بروز و کاهش این عارضه موثر می باشد. هدف این مطالعه تعیین ارتباط تعداد دفعات مصرف فیلتر $CO_2$ بر درد شانه بیمار است.

**مواد و روش‌ها:** این مطالعه شبه تجربی بوده که در آن ۴۵ نفر از بیماران کاندید جراحی لاپاراسکوپی کله سیستکتومی در بیمارستان علامه بهلول گناباد در طی سالهای ۱۳۹۹ -۱۴۰۰ که واجد معیارهای ورود به مطالعه بودند مورد بررسی قرار گرفتند. افراد ابتدا به صورت در دسترس انتخاب و سپس به روش بلوک های جایگشتی سه تایی به سه گروه تخصیص یافتند. در یک گروه فیلتر بار اول، گروه دوم فیلتر دوبار مصرف و در گروه سوم فیلتر سه بار مصرف استفاده شد. سپس درد شانه بیماران پس از عمل با مقیاس آنالوگ دیداری درد اندازه گیری شد. جهت تحلیل داده ها از نرم افزار SPSS نسخه ۲۰ استفاده گردید.

**یافته‌ها:** اکثریت واحدهای پژوهش زن (۶۶/۶ درصد)بودند. میانگین سنی واحدهای پژوهش ۱۴/۳۸ ±۴۱/۹۵ و میانگین وزنی ۸/۶۶ ±۷۱/۶۸ کیلوگرم بود. نتایج نشان داد که درد شانه راست در زمان های مختلف ۶،۳،۱ و ۱۲ ساعت پس از عمل در سه گروه تفاوت اماری معناداری داشت. به گونه ای که در کسانیکه از فیلتر چند بار مصرف استفاده شده بود نسبت به بیمارانی که از فیلتر یکبار مصرف استفاده شده درد شانه بیشتری را تجربه کردند($P<0/05$).

**نتیجه‌گیری:** با توجه به یافته های مطالعه، استفاده از فیلتر یکبار مصرف جهت کاهش درد بیماران توصیه می گردد.

**کلیدواژه‌ها:**
درد شانه،
کله سیستکتومی،
فیلتر co2،
لاپاراسکوپی

**نویسنده مسئول:**
**مهرسا بصیری مقدم**
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## Introduction

Gallstones as the most common causes of gastrointestinal dysfunction have been responsible for two million outpatient care visits and approximately two thousand deaths annually in the United States in recent years [1]. Gallstones account for 13%-50% and 2%-10% of gastrointestinal diseases in Western and Eastern countries, respectively [2]. Most of these stones are asymptomatic throughout the patient's life; nonetheless, in some patients, bile duct obstruction by gallstones results in such symptoms as colicky pain, nausea, and tenderness in the right upper quadrant of the abdomen. If this pain spreads to the sternum or right shoulder, cholecystectomy is required [3].

The best treatment for gallstones is the surgical removal of the gallbladder, and currently, laparoscopy is the gold standard for treating gallstones [1,4-6]. Laparoscopic surgery has almost replaced open surgery due to small incisions, a short recovery period, and fewer complications [1,7,8]. It has been reported that more than 600,000 laparoscopic cholecystectomies are performed annually in the United States, and the trend and need for this procedure are expected to increase in the coming years [9]. In this method, the abdominal cavity needs to be expanded to offer a suitable space for working with the necessary devices and tools. Therefore, nitrogen, helium, and various gases, such as CO2, are used, with their specific advantages and disadvantages [11, 10].

Carbon dioxide is most frequently used gas for insufflation of the abdominal cavity since it is non-flammable, completely dissolves in the blood and is rapidly absorbed and excreted through the respiratory tract [10]. One of the most important complications after cholecystectomy is postoperative pain, and the incidence of shoulder pain after this procedure has been reported as 63% [11]. Given that in the laparoscopic method, incisions are smaller and the intercostal nerves and abdominal wall muscles are not cut, it causes less pain than open surgeries. However, for various reasons, these patients still experience postoperative pain [8].

Pain in these patients can be felt at the surgical site or radiate to the shoulder. It is hypothesized that excessive diaphragm tension due to pneumoperitoneum pressure leads to referred shoulder pain mediated by the phrenic nerve [10, 11]. Lack of pain control after surgery causes delay in the patient's ability to move, increased length of hospitalization or readmission to the hospital, incomplete recovery, decreased quality of life, and patient dissatisfaction [12, 13]. Therefore, using pain relief methods in patients undergoing laparoscopic cholecystectomy can effectively reduce health costs and increase patient satisfaction [12-14]. Several studies have addressed the reduction of shoulder pain after laparoscopic surgery [15-17].

Considering the mechanism of shoulder pain in laparoscopic surgery, it is likely that CO2 filtration could effectively mitigate this pain in patients. This filter is intended to clean and remove impurities in CO2 gas to prevent pain in patients by preventing delays in gas absorption. Researchers' clinical experiences indicate that the same filter is used multiple times in the operating room, and a new filter is used for some patients. Therefore, given that no study was found in this field, the present study aimed to assess the effect of the number of times the filter is used on patients' right shoulder pain.

## Materials and Methods

In this quasi-experimental study, right shoulder pain in patients undergoing laparoscopic cholecystectomy was compared using single and multiple uses of CO2 filter from 2020-2021. The study population consisted of 45 individuals who underwent laparoscopic cholecystectomy at Allameh Bohlul Gonabadi Hospital and were randomly assigned to three groups of 15 using permuted block randomization. The inclusion criteria were patient consent, no previous abdominal surgeries, and no pain in the shoulder area before surgery. On the other hand, the exclusion criteria entailed changing the surgical method to laparotomy for any reason and performing other surgeries during laparoscopy.

The visual pain scale and a data collection were employed to gather data. The data collection form encompassed age, gender, marital status, occupation, education, duration of surgery, amount of fluid received, amount of bleeding, number of ports, and size. Content and face validity were used to determine the validity of the data collection checklist. The tool was prepared based on scientific literature and then presented to three anesthesiologists and four faculty members in anesthesia and operating room, and the necessary modifications were made. Cronbach's alpha method was used to determine instrument reliability ($\alpha = 0.83$). Due to the lack of access to a similar study, a pilot study was first conducted on 15 patients (three groups of 5).

Following that, based on the mean pain intensity, the sample size was calculated at 36 cases using G POWER software (version 3.1.9.2) and the F-distribution test, the ANOVA: Fixed effects, omnibus, one-way considering an effect size of 0.69, a test power of 80%, and a confidence interval of 95%.

Nonetheless, it increased to 45 people taking into account a sample attrition of 20%. To implement the project, after obtaining permission from the Ethics Committee of Gonabad University of Medical

Sciences and obtaining a letter of introduction for sampling, the researcher referred to the research setting and initially, patients were selected via convenience sampling method and examined for meeting the inclusion criteria.

After obtaining informed consent, patients were allocated to three groups using a permuted block randomization (group A underwent laparoscopy with new filters, group B underwent laparoscopy with twice-used filters, and group C underwent laparoscopy with thrice-used filters). The three permutation blocks were in six positions: ABC, ACB, BAC, BCA, CAB, and CBA. Thereafter, using dice, one of the six possible positions was selected and the patients were assigned to groups. It is worth noting that due to the replacement of filters after anesthesia, patient blinding was not required; nonetheless, data collectors and statistical analysts were blinded.

All patients underwent general anesthesia in the supine position, and a 10-mm port was placed in the umbilical, and another 10-mm port was positioned below the xiphoid process. Moreover, two 5-mm ports were located in line with the previous two ports and on the patient's right lateral side. The CO2 intra-abdominal pressure was 14 bar for all samples. At the end of the operation, the holes created in the patient's abdomen were all repaired in the same way using 2-0 nylon sutures. After the operation, pain in the patient's right shoulder was assessed by an uninformed questioner based on a visual pain scale at 6, 3, 1, and 12 hours after the operation, and information was collected.

It is noteworthy that the visual analog scale (VAS) for measuring pain intensity was a 10-cm continuum, with the word "no pain" written on the left end and the word "most severe pain" on the right end. The validity and reliability of this scale have been confirmed in various studies. The collected data were entered into SPSS software (version 20) and analyzed. Descriptive statistics included mean and standard deviation and frequency distribution tables. One-way analysis of variance was used to compare the mean postoperative shoulder pain in the three groups. The Kruskal-Wallis test was used to compare the mean of quantitative variables with a non-normal distribution in the three groups.

## Results

The majority of the study subjects were female (66.6%) and illiterate (37.8%). The mean age of subjects was 41.95±14.38 years (range 50-83 years) and their mean weight was 68.71±8.66 kg. The results of the Shapiro-Wilk test illustrated that all quantitative variables were normally distributed (P>0.05), except for pain 6 and 12 hours after the surgery, which were not normally distributed (P<0.05). The results of the statistical analysis of demographic data in the three groups demonstrated no statistically significant differences (P>0.05). One-way ANOVA showed that the mean right shoulder pain one hour after the surgery was significant in the three groups, with group C (the group for whom the CO2 filter was used for the third time) experiencing the most pain and group A (the group for whom the CO2 filter was used for the first time) experiencing the least pain (P=0.008).The results also pinpointed that right shoulder pain three hours after the surgery was significant in the three groups, with group C experiencing the most severe pain and group A experiencing the lowest pain (P=0.001) (Table 1).

The results of the analysis of data related to the patient's shoulder pain six hours after the surgery revealed that all three groups had postoperative shoulder pain. In group A, this mean was lower and in group C, the pain was higher. The Kruskal-Wallis test results indicated that this difference was significant in the three groups (P=0.001). In the 12 hours after the operation, shoulder pain was also present in all three groups, with the lowest pain level in group A and the highest pain level in group C, and as before, the differences were significant (P=0.001) (Table 2).

According to Pearson's correlation coefficient test, there was a significant relationship between surgery duration and right shoulder pain 1 and 3 hours after the surgery (P<0.05). Nonetheless, other quantitative variables did not have a significant relationship with right shoulder pain 1 and 3 hours after the surgery (P<0.05). Furthermore, there was no significant relationship between quantitative variables and right shoulder pain 6 and 12 hours after the surgery (P<0.05) (Table 3).

**Table 1.** Comparison of mean pain scores at 1 and 3 hours after surgery

| Pain | One hour after the surgery | Three hours after the surgery |
|---|---|---|
| Statistical Group | Mean±standard deviation | Mean±standard deviation |
| Group A | 4.13 ±3.22 | 2.73 ±2.60 |
| Group B | 5.60± 2.66 | 4.13± 2.13 |
| Group C | 7.40± 2.16 | 6.46 ± 2.07 |
| One-way ANOVA test result | f=5.424<br>df=2<br>P=0.008 | f =8.167<br>df=2<br>P=0.001 |

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**Table 2.** Comparison of mean pain scores at 6 and 12 hours after the surgery

| Pain | 6 hours after the surgery | 12 hours after the surgery |
|---|---|---|
| | Mean | Mean |
| Group A | 15.03 | 13.27 |
| Group B | 21.57 | 22.17 |
| Group C | 32.40 | 33.57 |
| Kruskal-Wallis test result | X2=14.32 df=2 P=0.001 | X2=20.88 df=2 P=0.001 |

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**Table 3.** Determining the correlation between quantitative variables and pain score

| Pain | 1 hour after the surgery | 3 hours after the surgery | 6 hours after the surgery | 12 hours after the surgery |
|---|---|---|---|---|
| Statistical variable | Pearson correlation coefficient | Pearson correlation coefficient | Pearson correlation coefficient | Pearson correlation coefficient |
| Weight | r=-0.154 P=0.314 | r=-0.291 p=0.053 | r=-0.187 P=0.219 | r=-0.142 P=0.352 |
| Age | r=-0.097 P=0.52 | r=-0.212 P=0.162 | r=-0.245 P=0.105 | r=-0.272 P =0.070 |
| Surgery duration | r=0.381 P=0.010 | r=0.320 P=0.032 | r=0.134 P=0.379 | r=0.076 p =0.622 |
| Amount of fluid intake | r=0.248 P=0.101 | r=0.148 P=0.333 | r=0.015 P =0.922 | r=-0.062 P=0.685 |

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## Discussion

This quasi-experimental study aimed to determine shoulder pain in patients after laparoscopic cholecystectomy and its relationship with the frequency of CO2 filter use. As evidenced by the results of the study, the repeated use of CO2 filters can increase shoulder pain in patients, and the use of disposable filters can play a significant role in the mitigation of postoperative pain in this group of patients. In this regard, no similar study was found on the comparison of the frequency of filter use. Nevertheless, ome studies have been conducted on the effects of CO2 gas on shoulder pain in people undergoing laparoscopic cholecystectomy. For instance, in the study by Zahedian et al. [8], it was found that if CO2 gas was instilled into the patient's abdomen at a slower rate, he/she would experience less postoperative shoulder pain.

In a similar vein, Sayadi et al. [18] revealed that the injection of CO2 gas into the intra-abdominal space brings about transient changes in liver enzyme levels, which then decrease to the initial level after a while. Along the same lines, Anvar et al. pointed out that carbon dioxide pressure is related to postoperative shoulder pain, and higher pressures cause more shoulder pain [19]. Yazdi Moghaddam et al. demonstrated that one of the factors related to postoperative shoulder pain is the blowing of carbon dioxide gas into the peritoneal cavity [20]. In the same context, Yasir et al. reported that laparoscopic cholecystectomy with low carbon dioxide pressure significantly reduces the frequency and severity of shoulder tip pain after the surgery [21].

Dey and Malik also investigated the effect of carbon dioxide pressure and duration of laparoscopic cholecystectomy on postoperative shoulder pain. The results of their study indicated that carbon dioxide pressure was not significantly associated with shoulder pain [22]. This difference can be attributed to the amount of pressure used in the study. In both groups, the pressure was within the normal range, with a difference of one millimeter of mercury. Among the notable limitations of this study, we can refer to the fact that cultural differences and individual characteristics may affect the severity of shoulder pain in patients.

## Conclusion

Shoulder pain after laparoscopic surgery is a common complication that can be of great concern to patients. This type of pain is mainly caused by phrenic nerve irritation and the pressure of carbon dioxide gas injected during the procedure to create a workspace in the abdomen. Several factors can affect the occurrence of shoulder pain. The findings of this study pointed out that the frequency of CO2 filter use is associated with shoulder pain in patients after laparoscopic cholecystectomy. Disposable filters cause less pain, reduce the demand for postoperative painkillers, and mitigate hospitalization, thereby improving the quality of life in the early stages of postoperative rehabilitation. It is the mission of the medical staff to provide the best services with the least complications for the patient. Therefore, it is recommended to use

disposable carbon dioxide filters to reduce patient pain and increase their willingness to undergo laparoscopy.

## Ethical Considerations

### Compliance with ethical guidelines

This article is the result of a research project conducted at Gonabad University of Medical Sciences, which has received approval from the Regional Ethics Committee of Gonabad University of Medical Sciences. Informed written consent has been obtained from the patients, and all ethical codes for human research have been adhered to.

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### Authors' contributions

Alireza Talai: proposal writing, data gathering
Zahra Sadeghi Nougabi: data gathering
Arash Hamzei: data interpretation
Mehrsa Basiri Moghaddam: proposal writing, data analysis, data interpretation, article writing

### Conflicts of interest

The authors declare that they have no conflict of interest.

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