Original Article

# Low Pressure versus Standard Pressure Pneumoperitoneum in Laparoscopic Appendectomy: A Randomized Controlled Trial

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**Abstract**

**Background:** The creation of pneumoperitoneum using higher pressure is believed to be associated with increased postoperative abdominal pain. **Aim:** This study aimed to compare postoperative abdominal pain following low pressure laparoscopic appendectomy and standard pressure laparoscopic appendectomy. **Methods:** This was a prospective, double-blind, randomized controlled trial of 54 patients aged between 18 and 56 years with clinical and/or radiologic diagnosis of acute appendicitis. The patients were randomly allocated to two groups: low pressure laparoscopic appendectomy (n = 26) and standard pressure laparoscopic appendectomy (n = 28). The intra-abdominal pressure was kept in either low pressure (9 mm Hg) or standard pressure (13 mm Hg). Abdominal and shoulder pain scores were assessed using the visual analog scale at 6 hours and 3 days post procedure. Postoperative analgesia requirement, duration of surgery, complications, and hospital stay were recorded. **Results:** Both groups match for the demographic parameters. Three patients required conversion from low to standard pressure. There was no difference between the two groups in terms of abdominal pain ($P$ = 0.86) and shoulder pain ($P$ = 0.33), duration of surgery ($P$ = 0.51), complications ($P$ = 0.17), and length of hospital stay ($P$ = 0.83). **Conclusion:** The use of low pressure pneumoperitoneum did not reduce the incidence of abdominal pain in patients who had laparoscopic appendectomy. Patients with acute appendicitis can be treated with either low or normal pressure pneumoperitoneum depending on the experience of the surgeon.

**Keywords:** *Laparoscopic appendectomy, laparoscopic shoulder pain, pneumoperitoneum, post laparoscopic abdominal pain*

## Introduction

Minimally invasive surgery is associated with a lot of benefits, which include less postoperative pain, less bleeding, better cosmesis, shorter hospital stay, and early return to normal daily activities compared to open surgery.[1] Laparoscopic appendectomy is one of the most common minimally invasive procedures done in Nigeria.[2,3] Creation of pneumoperitoneum is the initial step when performing a laparoscopic appendectomy and is required to create a workspace between the abdominal wall and intra-abdominal organs, and traditionally, the pressure used for laparoscopy is often between 12 and 15 mmhg.[4] Low pressure pneumoperitoneum is generally defined as an intra-abdominal pressure between 6 and 10 mmhg.[4,5] The international guidelines recommend the use of "the lowest intra-abdominal pressure allowing adequate exposure of the operative field rather than a routine pressure".[6]

It has been posited that the degree of stretching of the peritoneum from the pressure of pneumoperitoneum is associated with more postoperative pain.[7] Approximately one third of patients have been observed to have significant pain post laparoscopic surgery.[4,8] Significant postoperative pain reduces the quality of

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life of the patient and is associated with paralytic ileus, chest infection, urinary retention, all of which may be counterproductive to the expected outcome typical of minimally invasive procedures leading to prolonged hospital stay and morbidity.[9] Theoretically, lowering the pressure of pneumoperitoneum may reduce the rate and severity of abdominal and shoulder pain following laparoscopy. This study aims to compare outcomes of patients having laparoscopic appendectomy using low pressure pneumoperitoneum and normal pressure pneumoperitoneum.

## Methods

### Study design and participants

This is a randomized, double-blind (participants and research staff) trial done at Cedarcrest hospital, Abuja. Patients were enrolled if they were aged 18 years and older with a diagnosis of acute appendicitis (defined as patients with pain in the right lower quadrant, tenderness in the right iliac fossa maximum at the McBurney's point on examination, and imaging, ultrasound or abdominal computed tomography, suggesting acute appendicitis). Consent was obtained for all participants, and the trial was approved by the Federal Capital Territory health research ethics committee (reference number FHREC/2022/01/177/19).

### Randomization and blinding

The participants were randomly assigned to either the low pressure pneumoperitoneum or standard pressure pneumoperitoneum after intubation by a nurse picking one of the identical labelled notes from a closed envelope. Patients, caregivers, and the research assistant assessing outcomes were blinded to the allocation.

### Procedure

As per unit protocol, all procedures were performed in a standardized manner employing general anesthesia. Intravenous ceftriaxone 1 g 12 hourly and intravenous metronidazole 500 mg 8 hourly were the antibiotics of choice, with 100 mg of suppository diclofenac, administered in the recovery room following surgery. Standard pressure laparoscopic appendectomy (SPLA) is defined as a procedure performed at an intra-abdominal pressure of 13 mmHg throughout the procedure. Low pressure laparoscopic appendectomy (LPLA) is laparoscopy performed at an intra-abdominal pressure of 9 mmHg after initial trocar insertion at a pressure of 13 mmHg. Conversion to standard pressure is defined as changing from low pressure to 13 mmHg or more at any point in time after initial trocar insertion, while conversion to open is defined as abandonment of laparoscopy for an open procedure. Pneumoperitoneum was introduced via a Verres needle at the umbilicus, and insufflation to 13 mmhg was achieved with $CO_2$. Thereafter, all trocars were inserted, and the pressure was set to 9 mm Hg in those who were randomized to LPLA. The flow rate for $CO_2$ was kept fixed at 10 L/min to avoid any fluctuations in intra-abdominal pressure owing to either unidentified leak or use of a suction device. Patients were commenced on oral sips after recovery from anesthesia. The patients were discharged if the blood test results were grossly normal (white cell count <10 × 109/L, neutrophil % <85%, and C-reactive protein <50 mg/L), the patients tolerated oral intake, they had no fever, and they had good pain control. The wound was inspected, and the dressing was changed 3 days after the surgery.

### Outcomes

The primary outcome was postoperative abdominal pain measured 6 hours and 3 days following surgery using the numerical rating scoring system. Secondary outcomes were shoulder pain measured 6 hours and 3 days following surgery using the numerical rating scoring system, duration of operation in minutes, complications, and length of postoperative stay time in hours.

### Statistical analysis

The sample size calculation was done using the formula for comparative study for a large effect size.[10,11] Baseline characteristics for each group were recorded as frequencies with percentages for categorical data, means with SD for data with normal distribution, or medians with an interquartile range for data with non-normal distribution. Analysis of the data was per-protocol based on the final pressure group they underwent.

For the primary outcome, normally distributed data were reported with means and *P* values using the T-test. A *P* value of <0.05 was regarded as being statistically significant. Comparison between groups was reported using Chi-square and Fisher's exact test.

## Result

We enrolled our first patient on June 27, 2022 and the last on September 23, 2023. Recruitment was stopped when the planned sample size was reached. A total of 54 patients were included in the study. Twenty-eight in the normal pressure group ad 26 patients were in the low-pressure group. Three patients were converted from low to high pressure, while there was no conversion to open. In the time period, 68 patients were eligible for the study [Figure 1]. Two patients did not give consent, while 12 patients did not meet the inclusion criteria (two patients were less than 18 years, five patients had complicated appendicitis, four patients with acute

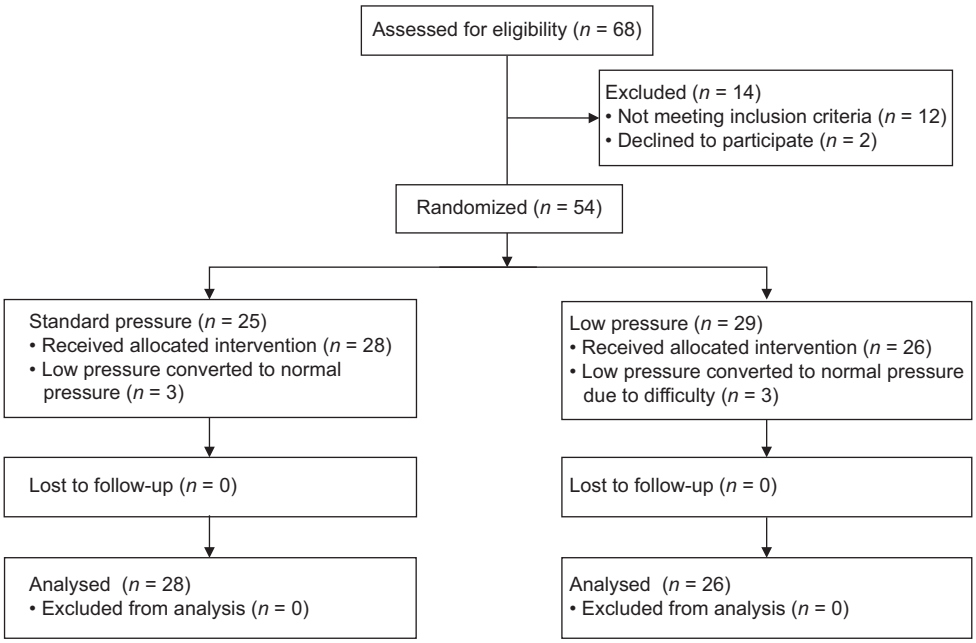


**Figure 1:** Flow diagram of patients undergoing laparoscopic appendectomy. The diagram includes detailed information on the excluded participants

**Table 1: Baseline information both groups**

| | Low pressure | Normal pressure | *P* |
|---|---|---|---|
| Age (years) | 36.5±18.3 | 28.7+13.7 | 0.09 |
| Sex | | | 0.15 |
| Male | 8 | 10 | |
| Female | 18 | 18 | |
| Duration of surgery (minutes) | 40.9±16 | 37.8+18.2 | 0.51 |
| Conversion from low pressure to standard pressure | 3 | 0 | - |

**Table 2: Outcomes of patients**

| | Low pressure | Standard pressure | *P* |
|---|---|---|---|
| Abdominal pain 6 h | 3.2±2.2 | 2.5+1.6 | 0.21 |
| Abdominal pain 3 days | 1.6±1.3 | 1.5+1.2 | 0.86 |
| Shoulder pain 6 h | 0.3±0.6 | 0.5+0.8 | 0.34 |
| Shoulder pain 3 days | 0.20±0.40 | 0.35+0.62 | 0.33 |
| Length of stay (hours) | 25.0±12.4 | 24.3±9.5 | 0.83 |
| Wound infection | 0 | 3 | 0.17 |

appendicitis in third trimester of pregnancy, and one with appendiceal cancer).

There were 18 males and 36 females in the study giving an M:F of 1:2. The mean age of patients in this study was 31.6 ± 16.4 years (range 18–56) [Table 1].

There were four complications overall (7.4%). Three port site infections (5.6%) were managed by dressings alone and one patient with pulmonary embolism [Table 2]. There were no mortalities. Three patients had port site infection in the standard pressure group and none in the low-pressure group ($P$ = 0.17). Other outcomes are as seen in Table 2.

## Discussion

The creation of pneumoperitoneum is a significant consideration as it is often the first step in every laparoscopic procedure. "The higher the pressure, the better the view" used to be the axiom invoked by surgeons who needed adequate exposure for laparoscopic procedures. However, the maintenance of elevated intra-abdominal pressure for the duration of the procedure is associated with numerous undesirable consequences including postoperative abdominal and shoulder tip pain.

In this trial, there was no significant difference in the pain scores of patients who had SPLA and LPLA at 6 hours and 3 days. In addition to stretching of the peritoneum from the degree of pressure from pneumoperitoneum, abdominal pain following laparoscopy could occur from sites of port insertion, areas of dissected viscera, and irritation of the peritoneum from converted $CO_2$ to carbonic acid.[7] Our finding is similar to studies comparing standard and low pressure pneumoperitoneum in patients undergoing laparoscopic cholecystectomy.[12-14] It is also possible that the operating time of a laparoscopic appendectomy is too short to demonstrate a clinical difference.

Regarding postoperative shoulder pain, there was no difference between SPLA and LPLA in the shoulder pain score after 6 hours and 3 days. For patients who had laparoscopic cholecystectomy, there is

also no widely accepted evidence that low pressure pneumoperitoneum was found to be associated with lower shoulder pain.[12-16] The origin of the shoulder pain is partly understood, and some experts believe it is caused by the overstretching of muscle fibers of the diaphragm due to the high rate of insufflation and diaphragmatic irritation.[4,15] It is likely that barotrauma is not solely responsible for shoulder tip pain, which could also explain why other causes of massive abdominal distension such as massive ascites and distal intestinal obstruction do not often present prominently with shoulder-tip pain.[16] More work is needed to properly explain this phenomenon.

A number of studies have looked at methods to reduce the incidence and severity of shoulder tip and abdominal pain following laparoscopic procedures. Some of these methods include low-pressure insufflation,[16] slow rate of insufflation,[7] no $CO_2$ insufflation,[17] use of warmed gas,[18] pre-emptive anti-inflammatory medication,[19] pre-emptive diaphragmatic local anesthetic irrigation,[20] postoperative subdiaphragmatic suction,[21] and use of regional block.[22] Use of any of these methods depends on the experience of the surgeon/anesthetist and institutional guidelines.

In this study, although the operative duration for SPLA was shorter than LPLA, the difference was not statistically significant. One major argument against low pressure pneumoperitoneum is that of safety. Lower pressure is associated with a smaller working space and may cause reduced visibility and difficult dissection, potentially resulting in longer time spent in completing the procedure. However, in this study, there was no difference in postoperative morbidity and duration of surgery between patients who had LPLA and SPLA. Evidence also agrees that in expert hands, low pressure pneumoperitoneum has no influence on intraoperative complications or conversion rate.[23,24]

The mean length of postoperative hospital stay was 24.5 hours, and there was no difference in the length of stay between both groups. This finding is also similar to length of stay in patients who had laparoscopic cholecystectomy using standard or low pressure pneumoperitoneum.[8,13,14]

Most of the similar studies have been done comparing pneumoperitoneum pressures in laparoscopic cholecystectomy, gynecological cases, and donor nephrectomy.[4,25,26] To the best of our knowledge, this is the first study comparing low and normal pressure pneumoperitoneum in patients undergoing laparoscopic appendectomy.

The setting of the study is a limitation. Cedarcrest hospital, the primary site of the study, is a relatively high-end hospital. Locally, laparoscopic appendectomy remains quite expensive and may cost multiple times the price of open appendectomy. Hence, the sample subjects were predominantly middle-high income class often with very early presentation and potentially better outcomes. For better generalizability, it would be important to test these effects on more economically diverse samples. The other main limitation of the study is the sample size, with the potential for type II errors given that the study was powered to detect a large effect size. Further multicenter studies with a larger study population could confirm this study's findings more definitively.

## Conclusion

There is no conclusive evidence to support the routine utilization of low pressure pneumoperitoneum for laparoscopic appendectomy in healthy low anesthetic risk patients. There was no significant reduction in postoperative abdominal or shoulder pain demonstrated, and its influence on other parameters such as operative time and length of hospital stay was not significant. The utilization of low pressure during laparoscopic appendectomy should be at the discretion of the surgeon based on preference and experience.

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### Conflicts of interest

There are no conflicts of interest.

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