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# Systematic review on techniques for the creation of pneumoperitoneum in laparoscopic surgeries

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## ABSTRACT

Recently, laparoscopic surgeries (LPSs) are becoming increasingly prevalent. Incorporating these methods into clinical practice necessitates an in-depth understanding of the surgical techniques and multifaceted instrumentation that are specific to a slightly invasive operation. Within this systematic review, attention is directed to the technique for pneumoperitoneum creation, like the open and closed technique, to select optimal procedures along with appropriate utilization, with prominence on complication avoidance. This systematic literature review (SLR) examined significant findings from 2018 to 2023. This SLR complies with the quality standards suggested by the PRISMA document. Web of Science, SCOPUS, ProQuest, ScienceDirect, and SpringerLink are the resources. The exclusion criteria included case reports, abstracts, and letters, as well as inclusion criteria included randomized, quasi-randomized, non-randomized, and cohort investigations on human patients, provided that they liked access safety methods and presented values. According to the findings, it can be concluded that the LP inspection of the abdominal cavity (AC), which necessitates cannula implantation, is safe and effective. Closed (Veress needle technique) and open (Hasson technique) pneumoperitoneum induction techniques are frequently utilized. Most laparoscopy (LP) surgeons prefer closed LP utilizing a Veress needle and the first trocar's masked insertion. Critics of the Veress needle, however, assert that this technique increases the risk of vascular injury. According to proponents of the open Hasson technique, vascular injury could be entirely avoided. The use of an open approach utilizing a blunt-tipped trocar for the formation of pneumoperitoneum may provide a potentially safer alternative during LPSs, depending on safety considerations.

**Key words:** Veress needle; Hasson technique; Open technique; Closed technique; Laparoscopic surgery

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## INTRODUCTION

Laparoscopy (LP) constitutes one of the most effective surgeries performed in medicine and is currently the treatment of choice for benign as well as cancerous tumors requiring surgical intervention.[1] Significant issues from LP are uncommon, happening in only three to six cases per 1000.[2] Yet, access-connected complications account for one-third to around one-half of said negative outcomes.[2] In an estimated 0.4/1000 laparoscopic surgeries (LPSs), problems may arise that include serious and possibly life-threatening negative outcomes. These occurrences may involve the perforation of the colon, principal abdominal vessels, along with anterior abdominal wall's (AW's) vessels. These variables constitute the access phase of a LPS, the most crucial step. Post-operative infection, subcutaneous emphysema, and extraperitoneal insufflations are less severe complications.[3]

The pneumoperitoneum is indispensable for LPS because it allows for visibility and mobility at the surgical site.[4] There are different methods to create pneumoperitoneum during LPS.

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These techniques involve the closed technique of insufflation following Veress needle insertion through the umbilicus (infra or supra umbilical), open LP including dissection through the linea alba and peritoneum opening under direct vision, and direct trocar insertion.[5,6]

Hasson was the first to describe the open technique in 1970. This technique involves making a small umbilical incision and inserting a blunt trocar into the abdominal cavity (AC) under direct visualization. Then, pneumoperitoneum is promptly formed. Hasson proposed that its potential benefits include avoiding Veress needle and bladed trocar's blind insertion, preventing visceral and vascular injuries, preperitoneal insufflation and gas embolism, ensuring pneumoperitoneum, and performing a more anatomical AW repair.[5,6]

Approximately 50% of LPS complications are connected to access maneuvres and insufflation right into the peritoneal cavity. There has been no recent update on this, despite the description of numerous techniques for safety along with simple abdominal access. In addition, it has not yet been demonstrated that one technique is significantly preferable to another as per technique safety. Though none of the numerous methods for inducing pneumoperitoneum during LPS have been demonstrated to be completely effective or risk-free.[5]

The preferred gas for pneumoperitoneum is carbon dioxide. This is due to the fact that each of oxygen and air are less readily assimilated, and therefore, an air embolism is more likely to result in mortality.[4] Consequently, consideration must also be given to the selection of gas during the LP technique. Minor difficulties (e.g., entry failure, gas leakage nearby the trocar, along with subcutaneous hemorrhage) have been more prevalent than catastrophic complications (i.e., intestinal and vascular injury). These difficulties necessitate lengthier procedure periods and impede surgeons' ability to focus on operations during the perioperative period.[6] The main aim of this study is to examine the various methods of pneumoperitoneum creation in LPSs. In order to ensure the patient's safety during LPS, the techniques for the creation of pneumoperitoneum and their comparative evaluation will be discussed.

### Aims and objectives

1. To evaluate the safety and efficacy of various techniques for establishing pneumoperitoneum in laparoscopic surgeries..
2. To compare the incidence of complications associated with different methods of pneumoperitoneum creation.
3. To analyze the impact of pneumoperitoneum establishment techniques on patient outcomes, including postoperative pain, length of hospital stay, and recovery time.
4. To assess the cost-effectiveness of different pneumoperitoneum creation methods, considering equipment expenses, operative time, and complication management.
5. To identify gaps in current literature regarding pneumoperitoneum establishment techniques and suggest areas for future research to improve surgical outcomes and and patient safety.

## MATERIALS AND METHODS

This study focuses on pneumoperitoneum creation during LPSs. For the purposes of this systematic review, the inclusion criteria for selection of the articles are publications from the years 2018 to 2023 that were examined using the keywords LP, along with LP entrance, Veress needle, along with Hasson technique, and open trocar entry, along with complications, and also adverse events. In addition to an automated search, the bibliographies of the chosen articles were manually combed for articles missed by the computerized search. Exclusion criteria are case studies, abstracts, and letters. Also, studies on human subjects that contrasted access modalities and provided pertinent data on safety and effectiveness outcomes that had to be predetermined were excluded. Scopus, ProQuest, ScienceDirect, SpringerLink, Google Scholar, and Web of Science were utilized to conduct this review of the pertinent literature. The inquiries were restricted to publications written in English only. There were no geographical restrictions applied to the search results.

Figure 1 depicts each step of how the data were excluded and included in the PRISMA flow diagram are discussed. Endnote was used to import the references from the databases, which were then filtered for duplication, yielding a total of 79 unique articles. The identification of relevant articles was accomplished by a systematic examination of titles along with abstracts using the specified keywords. Subsequently, the references obtained were transferred to an Excel spreadsheet to facilitate the process of filtering along with doing further analysis. This included organizing the references based on the authors' names, publication year, title, and abstract. A total of 49 objects were transferred to Microsoft Excel. Each article's abstract was examined in Excel, with a focus on those that were directly related to the research goals. At the outset, a total of 39 articles were identified. However, several publications falling under the categories of gray literature, along with books, or even book sections were excluded from the analysis. Furthermore, a subset of papers was not accessible for downloading, thereby necessitating their removal. A total of 29 articles were included in the final selection. The process of doing a literature search to choose articles

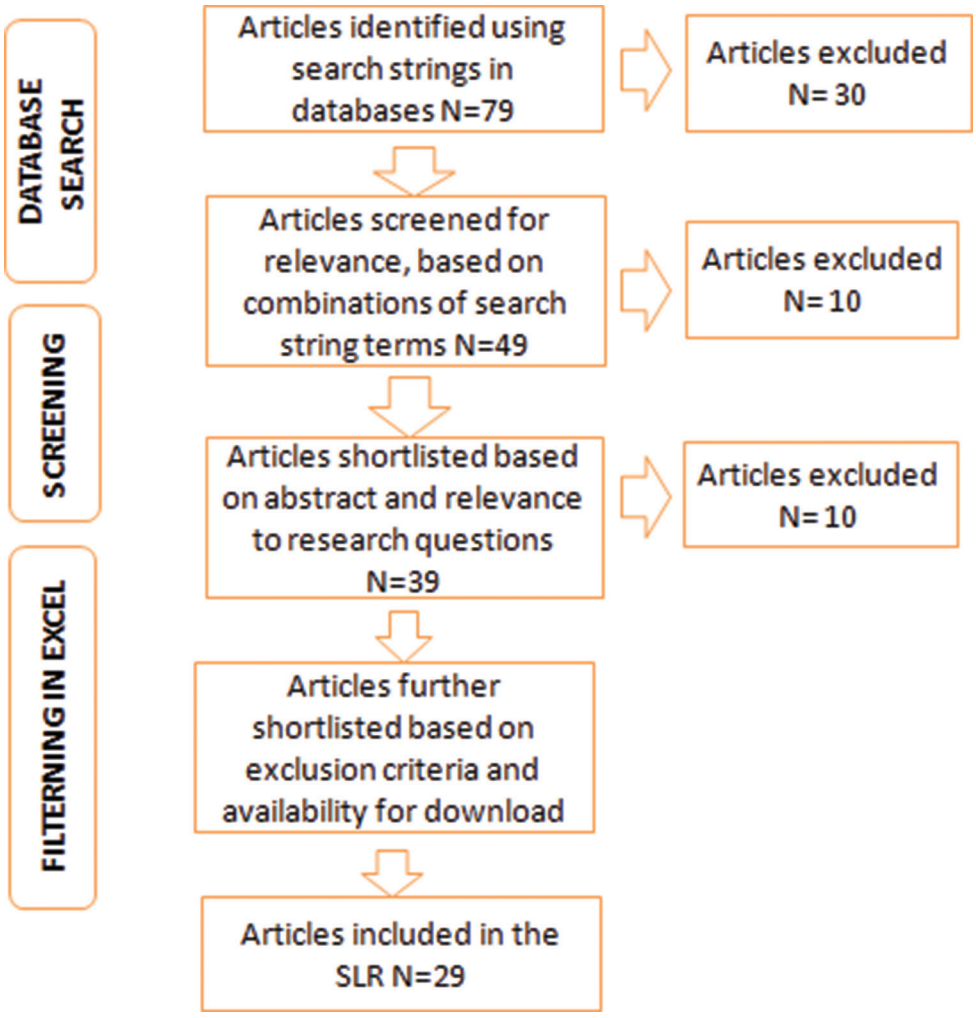


**Figure 1:** Literature search process of selection of articles for inclusion in the systematic literature review (based on the PRISMA flow diagram)

for a systematic literature review (SLR) is shown in a flow diagram (Figure 1), which is centered on the PRISMA 2009 Flow Diagram.

## RESULTS

### Pneumoperitoneum (abdominal insufflation)

LPS starts with intra-abdominal placement of the insufflation needle or even trochar, termed pneumoperitoneum, then AC's $CO_2$ insufflation to an intra-abdominal pressure (IAP) of 12–15 mmHg.[7,8] Establishing pneumoperitoneum is a crucial stage in LPS because of the iatrogenic injury risk to the main vascular structures (which are the vena cava and iliac vessels) along with the abdominal organs throughout abdominal entry (which are the intestine, liver, spleen, and also the omentum).[6]

### Types of the first entry of LP

#### *Closed access*

A Veress needle is used in the closed-access method to create pneumoperitoneum. This is the most common blind technique used by surgeons around the globe. The closed technique of access, which involves Veress needle insertion along with the creation of pneumoperitoneum, is a straightforward approach. However, it may not be suitable for some limited-access surgical procedures, like axilloscopy, along with retroperitoneoscopy, and also for fully extra-peritoneal hernia repair. Typically, a closed technique using a Veress needle is only practicable in pre-formed cavities such as the abdomen.[7]

#### *Open access*

Allowing direct entry using the open technique without the creation of pneumoperitoneum and the insufflator is connected after the blunt trocar is within the abdominal cavity under clear visibility. There are numerous methods of open access, including the Hasson, Scandinavian, and Fielding techniques.[7,8]

Certain surgeons, along with gynecologists, insert blind trocars without pneumoperitoneum. This form of access results in a significantly increased injury rate. For

sterilization, gynecologists perform this type of direct trocar entry. In individuals who have given birth several times, the lower AW exhibits laxity, resulting in a reduction in the thickness of the fascia and enabling manual elevation.[8] This allows for sterilization to be conducted. Yet, inadvertent severe primary port insertion incidents are documented in the literature.

### Different types of equipment create pneumoperitoneum

Various forms of equipment, like a Veress needle, a visual bladeless cannula, a reusable, threaded, disposable optical trocar, and a micro-optical system, were developed to ensure a safe initial entry.[9,10] However, the primary objective of the fingertip approach is to expedite and simplify the process of making a first incision in the abdomen while also minimizing the potential complications associated with creating a track (such as gas leaks, substantial damage to blood vessels, and harm to abdominal organs). Additionally, pneumoperitoneum can be created with the fingertip technique using only a 15-mm scalpel and without the use of any additional devices. The fingertip technique does not require additional instruments, retractors, assistance, or suturing.[11]

### Choice of gas for pneumoperitoneum

At first, filtered room air was used to create pneumoperitoneum. Due to the amplified air embolism risk with room air, $CO_2$ and nitrous oxide are now preferable gases. Carbon dioxide ($CO_2$) is considered a very suitable gas for pneumoperitoneum in medical procedures. This is mostly because of its low combustibility along with its high solubility in blood, which effectively reduces the likelihood of gas embolism occurring, with reported rates ranging from 0.0014% to 0.6%, which can result in patient mortality during LPS.[12-15] Amplified IAP and hypercarbia are the two primary components of $CO_2$ insufflation that have an effect on the cardiovascular, respiratory, and renal systems. $CO_2$ is used for insufflation because it is more diffusible (×200) than oxygen, is swiftly eliminated by the alveoli, and does not sustain combustion.[16] $CO_2$ is converted to carbonic acid when it comes into contact with peritoneal fluid. Furthermore, carbonic acid irritates the diaphragm, resulting in pain in the shoulder blades and distress in the abdomen. Carbonic acid has the advantage of altering the pH of peritoneal fluid (acidotic alterations) and acting as a moderate antiseptic, thereby reducing the risk of infection relative to other gases. Helium gas, which is inert by nature, is also tested in a number of facilities, but it provides no advantage over $CO_2$.[17-22] $N_2O$ gets absorbed 68% as quickly as $CO_2$ in the circulation. $N_2O$ has a moderate analgesic effect, so diagnostic LP under local anesthesia causes less pain. Under local anesthesia, $N_2O$ may also be used for brief operative procedures such as sterilization or drilling. $N_2O$ ought not to be the preferable pneumoperitoneum gas during extended LPSs as it facilitates combustion more effectively compared to air.[23]

## DISCUSSION

As stated by Raimondo et al.,[3] for LP entry, the direct trocar procedure is associated with better results, likened to the Veress needle and open methods. The direct trocar approach has been shown to be significantly related to a decreased risk of omental damage, unsuccessful entry, and extraperitoneal insufflation in comparison to the Veress needle method. In addition, it has been seen to result in lower rates of visceral injury and trocar site infection in comparison with the open method. In contrast to the open approach, the Veress needle method's utilization is linked to a much higher probability of omental damage, extraperitoneal insufflation, and incisional hernia. In addition, direct trocar had been the quickest technique, whereas the open technique was the slowest.

Since about 20 years ago, the question regarding which LP insufflation technique is superior has remained unanswered. The origin of the issue is the search for the technique with the fewest complications. Indeed, 50% of minor complications have been attributed to the initial introduction into the abdomen throughout the primary trocar insertion. Initially, it was theorized that the Veress needle technique would cause less noteworthy damage to intra-abdominal structures, such as the colon and blood vessels, due to the smaller diameter of the instrument.

LPS initially received a great deal of criticism from the surgical community as a result of these complications. To prevent these complications, other techniques, such as the open technique developed by Harrith Hasson, direct trocar insertion, along with optical trocars, drastically expending trocars, and disposable shielded trocar utilization,[24-26] have been introduced into clinical practice. Currently, the Veress needle procedure, along with Hasson's approach and their respective adaptations, are the prevailing procedures often used in contemporary practice.[27] In terms of the time required to create pneumoperitoneum, the time required to close the wounds, the total operating time, and the complications related to each technique, our studies revealed that failure of technique was more prevalent with the closed technique, while port site infection and air leakage were more of a concern with the open technique.

According to a study by Sahan et al.,[16] the Veress needle technique is among the most prevalent closed-entry methods. In contrast to other methods, this technique requires an increased amount of needle insertion attempts to acquire pneumoperitoneum due to access failure; this is especially challenging at the beginning of the learning curve. Conversely, the Hasson technique and its variations are a common open-entry technique. Although this technique appears to be safer than the Veress method, it

has some drawbacks, such as the requirement for assistance, the possibility of gas leakage, the danger of subcutaneous hemorrhage, and the lengthy procedure time.

Since implementing the fingertip technique in 2018, the LP practice has routinely utilized it for establishing pneumoperitoneum and initial port placement. This approach has been clinically demonstrated to provide convenient and rapid port insertion while exhibiting a decreased incidence of complications compared to other procedures.[19]

Six studies[28-30] have demonstrated that it is possible to perform LPS with minimal pneumoperitoneum pressure. None of the studies, however, evaluated the effects on recovery quality. In this review, one trial on an intraoperative pneumoperitoneum pressure (IPP) strategy was associated with a quicker recovery in the early post-operative period. It is worth mentioning that although some metrics used in the intervention group were predetermined and considered standard, the IPP approach protocol aimed to provide an appropriate IPP where surgeons may perform the intervention. The lithotomy position, profound neuromuscular blockade, and pre-stretching of the AW are crucial factors that enable improved individualization of IPP. Comparable surgical expertise existed between the two research groups, as LPS was performed at each participating center by a surgeon with prior LPS experience.

One of the most important stages in this type of surgery is the induction of pneumoperitoneum, which is not physiological and has negative hemodynamic and respiratory consequences.[31] With proper anesthetic management, these side effects can be reduced.[32-35] During this initial phase, one of the most hazardous outcomes of LPS is bleeding caused by the accidental rupture of a major vessel.

The level of safety of the closed technique has been questioned since its inception. To prevent injury to the viscera and blood vessels, the open technique has been advocated. However, the surgeon still faces the problem of iatrogenic injuries during LPSs. The conventional closed technique for creating pneumoperitoneum involves the first blind insertion into the AC. It has been shown that over 50% of injuries associated with this procedure may be traced to the blind entrance phase, which occurs before the commencement of anatomical dissection.[27]

### Limitations of the study

1. The availability of literature on pneumoperitoneum creation techniques is limited, potentially affecting the comprehensiveness of this systematic review.
2. Variability in study designs and methodologies across the included literature has made direct comparisons challenging.
3. Bias within individual studies, such as publication bias or selective reporting, could influence the overall findings and conclusions of this systematic review.

## CONCLUSION

Closed (Veress needle) and open (Hasson technique) techniques are commonly utilized to create pneumoperitoneum. This systematic review demonstrates the superiority of open technique over closed technique, and the literature supports this position. Surgical professionals are expected to be skilled in both methods. The results of this investigation suggest that the open technique of pneumoperitoneum is less time-consuming and safer compared to the closed technique. The first stage of any LPS is the creation of pneumoperitoneum, for which carbon dioxide is the gas of choice. Pneumoperitoneum creation under low pressure is a secure procedure, especially when performed by an experienced surgeon, with clinically insignificant systemic effects. However, the comfort level of the surgeon is greater with normal pressure than with minimal pressure. For patients enduring sophisticated LPSs, it is recommended to begin the operation with a low-pressure pneumoperitoneum. As needed for the surgeon's comfort, a low-pressure pneumoperitoneum may be increased further.

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**AZN**- Preparation of intellectual content, collecting literature, draft preparation, sorting literature, manuscript preparation. **WR**- Concept and design, manuscript preparation, editing, and manuscript revision and submission; **VB**- Design of study, analysis and interpretation of literature; **LR**- Review manuscript.
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