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Risks of anaesthetic management during laparoscopic interventions on the abdominal aorta and its branches

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Abstract

Aims: The main goal of this study is to draw attention to the dangers of anaesthetic management during laparoscopic procedures on the abdominal aorta and its branches.

Methodology: In this study, the risks of anaesthetic management during laparoscopic interventions on the abdominal aorta and its branches were determined by a systematic search use. The most recent studies in Scopus, PubMed, and google scholar databases. The search terms used were: [Risk OR adverse effect OR side effects] AND [Anaesthesia OR Anaesthetic management] AND [laparoscopic intervention or laparoscopy] AND [abdominal aorta OR abdominal aortic aneurysms] were evaluated.

Results: 1070 articles using electronic databases were first collected. After a deep search, 238 articles were selected and given to the writers for additional evaluations. A thorough brainstorming session that resulted in the selection of 12 relevant papers for the evaluation was conducted. Abdominal aortic aneurysms (AAAs) that is affected by age necessitate surgical treatment. For AAA patients, laparoscopic surgery has become a vital procedure with a number of advantages. Laparoscopic surgery has become a standard medical procedure because it reduces tissue trauma and provides significant advantages. The administration of anaesthesia in patients having laparoscopic surgery, however, is crucial and demands special attention. Despite the rarity of absolute contraindications, the anaesthetist must carefully choose the patients who may undergo such procedures and must constantly be prepared for intraoperative issues. The pain experienced by patients having laparoscopic operations, such as appendectomy, is likely to be understated, so small incisions do not always imply reduced pain levels.

Scientific Novelty: This is the first systematic review that highlights anaesthetic management during laparoscopic interventions on the abdominal aorta and its branches risks.

Conclusion: In extended laparoscopic surgery, general anaesthesia and epidural analgesia can be used together with the advantage of reduced postoperative pain severity thanks to patient-controlled spinal anaesthesia.

Keywords: Spinal anaesthesia, abdominal aortic aneurysms, critical assessment tools

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Introduction

Laparoscopic surgery is one of the most important tools for diagnosis and treatment in the current medical era. This has been the industry norm ever since Phillipe Mouret effectively completed the first laparoscopic

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cholecystectomy in 1987 [1]. Less discomfort, quicker hospital stays, early mobilisation, and minimal damaging are all advantages of minimal access methods that have led to an increase in their use [2]. Pneumoperitoneum is needed for sufficient visualisation and operative handling during this minimally invasive treatment. The intra-abdominal pressure and the gas use both affect systemic changes, particularly cardiovascular changes. The primary concerns during laparoscopic surgery are the cardiovascular consequences of pneumoperitoneum, venous gas embolism, systemic carbon dioxide absorption, accidentally damaging intra-abdominal structures, and patient positioning [3, 4]. During the laparoscopy, the surgeon has a limited range of movement from a tiny invasion hole and has difficulty in feeling tissue, hence unable to judge the force needs to be applied.

The pathophysiologic changes brought on by the formation of the pneumoperitoneum and the necessary positioning of the patient confounds anaesthesia in laparoscopic operations. The length of the procedure is typically lengthier, the possibility of visceral damage, and the difficulty of estimating the amount of blood loss when haemorrhage happens all this contribute to the procedure's potential for high risk. To be ready to avoid, identify, and treat any potential changes that might take place during the operation, the anaesthesiologist needs to have a thorough knowledge of the pathophysiological effects caused by the pneumoperitoneum.

Research Problem

Laparoscopy for general surgery has advantages such as decreased intraoperative bleeding, decreased postoperative pulmonary problems, decreased postoperative wound infections, less metabolic disturbance, and better postoperative respiratory function. Additionally, it resulted in faster returns to regular activities, shorter stays in hospitals, and lower total medical expenses [5]. Anaesthesia during laparoscopy has become more logistically challenging in recent years as improved laparoscopic surgery has targeted elderly and sicker patients. Laparoscopy was developed as a secure, straightforward operation that could be done as an outpatient procedure, so it demands great care regarding the anaesthetic method. On the other hand, it can impair the patients' cardiovascular and respiratory systems. In order to provide the best anaesthetic treatment and enable early detection and complications reduction, laparoscopic surgery provides the anaesthesiologist with a number of new challenges.

Research Focus

The aim of anaesthetic management for patients undergoing laparoscopic surgery should be to facilitate physiological changes during surgery with minimal influence on the body's vital systems and rapid anaesthesia recovery with insignificant aftertaste. These changes may all be detected by keeping an eye on the electrocardiogram (EKG), the non-invasive arterial pressure (NIBP), the pulse oximeter (SpO2), the airway pressure, the et-CO2 concentration, the peripheral nerve stimuli, and body temperature. When a patient's cardiopulmonary function is impaired, it's also important monitoring their urinary production. Additionally, the urinary procedure reduces the possibility of bladder damage during port placement. Atropine must be used with caution because it raises the chance of tachyarrhythmia while also preventing vagal stimulated bradyarrhythmia [6]. There is a need of research to determine the risks of anaesthetic management during laparoscopic interventions on the abdominal aorta and its branches.

Research Aim and Research Questions

The main goal of this study is to draw attention to the dangers of anaesthesia used during laparoscopic procedures on the abdominal aorta and its branches. The following research questions have been address:

1. Does laparoscopic interventions poses any complications on the abdominal aorta and its branches?
2. Do pneumoperitoneum and the positioning of the patient confound anaesthesia in laparoscopic operations?
3. What are the risks of anaesthetic management during laparoscopic surgery?

Literature Review

The night before operation, doctors may give benzodiazepines or other benzodiazepine-like hypnotics to anxious patients. Ondensetron use is advised preoperatively because postoperative nausea and vomiting (PONV) is a laparoscopic surgical risk that is anticipated. The preferred anaesthetic methods for abdominal laparoscopic surgery include general anaesthesia with muscle paralysis, tracheal intubation, intermittent positive pressure breathing (IPPV) with small tidal volume, and addition of a positive end-expiratory pressure (PEEP) of 5 cms of water [7]. A more recent advancement in the anaesthetic technique is the use of a laryngeal mask airway (LMA), which maintains the patient's spontaneous breathing. Ryle's tube aspiration should be used to compress the stomach during trocar insertion to lessen the possibility of gastric injury. It is controversial whether nitrous oxide should be used during laparoscopic surgery since it might result in intestinal distension [8]. Because it has fewer symptoms that can cause arrhythmia and cardiac depression, isoflurane is the favoured volatile anaesthetic drug.

For casual gynaecological laparoscopic operations, epidural anaesthesia has been used to decrease problems and speed up the post-anaesthesia healing process [9]. Some studies claim that ventilation with a large tidal volume of 12 to 15 ml/kg stops the progression of alveolar atelectasis and hypoxemia and allows for more effective alveolar ventilation and carbon dioxide elimination [10], but other studies back ventilation with a moderate tidal volume and the addition of PEEP. The difference between PaCO2 and PECO2 can be used to assess the ventilation's effectiveness. In healthy individuals undergoing general anaesthesia, it ranges from 2 to 9 mmHg [11]; however, the gradient between PECO2 and PaCO2 may become elevated and unstable in patients with impaired cardiopulmonary function. Therefore, arterial blood gas measurement may be required to directly estimate PaCO2 in order to identify hypercarbia [12]. A PECO2 sensor is useful for venous gas embolism early identification as well [13]. In anaesthetised patients getting IPPV, It's important to check the airway pressure on a frequent basis because a high airway pressure alert can help identify an excessive increase of intra-abdominal pressure [14]. The literature review provides information about the previous studies concerning the risk during the laparoscopy with varying results. In the present systematic review focused on the risks of anaesthetic management during laparoscopic interventions on the abdominal aorta and its branches. This will provide information in managing these risks for the laparoscopic surgery.

Metodology

General Background

The studies included in this review used a range of study designs, many of them did not adhere to traditional procedures for data collection and theoretical tenets. One carried out keyword searches in the Scopus, PubMed, and Google Scholar databases to find pertinent papers. The search terms used were: [Risk OR adverse effect OR side effects] AND [Anesthesia OR Anesthetic management] AND [laparoscopic intervention or laparoscopy] AND [abdominal aorta OR abdominal aortic aneurysms]. These keywords were intended to help locating the papers that addressed the subject of our research. We looked for and selected peer-reviewed English-language research articles from these keyword searches. The relevancy of the titles, abstracts, and keywords was checked by two independent reviewers. Publications having titles or abstracts that complied with the requirements for this systematic review were chosen for a more thorough examination. Before adding the article to the research, the whole text of each article was read in case there was any ambiguity. Pre-prints were not included since we were unable to assess their reliability because the scientific community had not yet publicly recognised them through the peer-review process. Articles that omitted any of the aforementioned details were not included in this study (Table 1).

Table 1. Inclusion and exclusion criteria for studies

Inclusion criteria	Exclusion criteria
Studies on risks of anaesthetic management during laparoscopic interventions	Anything not including the listed topic
Peer reviewed scientific articles	Anything other than peer-reviewed articles and literature
English language research	Publications in languages other than English

Author's development

Data Analysis

The current study conforms to all advised research ethical standards. Since this study was a review of the findings of other previously published articles that were accessible to the public, the Research Ethics Committee did not formally approve it.

Results

A number of standards were utilised for the article eligibility, as listed in Table 1, in accordance with the PRISMA principles and critical assessment tools to guarantee the calibre and consistency of the identified articles. The authors first retrieved 1070 papers for use in electronic databases. These publications were then compared to the study's goals, and any that didn't fit the bill were disregarded. 238 publications were chosen after further screening and dispersed to the authors for additional evaluations. A comprehensive brainstorming session by the authors led to the inclusion of 12 pertinent articles in the review (Figure 1).

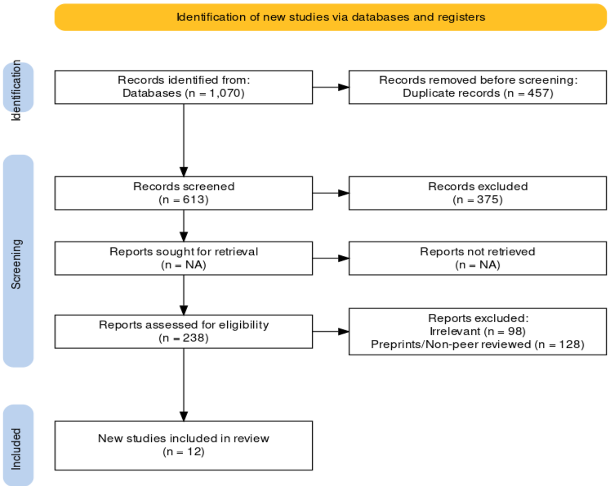

Figure 1. The PRISMA flow chart of the literature selection for the systematic literature review (author's development)

Discussion

The present study focuses on the risks of anaesthetic management during laparoscopy. The 13th most common cause of mortality in the US is abdominal aortic aneurysms (AAAs) [15] and each year, 40,000 individuals have elective AAA repair [16]. With an average age of 70, AAA primarily affects the aged, and its frequency rises as people mature. Surgical treatment options rely on the site and severity of the illness and may include open repair or endovascular stenting. Laparoscopic surgery, as opposed to open surgery, carries a 0.3% to 1.8% reduced chance of cardiovascular morbidity and death [17]. As a result, laparoscopic surgery is commonly performed on high-risk individuals. However, compared to low intra-abdominal pressure, high intra-abdominal pressure brought on by CO_2 insufflation in these high-risk individuals is linked with more changes in hemodynamic parameters, raising the risk of cardiovascular problems [18]. In current study, we systematically reviewed the risks of anaesthetic management during laparoscopy.

An increase in intra-abdominal pressure causes the venous blood return to be mechanically impaired, which causes the preload to decrease and the afterload to rise. The systemic vascular resistance (SVR), mean arterial pressure (MAP), and heart output will all rise [17]. The top portion of the body is typically most affected by high MAP. A further reduction in blood flow downstream to the coarctation may result from a rise in the SVR caused by the development of pneumoperitoneum, along with a decline in the stroke volume, cardiac, and ejection velocity parameters. Laparoscopic procedures benefit from low-pressure pneumoperitoneum because it reduces the negative cardiovascular impacts of CO_2 insufflation [18]. The results of the given systematic review are in line with the previous studies highlighting the risks during laparoscopy.

To reduce circulatory alterations during pneumoperitoneum, intra-abdominal pressure should be kept below 12 mmHg [19, 20]. It is thought that sufficient tissue perfusion requires a MAP 60 mmHg. Laparoscopy surgery had advantages such as decreased intraoperative haemorrhage, decreased postoperative pulmonary problems, decreased postoperative wound infections, decreased metabolic disruption, and better postoperative respiratory function. It also produced better cosmetic results, allowed for a quicker return to normal activities, and reduced hospital stays, which reduced overall medical costs [5]. In current study, the findings also suggested the advantages and disadvantages as reported previously.

Laparoscopic procedures have several advantages and disadvantages as presented in Table 2.

Table 2. Laparoscopic surgery advantages and disadvantages in terms of surgery

Advantage	Disadvantage
Intraoperative:	

Less blood and coagulation factor transfusions are necessary due to decreased blood loss [21] Reduced tissue trauma An image of the whole abdominal cavity	Extended operational period A higher price Technique is more difficult and there is no tactile feedback Surgery to treat bleeding issues may take longer than expected Some surgical devices are not functional
Postoperative:	
Improved anaesthetic outcomes Less pain and less need for analgesia Longer recovery times with preserved lung function Lower incidence of wound infections Reduced hospitalisation	Tissue damage and nerve damage brought on by placement and lengthy operations

Source: [22-26]

Surgery needs and physiological changes during the surgery process must be taken into account when managing anaesthesia for patients having laparoscopic surgery. The most common way to conduct laparoscopic surgery is under general anaesthetic with positive pressure ventilation and a cuffed endotracheal tube, which provides the over minute respiration and PaCO2 control. Due to the elevated danger of aspiration and ventilation issues brought on by the greater airway pressures necessary during pneumoperitoneum, the use of the laryngeal mask airway (LMA) during laparoscopic abdominal surgery is still debatable [27]. In the present study one focused on the risk of the anaesthetic management during the laparoscopy.

The objective of anaesthesia is to maintain greater arterial blood pressure (ABP) proximally, maintaining ABP distal to coarctation at 60 mmHg or higher. Other accompanying diseases like left ventricle enlargement, intracranial aneurysm and ischemic heart disease, may change the condition management [28]. The primary issues with laparoscopy are higher intra-abdominal pressures, patient positioning, and carbon dioxide insufflations. Pneumoperitoneum should be started with reduced gas flow and intra-abdominal pressures should be kept as low as possible to reduce hemodynamic alterations [29]. The current study highlight that anaesthesia poses risks during laparoscopy management.

The minimum pressure required to cause minor hemodynamic alterations during pneumoperitoneum is 12 mmHg. The preload decreases when the intra-abdominal pressure rises, as a consequence the afterload, the systemic vascular resistance and the intra-abdominal pressure rise [30]. The upper part of the body is typically most affected by high ABP. The development of pneumoperitoneum increases total peripheral resistance and decreases the heart ejection velocity, as well as stroke volume parameters [31, 32]. Further reduction in blood flow downstream to the coarctation may result from these alterations. To keep the blood pressure within safe ranges, intrusive ABP tracking is used. It's crucial to choose the right location for ABP tracking. It is wise to assess ABP both proximally and distally to the coarctation in order to gauge the body's circulation. With the exception of brief gynaecological operations, local or regional methods have not been recommended as the only type of anaesthesia for laparoscopic abdominal treatments. In order to eliminate the pain of surgical stimulus, which could result in myocardial depression and exacerbate the effects of the pneumoperitoneum, a strong block (T2-T4 level) is necessary [4]. Additional drawbacks include the need for more breaths to be taken in, how the patient is positioned, and diaphragmatic discomfort, which may not be relieved in a conscious patient by spinal anaesthetic alone [33].

The patient's circulatory system state is influenced by a wide range of laparoscopic surgery-related variables. The most notable example of this is the rise in intraabdominal pressure (IAP) brought on by the patient's posture and CO2 expansion. As pneumoperitoneum develops, the IAP gradually increases, increasing strain on the splanchnic vessels. In the initial stages of the laparoscopic operation, this causes an increase in loading and a subsequent rise in blood pressure. Catecholamines may be released in reaction to pain and the neuro-humoral response to peritoneal straining, which can cause serious increases in blood pressure and tachyarrhythmia [34]. Vein failure is a possibility if IAP is greater than IV pressure in the splanchnic veins; this effect is then reversed to increase inferior vena cava compression. Hemodynamic instability may be exacerbated by co-morbidities, surgical handling, anaesthetic-induced vasodilation, release of prostaglandins and hemodynamic instability. Changes in the patient's posture are also essential. For instance, cholecystectomy surgery involves anti-Trendelenburg posture, which may result in a reduction in the Cardiac Index (CI) because of a reduced venous return from the lower body. Trendelenburg posture is frequently required for procedures in the lower abdomen quadrants. Venous return rises as a result of the elevated lower torso, which in turn elevates CI, central venous pressure (CVP), and intracranial pressure (ICP) [34, 35]. The results of this study showed that the patient's circulatory system state is important during the laparoscopy.

The anaesthetist should be ready for either severe hypertension or severe hypotension depending on the stage and method of the operation. IAP should be closely monitored, with a goal of ≤15 mmHg [36]. Postoperative lung function is also impacted by intraoperative lung airflow compromise and atelectasis development [37]. These findings are in accordance to our research hypothesis.

Patients who have had laparoscopic surgery have both the forced expiratory volume and vital capacity [38]. The circulation of abdominal organs like the kidney and liver will be compromised as IAP increases and surpasses the abdominal arteries' arterial pressure, and venous outflow will be decreased. Reduced glomerular filtration results from decreased urine output and retained creatine, as well as decreased renal blood flow. Optimising the venous capacity can lessen the impact of this [39]. The findings of this study are in line with our research question.

The anaesthetist should monitor the patient's renal function, perioperative diuresis, and intravascular volume condition. Hepatic failure and an increase in liver enzymes can be observed if the liver's blood flow or venous outflow are compromised [40]. These side effects are typically self-limited and have no morbidity in individuals with adequate liver function [41]. The anaesthetist should be concerned about liver function if there is a history of liver dysfunction or if the increase in IAP is markedly protracted.

As with pneumoperitoneum, CO_2 in the abdominal region will eventually be reabsorbed into the bloodstream. IAP, the site of CO_2 administration, and the stage of the process all affect abdominal CO_2 resorption. There is proof that pleural CO_2 will not be resorbed as quickly as extra-peritoneal insufflates CO_2, which is used in laparoscopic circumcision [42]. CO_2 resorption will rise at the start of the operation with the commencement of pneumoperitoneum, reach a stable state, and may temporarily rise again after the release of pneumoperitoneum at the end of the surgery because of the increase in venous return with lowering IAP. After being reabsorbed, the CO_2 is then transported to the lungs, where it will be expelled with the CO_2 produced by normal metabolism. Because CO_2 partial pressure impacts acid-base balance, breathing needs to be controlled to prevent hypercapnia and acidosis. To meet the respiratory demand brought on by a rise in CO_2 resorption in the pneumoperitoneum, minute respiration must be raised by up to 15% [43]. The findings of our review also suggested that anaesthetic management should be done through restoration of respiratory function.

It has been proven that using a valve-less trocar by the surgeons during robot-assisted radical cystectomy enhances respiratory mechanics. It has also been suggested that this technique may reduce the need for extended pneumoperitoneum [44]. The results of this systematic review are in line with the findings of this study.

The doctors should be requested to lower IAP or temporarily halt the CO_2 supply if ventilator adjustment is not an option. Otherwise, hypoventilation causes acidity and hypercapnia. Acidosis and elevated pCO_2 cause the cerebral arteries to dilate, which is followed by a rise in cerebral blood flow and ICP. In individuals with right heart failure, acidosis can cause pulmonary vasoconstriction, which raises pulmonary vascular resistance and increases the right-left shunt, all of which can result in cardiac decompensation. Therefore, it's crucial to continuously check the patient's end-tidal pCO_2 ($petCO_2$), acid-base balance, and gas exchange.

The danger of postoperative nausea and vomiting (PONV) and anaesthesia gas emissions in the operating room are both decreased when propofol is used in total intravenous anaesthesia (TIVA) [45]. In addition, propofol might prevent an increase in intraocular pressure (IOP) after Trendelenburg posture and pneumoperitoneum, in contrast to sevoflurane [26, 45]. While inhalational anaesthesia has been controversially discussed even in cardiac surgery, balanced anaesthesia provides the benefits of better monitoring and perhaps safer anaesthetic supply if venous access is not visible, such as if arms are linked to the body throughout the treatment, [26, 46]. Additionally, compared to propofol, the suppression of spine responses is more evident when using volatile anaesthetics like sevoflurane [47, 48].

In extended laparoscopic surgery, general anaesthesia and epidural analgesia can be mixed with the advantage of reduced postoperative pain severity thanks to patient-controlled spinal anaesthesia (PCEA). There is evidence that individuals undergoing upper abdominal laparoscopic surgery who have pulmonary risk factors benefit even more from thoracic epidural analgesia [49]. For every patient, the advantages of spinal anaesthesia may not, however, exceed the risks. As a result, thorough individual benefit-to-risk analysis is required. To enable sufficient ventilation when IAP is raised in a pneumoperitoneum with CO_2 and extreme placement, the airway control is crucial. Higher ventilation rates and aspiration avoidance are both feasible here. Even though intubation is the gold standard, the use of second generation supraglottic airway devices can be investigated in some circumstances, such as lower abdominal and pelvic surgeries. Because they provide an optimal fit and the option to insert a stomach tube, these devices may be able to provide safe breathing in laparoscopic procedures even in obese individuals [50]. There is evidence that when laryngeal masks are used instead of endotracheal intubation, PONV and postoperative throat pain diminish, as well as hemodynamic alterations that occur during endotracheal intubation are prevented [51, 52]. It has been established that pressure-controlled breathing and muscle inhibition are the best methods for ensuring adequate oxygenation and lung protection [53]. There is some evidence to suggest that deep neuromuscular blocking, as opposed to mild neuromuscular block, can enhance surgical conditions and potentially enable for the use of reduced IAP [54]. The question of whether this technique is usually advised, should only be used in certain procedures, or even be reserved for challenging surgical circumstances, is still up for debate [55, 56]. Controlling and treating atelectasis development calls for careful lung recruitment strategies and adjustment to an adequate positive end-expiratory pressure (PEEP) [57]. Therefore, careful consideration of anaesthetic management during laparoscopic procedures should be made depending on the type of operation and the health of the patient.

Conclusions and Implications

1. Abdominal aortic aneurysms (AAAs) are most common in elderly people and must be treated surgically.
2. The laparoscopic procedure has gained popularity and offers AAA patients a number of advantages.
3. The laparoscopic surgery provides significant advantages through decreased tissue trauma. However, the management of anaesthesia in patients having laparoscopic surgery is vital and necessitates special attention.
4. Although absolute contraindications are uncommon, the anaesthetist must carefully choose which patients can endure such operations and must always be ready for intraoperative problems. The pain experienced by patients having laparoscopic operations, such as appendectomy, is likely to be understated, so small incisions do not always imply reduced pain levels.
5. Total intravenous anaesthesia with propofol lowers the risk of postoperative sickness and vomiting and lessens anaesthesia gas emissions in the operating room and surrounding areas.
6. In order to reduce subsequent pain severity, general anaesthesia and patient-controlled epidural anaesthesia can be used during intensive laparoscopic surgery.
7. It is also possible to accomplish the anaesthetic management through restoration of respiratory function.
8. The risks of anaesthesia should always be considered in laparoscopic surgeries in order to avoid complications during and after the surgery.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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