Review/*Derleme*

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Laparoscopic Surgery and Anesthesia

Laparoskopik Cerrahi ve Anestezi

Begum Nemika Gokdemir, Nedim Cekmen

Baskent University, Faculty of Medicine, Ankara Hospital, Ankara, Turkey

ABSTRACT

Laparoscopic surgery (LS) is superior to conventional laparotomy due to its advantages, such as less trauma, early mobilization, minimal blood loss, less scarring, reduced postoperative pain, shorter postoperative recovery time and hospital stay, and lower mortality and morbidity. Significant hemodynamic, cardiopulmonary, and physiological changes occur in the systems due to increased intra-abdominal pressure and hypercarbia after carbon dioxide insufflation is applied for pneumoperitoneum (PP) during LS. The main goals in anesthesia management are understanding the primary pathophysiology, optimizing functional status and hemodynamics, and managing comorbidities. To minimize the effects and impacts of PP in patients who will undergo LS, as in every patient, comprehensive preoperative evaluation should be carried out by multidisciplinary approach that includes an anesthesiologist and surgeon. Our review emphasizes the importance of pathophysiological and systemic changes during LS performed by applying PP and summarizes the recovery and postoperative complications of anesthesia methods applied in clinical practice.

Keywords: Laparoscopic surgeries, pneumoperitoneum, hemodynamic and cardiopulmonary changes, anesthesia

ÖZ

Laparoskopik cerrahiler (LC), daha az travma, erken mobilizasyon, minimum kan kaybı, daha az yara skarı ve ağrı, daha kısa postoperatif iyileşme ve hastanede kalış süreleri ve daha düşük mortalite ve morbidite gibi avantajları nedeniyle konvansiyonel laparotomiden üstündür. Laparoskopik cerrahiler sırasında, uygulanan karbondioksit insuflasyonuna bağlı olarak intraabdominal basınç artışı ve oluşan hiperkarbi sonucunda sistemler üzerinde önemli hemodinamik, kardiyopulmoner ve fizyolojik değişiklikler meydana gelir. Anestezi yönetiminde ana hedefler, temel patofizyolojiyi anlamak, fonksiyonel durumu ve hemodinamiyi optimize etmek ve komorbiditeleri yönetmek olmalıdır. Laparoskopik cerrahiler geçirecek hastalarda pnömoperitonyumun (PP) etkilerini ve sonuçlarını minimalize etmek için her hastada olduğu gibi ayrıntılı preoperatif değerlendirme, anesteziyolog ve cerrahı içeren multidisipliner bir yaklaşımla yapılmalıdır. Derlememiz, PP uygulanarak gerçekleştirilen LC sırasındaki patofizyolojik ve sistemik değişiklerin önemini vurgulamakta, klinik pratikte uygulanan anestezi yöntemlerinin LC sonrası derlenme ve postoperatif komplikasyonlarını özetlemektedir.

Anahtar sözcükler: Laparoskopik cerrahi, pnömoperitonyum, hemodinamik ve kardiyopulmoner değişiklikler, anestezi

INTRODUCTION

Laparoscopic surgery (LS) has been an appropriate diagnosis and treatment method since the first laparoscopic cholecystectomy was performed. Laparoscopic surgery, especially cholecystectomy, colectomy, appendectomy, hysterectomy, adrenalectomy, sleeve gastrectomy, Roux-en-Y gastric bypass, and kidney, liver, and pancreas, inguinal hernia repair, are responsible for >2 million annual surgical procedures worldwide (1-3). Although the overall mortality of LS is low, it is approximately between 0.3%-1.8% (2,3). This mini-invasive procedure is superior to traditional laparotomy because of mini-incision, less trauma, minimal blood loss, less scarring, reduced postoperative nausea-vomiting (PONV), and postoperative pain, early mobilization, shorter postoperative recovery time and hospital stay, lower mortality and morbidity, and healthcare costs (2,3). Laparoscopic surgery minimizes surgical trauma due to decreased secretion of acute inflammatory markers, rapid return of cytokine levels to normal values, and low cortisol levels. Accordingly, it has been shown that immune functions are better preserved. The most critical factor is diminished surgical trauma due to small incisions and minimal traumatic surgery techniques (4,5).

An intraabdominal pressure (IAP) of 12-15 mmHg is used during pneumoperitoneum (PP). Significant hemodynamic, cardiopulmonary, and physiological changes occur in the systems due to increased IAP and hypercarbia after carbon dioxide (CO_2) insufflation is applied for PP during LS (Table I) (6-9). Although it has been preferred more due to its many

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***Corresponding author:** Begum Nemika Gokdemir • begokdemir@yahoo.com
Begum Nemika Gokdemir 0000-0003-0114-5845 / Nedim Cekmen 0000-0002-6916-1772

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advantages in recent years, LS also has some hemodynamic, systemic, and ventilatory difficulties due to PP, systemic gas absorption, embolism, intra-abdominal vascular and organ injuries, and patient position (2,5,9-12). The main goals in anesthesia management are understanding the primary pathophysiology, optimizing functional status and hemodynamics, and managing comorbidities.

Herein, our review emphasizes the importance of pathophysiological and systemic changes during LS performed by applying PP and summarizes the recovery and postoperative complications of anesthesia methods applied in clinical practice.

PREOPERATIVE EVALUATION

Detailed preoperative evaluation should be performed in patients who come for LS, and they require special attention, especially patients with cardiopulmonary disease. The preoperative thorough anesthetic evaluation aims to estimate and reduce the risk of mortality and morbidity due to anesthesia and surgery (10-13).

Laparoscopic surgey is a method frequently used in all including high risk patient groups such as the elderly, pregnancy, infant and pediatric, obesity and cardiovascular (including congenital heart disease (CHD)), congestive heart failure (CHF), valvular heart disease (VHD), ischemic heart disease (IHD), pulmonary hypertension (PH), chronic obstructive pulmonary disease (COPD), restrictive pulmonary disease, and chronic kidney disease (CKD) (14-15).

In addition to the routine evaluations performed in the preoperative period, electrocardiography (ECG) and transthoracic echocardiography (TTE) should be performed in patients with pulmonary disease (such as COPD, asthma, and emphysema), and if necessary, X-ray or thoracic computer tomography evaluation should be supported by pulmonary function testing (PFT) (13,16-18).

PREMEDICATION

Premedication should be done with the appropriate drug according to the patient's current clinical situation and comorbidities. The drug chosen for premedication should have minimal side effects and should relieve the patient. A short-acting benzodiazepine for premedication (usually midazolam is given) and the suitable dose and timing of administration are crucial to achiev maximum effect (10,13). In our clinic, we administer intravenous (IV) midazolam for premedication.

MONITORING

Suitable anesthetic methods with adequate monitoring to determine and decrease complications and provide optimal anesthesia care during LS should be used. Standard monitoring should be performed according to the risk assessment made in the preoperative period. Electrocardiography, heart rate (HR), noninvasive blood pressure (BP), respiratory rate (RR), pulse oximetry (SpO_2), end-tidal carbon dioxide ($EtCO_2$), IAP, airway pressure, and body temperature monitoring for all surgical cases should be performed. Invasive monitoring should be performed in addition to standard monitoring based on the risk of the operation, duration, and concomitant diseases. During LS, intraperitoneal insufflation of dry, unheated gas, possibly accompanied by irrigation with cold fluids, causes the patient to lose heat at least equal to that at laparotomy. In addition, it is very important to remember that excessive gas leakage from the cannula causes rapid hypothermia in the patient. When the procedures last several hours, it is important to apply protective methods to prevent heat loss by monitoring the body temperature.

Therefore, hypothermia should be prevented during the operation (2,5-7,10,12). Careful monitoring of cardiovascular parameters, arterial blood gases (ABGs), and urine output (UO) is indicated for patients who have hemodynamically unstable cardiopulmonary dysfunction, are elderly, or obese. Individualized preoperative risk evaluation, treatment optimization, and advanced perioperative planning can reduce difficulties and complications (10,12).

Although $EtCO_2$ is used in all general anesthesia (GA) applications, following up in LS is especially important, which gives us valuable information about PP effects (19,20). The normal partial pressure of carbon dioxide ($PaCO_2$)-$EtCO_2$ difference is 2-5 mmHg. The difference increases slightly with age, attributed to an age-related decrease in functional residual capacity (FRC) and a rise in alveolar dead space (21-23). This typical minor disparity between these increases has a wide range of factors. These factors are generally evaluated in three main classes: a) Ventilation (V) impairment in the lung, b) Perfusion (Q) impairment in the lung, c) Ventilation/Perfusion (V/Q) mismatch (24). Maximum end-expiratory PCO_2, known as end-tidal PCO_2 ($PetCO_2$), is evidence of CO_2 production by cellular metabolism, absorbed in the peritoneal cavity and through the pulmonary exchange. The rapid increase in $PetCO_2$ in anesthesia for LS indicates a serious complication. Therefore, continuous and careful monitoring of $EtCO_2$ in capnography is a very useful and effective noninvasive monitoring technique (19).

A rapid decrease in $PetCO_2$ may indicate a decrease in venous return, cardiac output (CO), and pulmonary artery obliteration. This picture occurs in massive gas embolism with a decrease in $PetCO_2$. The V/Q ratio is usually higher than 1 in the anesthetized patient undergoing mechanical ventilation, so a $PaCO_2$-$PetCO_2$ gradient of 10 to 15 mmHg should be expected. However, the gradient between $PaCO_2$ and $PetCO_2$ should be carefully evaluated, as $EtCO_2$ can differ significantly from $PaCO_2$ in the V/Q mismatch. In patients with cardiorespiratory dysfunction, the difference between $PetCO_2$ and $PaCO_2$ rises markedly, so direct $PaCO_2$ measurement with ABG analysis may be necessary to detect hypercarbia (19,20,24-26).

Anesthesiologists need to provide optimal conditions for hemodynamics, ventilation, oxygenation, and perfusion, maintain body temperature, acid-base, and fluid-electrolyte balance, and control pain perioperatively to ensure better outcomes.

During positive pressure ventilation (PPV), an elevated plateau and airway pressure alarm can help detect uncontrolled elevations in IAP (7,27,28). Adjusting positive end-expiratory pressure (PEEP) levels, especially in LS, is controversial. Optimal PEEP requirements in patients undergoing protective ventilation in abdominal surgery under GA have varied considerably from patient to patient (21-23,27,28). However, individualized PEEP is more advantageous than fixed PEEP, as it provides better respiratory mechanics and oxygenation and reduces the incidence and severity of pulmonary atelectasis (21,27-30). So, individualized PEEP is more important in the protective ventilation strategy to prevent progressive alveolar collapse and postoperative pulmonary complications (PPCs). There is insufficient evidence for optimal PEEP during mechanical ventilation in elderly and obese patients undergoing LS (21,27,31-33).

It is appropriate to start with a tidal volume of 6 mL kg^{-1} and not to increase the peak airway pressures above 30 mmHg (21-23,30). Alveolar overstrain should be avoided to prevent increased pulmonary vascular resistance and airway pressure. The respiratory rate was started at 12 breaths min^{-1} and then adjusted to keep the $PetCO_2$ at 30-35 mmHg and $EtCO_2$ at 30-35 mmHg. PEEP is set to 5-10 cmH_2O, ideally. Adequate PEEP and recruitment maneuvers (RMs) may contribute to maintaining V/Q matching. Higher PEEP levels can reduce preload and cause systemic hypotension. An increasing fraction of inspired oxygen (FiO_2) may be required rather than PEEP to improve oxygenation. Recruitment maneuvers were stopped if the plateau pressure reached 30 mmHg (28,29,31-36). To improve intraoperative oxygenation, postoperative atelectasis, and respiratory mechanics and reduce the incidence of PPCs in our adult, obese, elderly patients undergoing LS, we apply dynamic, individualized PEEP values under the guidance of driving pressure (ΔP=Plateau pressure-PEEP) considering their comorbidities.

Depth of anesthesia (Bispectral Index (BIS)) and neuromuscular monitoring (Train of Four (TOF)) should be performed in these patients (7,9,37,38). Train of Four should be performed to reduce abdominal distension and IAP during LS, to prevent sudden patient movements that may cause accidental injury to intra-abdominal structures, and to ensure adequate muscle relaxation (38). In our clinic, we apply standard monitoring, $EtCO_2$, airway pressures, and body temperature monitoring in patient follow-up. In operations exceeding 2 hours, we use a urinary catheter and, if necessary, ABG, BIS, and TOF monitoring were also performed depending on the patient's comorbidities.

ANESTHETIC APPROACH

Since LS procedures are performed more frequently in outpatient practice, they can be achieved using GA and regional anesthesia (RA) (39,40).

Laparoscopic surgery procedures include four stages (9,10,12):

1- Anesthesia induction

2- Insufflation

3- Desufflation

4- Recovery

Each stage has distinct hemodynamic, systemic, and physiological changes (Figure 1) (8-10,12).

1. Induction of Anesthesia

Patients undergoing LS should be a premedicated appropriately, but adequate preoxygenation should be ensured, especially during anesthesia induction. With careful consideration of the patient's physical condition, current cardiopulmonary

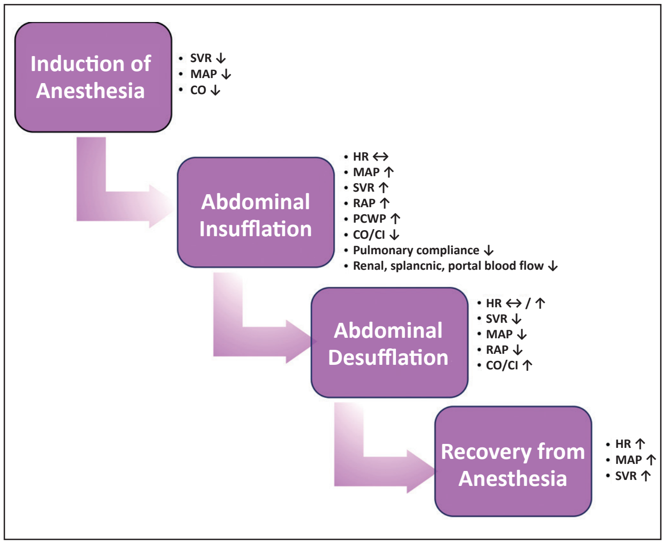

Figure 1: Hemodynamic and cardiopulmonary changes in phases of laparoscopic surgery. **SVR:** Systemic vascular resistance, **MAP:** Mean arterial pressure, **CO:** Cardiac output, **HR:** Heart rate, **RAP:** Right atrial pressure, **PCWP:** Pulmonary capillary wedge pressure, **CI:** Cardiac index.

functions, comorbidities, surgical features, and anesthesiologists' experience, anesthesia induction should preserve hemodynamic stability (10,12,39-42).

A balanced or total intravenous anesthesia (TIVA) technique can be used. However, there is no ideal anesthetic agent for LS patients, but the optimal anesthetic agent for LS takes advantage of the excellent pharmacokinetics of drugs. After premedication with benzodiazepines, balanced GA induction and maintenance can be achieved with concomitant use of lidocaine, opioids, propofol, etomidate, ketamine, α_2 agonists (Dexmedetomidine). Short acting volatile anesthetics such as desflurane and sevoflurane, and continuous infusion of propofol (propofol anesthesia has the advantage of less PONV) may be agents of choice during maintenance of anesthesia. Various muscle relaxants, including rocuronium, mivacurium, atracurium, and vecuronium, can be used (10,12,39-43). In our clinic, we generally apply TIVA (Propofol+remifentanil IV infusion) or balanced anesthesia (inhalation anesthetic+remifentanil or dexmedetomidine IV infusion) methods according to patients' physical status, current cardiopulmonary functions, comorbidities, and surgical features.

A supraglottic device can be used for airway management, but an endotracheal tube (ETT) is generally preferred for adequate ventilation. Intubation-free GA is as effective as ETT for PPV without gastric distension in non-obese and obese patients, a safely and effectively correctly positioned conventional LMA or ProSeal LMA. However, the LMA or ProSeal LMA should be preferred for shorter procedures that require low IAP and less tilt position. It also allows for PPV and accurate monitoring of $EtCO_2$. However, its use for PPV, in general, should be limited to healthy, frail patients, as airway pressures often exceeding 20 mmHg can occur after PPV, which increases during PP, as LMA cannot guarantee ventilation (44,45). If GA is to be used in our clinic, we generally prefer ETT.

During PP under PPV, keeping $EtCO_2$ generally at 35 mmHg without requiring increased minute ventilation is essential. To ensure the patient's ventilation and oxygenation during PPV, proper PEEP, RM, and the I: E ratio should be applied (10,31-35).

Hemodynamics, ventilation, oxygenation, and perfusion should be optimized to prevent complications and achieve better results. There should be sudden changes in BP and rhythm, and hypoxemia, hypercarbia, respiratory acidosis, and hypothermia should be prevented. Acid-base and fluid-electrolyte balance should be ensured, and pain should be controlled perioperatively (9,10,39).

Preemptive analgesia techniques using nonopioids such as non-steroidal anti-inflammatory drugs (NSAIDs), acetaminophen, α_2 agonists, and ketamine are practical in multimodal analgesia and outpatient surgery where fast recovery is aimed. Shoulder pain due to PP is quite common in the postoperative period and should be avoided (10,12,39,40).

REGIONAL ANESTHESIA FOR LAPAROSCOPIC SURGERY

Laparoscopic procedures have conventionally been performed under GA. Regional anesthesia may be preferred in some LS procedures because it provides many advantages, such as fewer hemodynamic changes, faster healing, reduced PONV, less postoperative pain, shorter stay, and less healthcare cost. Regional anesthesia techniques are divided into peripheral nerve blocks (PNBs) and and neuraxial blocks (10,39-42).

1. Peripheral Nerve Blocks

These regional techniques can be used in combination with GA. Five peripheral nerve blocks as regional techniques have been described for LS (46,47):

a) Transversus abdominis plane (TAP)

b) Quadratus lumborum (QL)

c) Erector spinae plane (ESP)

d) Rectus sheath

e) Paravertebral (PVB) blocks

Local anesthetic injection into laparoscopic access sites is common, but using RA techniques in LS has not become widespread. The use of the ESP and QL block for PNBs is very recent and limited. Transversus abdominis plane block can reduce pain scores and the need for opioids during and after laparoscopic cholecystectomy, bariatric surgery, and colorectal surgery. It has been shown in the literature that unilateral PVB can be beneficial in percutaneous nephrolithotomy, and ESP and rectus sheath blockade can increase the analgesic effect. Limited evidence supports the use of QL block in laparoscopic urologic surgery. Still, no recent evidence supports using TAP or QL block for laparoscopic gynecologic surgery. The literature shows that these blocks can provide multimodal analgesia and support intraoperative and postoperative analgesia and anesthesia during LS (46-55). Our clinic prefers mostly TAP and ESP blocks according to carefully considering patients' physical status, current cardiopulmonary functions, comorbidities, surgical features, and anesthesiologists' experiences during LS.

2. Neuraxial Blocks

It has been shown that LS procedures can be easily performed with existing drugs and used safely with minimal side effects thanks to spinal anesthesia (SA), epidural anesthesia (EA), and combined spinal-epidural anesthesia (CSEA) methods, even if the patient is awake in the Trendelenburg position. When LS is performed in awake patients under RA, it may provide some advantages over GA, such as maintaining spontaneous breathing, no airway manipulation, minimal respiratory changes, less neuroendocrine stress response, effective postoperative analgesia, minimal PONV, and more comfort (10,39-42).

a) Epidural Anesthesia

Epidural anesthesia is considering a secure alternative to GA in outpatient LS procedures. It allows the respiratory control mechanism to be maintained and to keep $EtCO_2$ unchanged (9,10,12). Furthermore, despite the rise in work of breathing and the V/Q mismatch, it does not cause a significant change in ventilation in the Trendelenburg position. A sensory block between T_4 and L_5 is required for surgical LS to be performed comfortably (9,10,40-42). Epidural anesthesia may allow LS to be performed safely and effectively, avoiding GA in patients with multiple comorbidities such as CHF, IHD, PH, CKD, COPD, and interstitial lung disease (56). Our clinic's general practice is the thoracic EA method in geriatric patients with multiple comorbidities and no PP contraindications. Our application method is as follows. Epidural anesthesia is carried out from T_5 to T_8 in seated position under strictly sterile settings once local anesthetic has been administered. After entering the epidural space from the midline with the Tuohy 18 needle using saline-resistant loss of technique, test dose is administered for determining the needle is located in the spinal or intarvascular space. Following confirmation of the correct location of the needle, an epidural catheter is inserted cephalically and fixed at 4 cm in epidural space. Then, a 20 mL mixture containing 15 mL of 0.5% bupivacaine, 1 mL of fentanyl and 4 mL of isotonic saline is injected into the epidural space. Patients are checked serially for a sensory block at 1-minute intervals with a pinprick test. After the sensory block at the T_4 level is achieved, the surgery is allowed to begin. For sedation, dexmedetomidine infusion is titrated to provide BIS values between 40 and 60 and administered first as a bolus and then as an IV infusion. General anesthesia is initiated if adequate anesthesia is not provided or patients cannot tolerate pain. We ensure the IAP does not exceed 12-15 mmHg as much as possible. After the sensory block level was checked by keeping the patient in the recovery room for at least 30 minutes, the patient was discharged to the ward. Patient controlled analgesia protocol was peformed for postoperative analgesia with 0.1% bupivacaine using the epidural cathater. Our clinic performed laparoscopic cholecystectomy with thoracic EA in 16 geriatric patients with multiple comorbidities (CHF, VHD, IHD, COPD, PH, CAD, CKD, hypertension, diabetes mellitus, and arrhythmia) without complications.

b) Spinal Anesthesia

Spinal anesthesia offers many advantages over GA in LS. However, using hyperbaric bupivacaine may not be ideal for LS because setting the patient in the Trendelenburg position may cause the spinal block to spread cephalad, a more pronounced sympathetic block, bradycardia, and hypotension. In recent years, many LS procedures have been performed under SA in the literature (10,57,58). We do not prefer SA in our clinic.

c) Combined Spinal-Epidural Anesthesia

The CSEA method has been used frequently. The advantage of the CSEA method is the fast onset of anesthesia and the ability to give intrathecal agents at initially minimal effective doses. Although the disadvantage of EA is the slower initiation of anesthesia, the epidural catheter provides many advantages in providing postoperative analgesia and more lengthy procedures (10,40-42,59,60).

Combined spinal-epidural anesthesia can be used safely in LS and has advantages such as more stable intraoperative and postoperative hemodynamics, less need for intraoperative anesthetic agents, postoperative surgical site pain, shoulder pain, and PONV compared to GA. The combination of GA and EA provides rapid recovery compared to a single GA and also helps to provide good postoperative analgesia (10,41,42,59,60).

As a result, SA, EA, and CSEA can be used safely according to GA with careful and appropriate patient selection in abdominal surgeries. While deciding to use an appropriate RA technique, the risk-benefit ratio must be taken into account, and it should be given carefully, considering the patient's physical condition, comorbidities, surgical characteristics, and the anesthesiologist's experience. Preoperative comprehensive preparation of the patient with a multidisciplinary approach, cooperation with the surgical team, necessary preparation, and close postoperative follow-up is significantly important in preventing complications.

2. Abdominal Insufflation

First step in LS is intra-abdominal insufflation by CO_2 with a Veres needle. Different gases can be used for PP, like nitrous oxide (N_2O), helium, argon, air, or oxygen (O_2), other than CO_2. Nitrous oxide is flammable; air and O_2 are prone to develop embolisms (2,5,6,10,25,61,62). Carbondioxide is the most used gas for PP because it has high blood solubility, is cheap, and lowers the risk of gas embolism (0.0014%-0.6%) (2,5,6,8,61). Ideally, for creating a PP and the most visually accurate visualization and manipulation of the abdominal viscera, sufficient 2.5 to 5.0 L of CO_2 is insufflated. Pneumoperitoneum necessarily elevates IAP and leads to hypercapnia, which can significantly affect essential systems. There are two primary consequences of CO_2 insufflation (2,6-10,25,39,40,61).

a) Increased IAP

b) Hypercarbia

In summary, increased IAP can lead to the following (8-10,12,39,40):

- Mechanically compression of inferior vena cava
- Mechanically compression of the aorta
- Reduced renal blood flow (RBF)
- Decreased splanchnic blood flow
- Reduced cerebral blood flow (CBF)
- Diaphragmatic displacement

These two main components make hemodynamic, cardiorespiratory, and physiological changes in the systems (Table I) (8-10,12,25,39,40). This step aims to increase IAP by 12 or 15 mmHg in adults. To minimize the adverse physiological effects of PP, a slower gas insufflation rate (1 L min^{-1}) and lower IAP (6-8 mmHg in infants and 12 mmHg in older children) is recommended (6,7,10,25). As a result of abdominal aortic compression and the released neurohumoral mediators (the renin-angiotensin-aldosterone system (RAAS) activation, high plasma epinephrine, norepinephrine, cortisol, vasopressin, atrial natriuretic peptide), within the first 5 minutes of abdominal insufflation, during PP, mean arterial pressure (MAP) and systemic vascular resistance (SVR) increses and a reduction in CO occurs (2,6,7,10,25).

Hypercarbia, which develops due to the absorption of CO_2, increases minute ventilation by 60% to normalize $EtCO_2$ and may activate the sympathetic nervous system, leading to a rise in HR, BP, myocardial contractility, resulting, arrhythmias (8-10,25). During the abdominal insufflation stage, accidental trocar placement in the abdominal organs or large vessels and CO_2 embolism are the two most important complications. In developing injuries, abdominal insufflation should be terminated quickly, according to the patient's clinic, and open surgery should be started. In case of CO_2 embolism, CO_2 insufflation should be stopped immediately and managed by setting the patient in the left lateral decubitus position and giving 100% FiO_2. In addition, transesophageal echocardiography (TEE) can detect gas embolism and help to establish the diagnosis (8,9,63-65).

Cardiovascular System Changes

Critical determinants of cardiovascular function due to PP performed during LS are IAP, hypercarbia, and patient position. Significant hemodynamic changes occur due to these param-

Table I: Two Components of Laparoscopic Surgery and Systemic Responses

	IAP ↑	Hypercarbia
Lungs	• Diaphragm displacement • Airway pressures ↑ • V/Q mismatch • Lung compliance ↓ • FRC ↓	• PAP ↑ • PVR ↑ • Pulmonary vasoconstriction • Subcutaneous emphysema • Gas embolism
Heart	• RAP ↑ • SVR ↑ • CO ↓	• Arrhythmia • Myocardial depression • Myocardial ischemia • Impaired hemoglobin affinity and O_2 transport
Splanchnic	• Splanchnic blood flow↓ • Hepatic artery/Portal venous blood flow ↓ • Gut blood flow ↓ • Risk of regurgitation of gastric contents ↑	• Hepatic/Intestine tissue pH ↓
Renal	• Renal blood flow ↓ • GFR ↓ • Oliguria	• Renal proton excretion ↑
Vascular	• MAP ↑ • SVR ↑ • IVC and aortic compression	• SVR ↓
Cerebral	• Intracranial pressure↑	• Cerebral blood flow ↑

IAP: Intraabdominal pressure, **PAP:** Pulmonary arterial pressure, **PVR:** Pulmonary vascular resistance, **V/Q:** Ventilation/Perfusion, **FRC:** Functional residual capacity**,** **RAP:** Right atrial pressure, **SVR:** Systemic vascular resistance, **CO:** Cardiac output, **GFR:** Glomerular filtration rate, **IVC:** Inferior vena cava, **MAP:** Mean arterial pressure.

eters. These include hypertension, hypotension, arrhythmias, and cardiac arrest. The severity of the cardiovascular changes is based on the volume of CO_2 absorbed, the magnitude of the IAP, the fluid status, the ventilation parameters, the surgical, and the anesthetic agents used (8-10,25,39,40). Position changes in CO occur as IAP increases during abdominal insufflation. Following abdominal insufflation, substantial changes in SVR and CO occur due to the increase in intra-abdominal pressure, Trendelenburg or reverse Trendelenburg position. Table II summarizes the aferomentioned changes (8-10,25,66). Given this information, 15 mm Hg defines the critical IAP threshold, as a further increase in IAP will reduce CO. It may be beneficial to perform TEE to see the results of increased IAP during LS on the cardiovascular system in more detail (9,64).

Bradyarrhythmias may occur, including significant rhythm disorder, bradycardia, atrioventricular dissociation, nodal rhythm, and cardiac arrest. These arrhythmias are caused by PP-stimulated peritoneal extension during Veres needle or trocar insertion, which stimulates the vagal nerve. Carbondioxide should be insufflated slowly within 1-5 minutes in a controlled way to prevent these rhythm disturbances. Tachyarrhythmias may occur due to increased CO_2 and catecholamine release. To reduce the severity of these hemodynamic changes, it may be more appropriate to apply PP in the supine position instead of head-down or head-up position (2,7,9,10,12,25,66).

Hemodynamic changes are better tolerated in patients with normal cardiovascular function due to quicker adjustments. However, in cases of cardiovascular dysfunction, careful monitoring of abdominal insufflation pressures, volume loading, and patient positioning is crucial, especially for anemic or hypovolemic patients. It is essential to bear in mind that extended periods of CO_2 absorption may lead to gas embolism. (6,9,25,63-65).

Pulmonary System Changes

There are two primary components of pulmonary changes during LS (6-10,14,15,25,26,66):

a) Abdominal insufflation with PP affects lung function

- Increased IAP
- Hypercarbia

b) Trendelenburg position

Pulmonary function changes during LS include reduced lung volumes, decreased pulmonary compliance, increased plateau and peak airway pressures (8-10,25,39,40).

Abdominal insufflation affects lung function. Intra abdominal pressure increases, and as a result, the diaphragm is displaced towards the head. In addition, this situation is exacerbated in the Trendelenburg position. Pneumoperitoneum can cause pulmonary vascular resistance and decreased CO when abdominal insufflation was carried out with IAP adjusted at 15 mmHg in compound with the reverse Trendelenburg position. Increases in MAP and CO have both been observed in the Trendelenburg position. Minute ventilation increases airway pressures and decreases pulmonary compliance with an increase in plateau and peak airway pressures due to an increase in IAP, which also promotes upward diaphragmatic displacement with position. A decrease in FRC causes early closure of smaller airways. It increases the risk of intraoperative atelectasis with decreased functionality due to V/Q mismatch leading to hypoxemia (Table II) (8,9,14,25,26,39,40).

During abdominal insufflation, CO_2 mixes with the blood and increases $PaCO_2$ within 1-5 minutes (6,8,9,25,66). Increasing RR is required to keep $PaCO_2$ within or near the normal range and to stimulate CO_2 exhalation (8,9,14,25,66). If there is a rise in $EtCO_2$ after 30 minutes, subcutaneous emphysema should be suspected, and the head and neck region should be carefully examined (8,9,12,14,25,66). Subcutaneous emphysema occurs secondary to gas extravasation into the subcutaneous tissue and is seen in 0.43%-2.3%. If subcutaneous emphysema persists, it can cause hypercarbia and respiratory acidosis, leading to more severe pulmonary changes (6,8,14,25,26,66).

If higher IAP occurs during abdominal insufflation, thoracic compliance decreases, and pneumothorax and pneumome-

Table II: Hemodynamic Effects of Patient Positioning and Intravascular Volume Status

Parameter	RAP	PCWP	SV	CO/CI	SVR	PC	PAP	FRC	V/Q mismatch	Atelectasis
Position										
Trendelenburg (Head down)	↑	↑	↑	↑	↑	↓	↑	↓	↑	↑
Reverse Trendelenburg (Head up)	↓	↓	↓	↓	↑↑	↑	↓	↑	↓	↓
Intravascular volume status										
Hypovolemia	↓	↓		↓	↑		↓			
Hypervolemia	↑	↑		↑	↑		↑			

RAP: Right atrial pressure, **PCWP:** Pulmonary capillary wedge pressure, **SV:** Stroke volume**, CO:** Cardiac output, **CI:** Cardiac index, **SVR:** Systemic vascular resistance, **PC:** Pulmonary compliance, **PAP:** Pulmonary arterial pressure, **FRC:** Functional residual capacity, **V/Q:** Ventilation/Perfusion.

diastinum may develop due to increased alveolar pressure, especially in patients with diffuse pulmonary dysfunction undergoing upper abdominal LS. In patients with severe pulmonary dysfunction, PFT and ABG should be performed preoperatively, and the patient should be prepared for surgery accordingly. In these patients, radial artery cannulation should be performed to monitor hemodynamic and cardiopulmonary changes in the intraoperative period closely. If hypercapnia, elevated airway pressures, and consequent refractory hypoxemia occur during LS, deflation should be followed by slow re-insufflation using lower IAPs (6-8,10,13-15,18,25,26,66,67).

Optimization of ventilation and oxygenation is based on surgery type and anesthesia strategy.

Ideally, PEEP is set to 5 to 10 cmH_2O. Adequate PEEP and RMs may contribute to the maintenance of V/Q matching. Higher PEEP levels should be avoided as it may reduce preload and cause systemic hypotension. Generally, the four major PPCs that can occur with PP include the following (9,14,15,21-23,27-30,66):

- Hypercarbia
- Hypoxemia
- Reduce lung compliance
- Subcutaneous emphysema

Risk factors for developing subcutaneous emphysema include the following (9,14,15,25,27,66):

- IAP>15 mmHg
- $EtCO_2$>50 mmHg
- Prolonged surgery >3.5 hours
- High gas flow rates
- Placement of cannulas outside the peritoneal cavity
- Use of >5 cannulas
- Disruption of fascial planes (2,3,8-10,14,15,26,66).

Hypercarbia can lead to systemic vasodilatation, arrhythmias, and myocardial depression. Therefore, $EtCO_2$ concentrations should be preserved to facilitate CO_2 exhalation and increase minute ventilation (8-10,14,15,25,26,66). Pneumoperitoneum and hypercarbia stimulates the sympathetic nervous system leading to release of catecholamines and vasopressin, SVR and MAP elevation. Treatment involves hyperventilation and, if inadequate, abdominal deflation. Triggering factors such as hypoxemia, hypercarbia, acidosis, hypotension, and hypothermia should be avoided, and appropriate ventilation, adequate fluid therapy, and low-dose vasopressor should be administered when needed (8-10,14,15,25,11,21,23,27).

In addition, in LS, PP reduces pulmonary compliance and venous return due to increased IAP leading to the deterioration of oxygenation and hemodynamics. Therefore, increased IAP and hypercarbia may trigger acidosis and lead to significant complications (8,9,14,15,25,26,66).

Renal System Changes

Pneumoperitoneum has essential effects on renal physiology. Reducing RBF depends on mechanical compression of the renal arteries due to elevated IAP (>20 mmHg) and a decline in CO, which induces RAAS (renal cortical vasoconstriction) (7-10,25,68,69). Direct compressions of the renal vasculature, kidneys, and ureters, as increased antidiuretic hormone (ADH, vasopressin), can reduce RBF, glomerular filtration rate (GFR) by 25%, and creatinine clearance (29,30). Although uncommon, patients with LS have a raised risk of acute kidney injury (AKI), especially CKD patients, and the most common sign is oliguria (Table I) (10,12,39,40,68-70).

Splanchnic System Changes

During abdominal insufflation, there is a decrease in macro and microcirculation in the splanchnic region due to the increased IAP. However, it may adversely affect liver function by causing decreased blood flow to the liver due to high IAP. Therefore, care should be taken not to increase IAP above 16 mmHg during LS. A high IAP of >20 mmHg can cause tissue acidosis with up to 40% reduction in gastrointestinal mucosal and mesenteric flow due to tissue hypoperfusion (Table I) (7-10,25,68,69,71).

Neurologic System Changes

The increase in sympathetic discharge due to hypercarbia during LS leads to an increase in SVR. In addition, with the Trendelenburg position after IAP elevation, an elevated intracranial pressure (ICP) and a decrease in cerebral perfusion pressure (CPP) can lead to brain edema. In addition, they limit cerebral venous drainage a due to changes in increased intrathoracic pressure in these patients, often contributing to transient neurological dysfunction, especially in long-term LS procedures that require a prolonged Trendelenburg position. Unless necessary, LS is not recommended for patients with intracranial pathology (Table I) (7,9,10,39,40,68).

3. Abdominal Desufflation

Desufflation is the removal of CO_2 and should be performed slowly. Despite desufflation, there may be a need for higher minute ventilation as CO_2 may remain stored in the body. Lungs and kidneys, meanwhile, eliminate CO_2. In the case of severe hypercarbia ($PaCO_2$>55 mmHg), the anesthesiologist should make the most appropriate decision on the timing of extubation to ensure adequate removal of CO_2, ventilation, and oxygenation. In normal individuals, hemodynamic changes return to average values shortly after desufflation, whereas those with cardiovascular and pulmonary disease may continue for ≥65 minutes. Elderly patients with cardiovascular disease may experience increased HR, CO, and decreased SVR during desufflation (8-10,14-17,25,66,68). A substantial reduction in stroke volume and cardiac index may occur, especially in patients with CHF. Therefore, close follow-up is required in these patients for myocardial ischemia and acute pulmonary edema symptoms in the early postoperative period (14,17,25,66,68).

4. Recovery

Extubation and recovery are the final stages of anesthesia. In the early postoperative period, the RR and $EtCO_2$ of spontaneously breathing patients extubated after LS were higher than those who underwent open surgery. The additional amount of CO_2 after LS can cause hypercarbia even in the postoperative period. This can lead to an increased need for ventilation due to the residual effects of residual anesthetic drugs and impair its ability to stimulate ventilation due to diaphragmatic dysfunction. Patients with pulmonary dysfunction may have trouble removing this excess CO_2 load, which can result in further hypercarbia and, eventually, respiratory failure. Decreased CO_2 excretion after inadequate desufflation in patients with LS may cause many signs and symptoms in the postoperative period. The most common findings were as follows (8-10,12,25,68):

- Incisional pain and numbness
- Dizziness
- Abdominal pain
- Shoulder pain
- Sore throat
- Headache and
- PONV.

Although these findings cause increased morbidity, most symptoms resolve within a week (68). The anesthesiologist should closely follow all the problems that develop after the surgery and deal with them sufficiently and carefully.

INTRAOPERATIVE COMPLICATIONS for LAPAROSCOPY SURGERY

a) Cardiorespiratory-related complications of LS:

Although LS is a minimally invasive surgical method, it always carries a different risk of cardiopulmonary complications. Table III shows cardiovascular and other complications during LS (8-10,14,15,25,66,68). Cardiac arrest cases have been reported in 2-20 of 100.000 LS (9,17,66). Arrhythmias and hypotension are temporary in most cases and improve with a reduction of decreased IAP and hyperventilation with 100% O_2 (9,10,12,14,66).

Tablo III: Complications of Laparoscopic Surgery

Cardiac complications • Hypotension • Hypertension • Bradycardia • Tachycardia • Arrhythmias • Dysrhythmias • Cardiac arrest
Pulmonary • Hypercapnia • Hypoxemia • Venous gas embolism • Pulmonary air embolism • Subcutaneous emphysema • Barotrauma • Pneumothorax • Pneumomediastinum • Pneumopericardium • Lung atelectasis
Damage to surrounding viscera (bowel, bladder, other organs)
Damage to vessels
Complications related to extremes of positioning
Acute kidney injury
Compartment syndrome
Postoperative shoulder-type pain

b) Inadvertent extraperitoneal insufflation:

Incorrect needle placement can lead to complications such as gas embolism, subcutaneous emphysema, pneumothorax, pneumopericardium, pneumomediastinum, and vascular, gastrointestinal, and urinary tract injuries due to accidental extraperitoneal insufflation (9,14,15,25,66,67,72,73). Although complications of LS are rare, they can occur even in the most experienced hands. Therefore, physicians' awareness, foresight, knowledge, attitude, and behavior regarding these complications are vital for their prevention and management. Laparoscopic surgery is becoming more and more accessible as a type of surgical intervention, and therefore appropriate case selection, preoperative planning, and a multidisciplinary team approach are crucial in reducing morbidity and mortality in these procedures.

POSTOPERATIVE PAIN and ENHANCED RECOVERY AFTER SURGERY (ERAS)

Effective and appropriate analgesia is one of the cornerstones of enhanced recovery after surgery (ERAS) programs and generally all anesthetic care. The main consensus in analgesia is the multimodal analgesia approach. Because these approaches are vital in reducing the surgical stress response, early return to normal functions, breathing, eating, sleeping, early mobilization, and basic human reasons. Laparoscopic surgery can cause minimal pain and discomfort during procedures. Prevention and treatment of pain after LS is based on the use of local anesthetics, NSAIDs, opioid analgesics, and multimodal analgesia methods are often preferred in combination (10,12,39,40,68,74). This method reduces the dose of opioids, minimizing side effects, decreasing postoperative pain and analgesic requirement, and leading to early mobilization of the patient, allowing an earlier return to normal activities. Paracetamol, NSAIDs, dexketoprofen, lidocaine, α_2 agonists (dexmedetomidine and clonidine), ketamine, magnesium, gabapentinoids, and dexamethasone are among the basic and most commonly used drugs (10,12,68,74).

POSTOPERATIVE NAUSEA and VOMITING

The PONV is common after LS procedures and may lead to late postoperative discharge. The incidence of PONV can be reduced with appropriate anesthetic techniques and the use of antiemetic drugs (75).

In LS, maintenance of anesthesia with propofol (which has the lowest incidence of PONV) may be preferable as it causes a lower incidence of PONV than volatile anesthetics (10,12,39,40,68,75). In preventing and treating PONV, the 5-HT_3 antagonist's granisetron, ondansetron, and dolasetron are effective drugs frequently used (10 minutes before extubation) in daily practice (10,12,39,40,68,75). It is known that the use of dexamethasone (in anesthesia induction) in the first 24 hours after LS reduces PONV and reduces the need for antiemetics without causing any side effects (75). In our clinic, we usually prefer granisetron, ondansetron, and dexamethasone.

PATIENT CHARACTERISTICS

Positioning

During LS, the Trendelenburg (head-down) or reverse Trendelenburg (head-up) position is applied to provide the most accurate surgical field visualization. The changes that occurred during these positions are given in Table II. In the Trendelenburg position, the diaphragm and abdominal organs move towards the head, lowering pulmonary compliance and increasing the plateau and peak airway pressures. In addition, venous return and pulmonary capillary wedge pressure (PCWP) increase in this position and prevent the decrease of CO after abdominal insufflation (9,10,12,16,17,24,25,39,40,68). The neuroendocrine response to the Trendelenburg position is characterized by increased norepinephrine levels and plasma N-terminal pro atrial natriuretic peptide (NTproANP) (9,10,16,17,25,68). This neuroendocrine response adversely affects positve ventilation and cardiopulmonary changes in the reverse Trendelenburg position (8-10,25).

With elevated IAP after abdominal insufflation, the reverse Trendelenburg position reduces venous return, RAP, CO, and PCWP (8-10,12,16,17,25,68). With the resulting neuroendocrine response, plasma norepinephrine amounts are further raised by the head-up position, increasing SVR and decreasing CO (8-10,25,68,69). Due to the hemodynamic, physiological, and cardiopulmonary changes that occur during LS, it is critical to evaluate the patient's intravascular volume status in the preoperative evaluation. The volume changes during these positions are given in Table II. Important preventive methods such as minimizing preoperative fasting, adequate preoperative hydration, and using IAP<15 mm Hg can decrease CO reduction (7-10,12,25,68,69).

Anesthetic Considerations in a Particular Patient

Laparoscopic surgery has different significant hemodynamic, systemic, and physiological changes with specific considerations. To minimize the effects and impacts of PP in patients who will undergo LS, as in every patient, thorough preoperative evaluation should be carried out by multidisciplinary team that includes an anesthesiologist and surgeon. These alterations in physiological parameters are influenced by various factors such as the intraoperative patient position and intravascular volume status. These effects are observed across diverse patient groups, encompassing the elderly, infants, children, pregnant individuals, those with obesity, pre-existing comorbidities, and cardiopulmonary conditions. Therefore, knowing these changes well ensures the correct management of these patients during LS. Some important perioperative aspects related to patients undergoing LS, having specific disaeses are summirized in Table IV (8-10,12-18,26,68).

Laparoscopic surgery also has an important role in bariatric surgery. The obese patient is at high risk for obstructive sleep apnea, chronically elevated IAP, restrictive lung disease, hypertension, CAD, and diabetes mellitus. Obese patients tend to have lower pulmonary compliance, higher plateau and peak airway pressures, and higher minute ventilation than non-obese patients to achieve normocarbia. At the same time, venous stasis and increased risk of thrombosis may occur more frequently in this patient group due to decreased venous blood flow from the lower extremities due to increased IAP. Mechanical ventilation settings in obesity anes-

Table IV: Anesthetic Considerations of Concomitant Cardiopulmonary and Other Diseases During Laparoscopic Surgery

Patients type	Hemodynamics changes	Potential complications	Pre-op management	Intra-op management	Post-op management
CHF	↑ RAP, ↑ SVR, ↑ PCWP, ↓ CO	Pulmonary edema, Cardiogenic shock	Diuresis to euvolemia, optimisation of CHF medication	↓ Afterload, IAP<15 mmHg	Monitor volume status, early diuresis
Valvular heart disease					
Aortic regurgitation	↑ SVR, ↓ CO	Increased valvular regurgitation, ↓ CO	Target SBP<140 mmHg	↓ Afterload	Target SBP<140 mmHg, monitor volume status
Aortic stenosis	↑ RAP, ↑ SVR, ↑ PCWP, ↓ CO	Myocardial ischemia, cardiovascular collapse	Avoid hypovolemia	Avoid vasodilators, HR 60-90, and phenylephrine for hypotension	Monitor volume status
Mitral regurgitation	↑ RAP, ↑ PCWP, ↓ CO	Increased valvular regurgitation, ↓ CO, pulmonary edema	Target SBP<140 mmHg	↓ Afterload	Target SBP<140, monitor volume status
Mitral stenosis	↑ RAP, ↑ PAP, ↑ PCWP, ↑ HR	Pulmonary edema and CHF, ↓CO	HR<70, NSR	HR<70, NSR, adequate preload, avoid N_2O	HR<70, NSR, monitor volume status
Tricuspid regurgitation	↑ RAP, ↑ PVR, ↑ PAP	Increased valvular regurgitation, ↓ CO			Target SBP<140, monitor volume status
Ischemic heart disease					
Acute coronary thrombosis	↑ Inflammation, hypercoagulable state	Peri/postoperative myocardial infarction	Continue aspirin before coronary stent	Continue β-blockers	Continue aspirin
Myocardial supply-demand ischemia	↑ SVR, ↑ LVEDP, HR variability	Peri/postoperative myocardial infarction	Continue β-blockers	Humidified peritoneal gas to reduce postop pain	Double product control (HR/BP), pain management
Bradyarrhythmias	↑ IAP, ↑ CO_2	Asystole		Slow insufflation. Consider atropine or glycopyrrolate pre-insulation if resting bradycardia	
Congenital heart disease					
Cyanotic heart disease	↑ RAP, ↑ PVR, ↓ CO	↓ CO, R→L shunt, hypoxemia		Measure $PaCO_2$	Measure $PaCO_2$
Surgical shunts	↑ RAP, ↑ PVR, ↓ CO	Shunt thrombosis		Minimise PEEP	
	↑ RAP, ↑ PVR, ↓ CO	Hypoxemia, R→L shunt, paradoxical embolism		Consider TEE for shunt monitoring	
Other conditions					
COPD	↑ peak and plateau airway pressures, ↑ CO_2	Acidosis, bullae rupture, subcutaneous emphysema, pneumothorax	Avoid steep Trendelenburg angles, and avoid atelectasis		

Table IV: Cont.

Patients type	Hemodynamics changes	Potential complications	Pre-op management	Intra-op management	Post-op management
Pulmonary hypertension	↑ CO_2→pulmonary vasoconstriction, ↑ PVR, ↑ PAP	Right ventricular failure	Pulmonary vasodilators,* avoid acidosis, hypercarbia, hypoxemia, hypothermia, N_2O		
Chronic kidney disease	↓ GFR, ↓ RBF	Oliguria, acute kidney injury	Avoid hypovolemia	IAP<15 mmHg	Monitor UO
Morbid obesity	Diaphragmatic displacement, ↑ baseline IAP, ↑ peak and plateau airway pressures, ↑ CO_2, ↓ PC	Respiratory acidosis, hypercarbia, higher ventilation requirements		Avoid steep Trendelenburg angles, and avoid atelectasis	Avoid early extubation, Extubate to CPAP/BIPAP

CHF: Congestive heart failure, **RAP:** Right atrial pressure, **PCWP:** Pulmonary capillary wedge pressure, **CO:** Cardiac output, **IAP:** Intraabdominal pressure, **CI:** Cardiac index, **SVR:** Systemic vascular resistance, **PVR:** Pulmonary vascular resistance, **PC:** Pulmonary compliance, **PAP:** Pulmonary arterial pressure, **FRC:** Functional residual capacity, **V/Q:** Ventilation/Perfusion, **SBP:** Systolic blood pressure, **CO_2:** Carbon dioxide, **HR:** Heart rate, **LVEDP:** Left ventricular end-diastolic pressure, **N_2O:** Nitrous oxide, **NSR:** Normal sinüs rhythm, **TEE:** Transesophageal echocardiogram, **GFR:** Glomerular filtrate rate, **RBF:** Renal blood flow, **UO:** Urine output, **CPAP:** Continuous positive airway pressure, **BIPAP:** Bi-level positive airway pressure. *Milrinone, nitric oxide, iloprost.

thesia are one of the most challenging tasks anesthesiologists face. It is essential to apply a protective mechanical ventilation method to ensure adequate ventilation, perfusion, and gas exchange. To prevent atelectasis and reduce PPCs, PEEP should be added (8-10 cm H_2O). Co-administration of PEEP and RMs are considered powerful intraoperative treatment methods to optimize ventilation, provide oxygenation, and alleviate hypoxemia in anesthesia practice (26-30,34-36).

Main points

- Understanding the cardiopulmonary and renal pathophysiological and physiological changes, as well as hemodynamic alterations associated with LS, is crucial.
- Communication with a multidisciplinary team that includes an anesthesiologist and surgeon should be made.
- Comprehensive preoperative evaluation, proper patient selection, optimizing comorbidities, and adequate monitoring should be performed.
- Laparoscopoic surgery procedures can be applied under GA, RA, and PSBs.
- Endotracheal tube is generally used in airway management but supraglottic devices can be used in selected patients.
- Significant hemodynamic, cardiopulmonary, and physiological changes occur in the systems due to increased IAP and hypercarbia during PP.
- Utilizing slow abdominal insufflation with maximum IAP <15 mmHg and minimized duration of extreme patient positioning.
- The main goal should be providing adequate ventilation, oxygenation, improved PC, and avoiding high airway pressures in PPV mode.
- Complications in LS are primarily due to PP, patient positioning, or surgical instruments.
- Detecting complications early may reduce mortality and morbidity and also hospital costs.

CONCLUSION

Management of patients undergoing LS perioperatively requires knowledge and experience. A minimally invasive technique has advantages such as early mobilization, minimal blood loss, less scarring, postoperative pain, hospital stay, and lower mortality and morbidity. Although LS is predominantly performed under GA, it has been frequently performed under RA and PNBs in recent years. Hemodynamic, cardiorespiratory, and ventilation-related changes are mainly due to increased IAP, hypercarbia, and position. The main goals in anesthesia management should be understanding the primary pathophysiology, appropriate patient selection, and optimizing the patient's functional status and hemodynamics. An anesthesiologist should understand the changes during LS and know how to handle them to prevent patients with cardiovascular or pulmonary comorbidities. Comprehensive preoperative evaluation, adequate monitoring, optimizing comorbidities, and suitable communication with the surgical team can reduce mortality and morbidity. The most effective method for managing postoperative pain is to apply multimodal analgesic regimens.

AUTHOR CONTRIBUTIONS

Conception or design of the work: NC
Data collection: NC, BNG
Data analysis and interpretation: NC, BNG
Drafting the article: NC
Critical revision of the article: NC, BNG
The author (BNG, NC) reviewed the results and approved the final version of the manuscript.

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