

LAPAROSCOPIC SURGERY IN CHILDREN: THE ANAESTHETIC PERSPECTIVE

Abstract

Laparoscopic surgery has revolutionized the field of abdominal, pelvic, urological and gynaecological procedures, offering numerous benefits over traditional open surgery. Laparoscopic surgeries are gaining popularity in children. However, when it comes to their management, special considerations and adaptations are necessary to ensure safe and effective outcomes. This chapter aims to provide a comprehensive overview of the unique challenges and considerations in laparoscopic surgery for paediatric patients.

The chapter begins by highlighting the physiological changes that occur during laparoscopy in paediatric patients. These include the effects of increased intraabdominal pressure and its impact on cardiovascular, respiratory and other systemic function. Understanding these changes is crucial for anaesthesiologists and surgeons to optimize patient care.

Anaesthesia management is a critical aspect of laparoscopic surgery in paediatric patients is highlighted. Gas absorption, particularly carbon dioxide, can have adverse effects on respiratory and acid-base status. The chapter discusses strategies for minimizing gas absorption and maintaining appropriate ventilation and oxygenation. Patient positioning plays a vital role in laparoscopic procedures and specific considerations must be made for paediatric patients. Proper positioning ensures optimal access to the surgical site while minimizing the risk of neurovascular compromise or injury. Additionally, the chapter addresses postoperative care and highlights the importance of monitoring

Authors

Meghna Singhal

Maulana Azad Medical College and Lok Nayak Hospital
New Delhi, India.

Kshitiz Hirani

Shreya Hospital
Shalimar Garden
Uttar Pradesh, India.

Isha Singhal

Seth G S Medical College and KEM Hospital
Mumbai, Maharashtra, India

Bisman Jeet Kaur Khurana

Post Graduate Institute of Medical Education and Research
Chandigarh, India.

and managing potential complications. This includes maintaining normothermia, implementing multimodal analgesia techniques and promoting early mobilization and recovery.

By understanding the unique challenges and considerations associated with laparoscopic surgery in paediatric patients, healthcare providers can improve patient outcomes and provide safer and more effective care.

Keywords: Laparoscopic surgery, Paediatric patients, positioning, Carbon dioxide absorption, intraabdominal pressure, physiological changes, anaesthesia management, postoperative care.

I. INTRODUCTION

- 1. Historical Background:** Laparoscopic surgery, initially introduced by Dimitri Ott, Georg Kelling and Hans Christian Jacobaeus in the early 20th century, has become the standard of care for adults^{1,2}. Recently, there has been a significant increase in the popularity of laparoscopic procedures in paediatric patients due to several advantages, such as minimal invasiveness, smaller incisions, improved cosmesis, shorter hospitalization, faster recovery, reduced pain and fewer complications^{3,4}.
- 2. Rationale for the Review:** Despite the growing use of laparoscopic surgery in paediatric patients, there are specific physiological considerations that must be taken into account during these procedures^{5,6}. This review aims to highlight physiology, anaesthesia management, complications and contraindications to surgery. The unique challenges associated with laparoscopic surgery in paediatric patients are presented in the chapter and it provide insights into their perioperative management.

II. PHYSIOLOGICAL CHANGES DURING LAPAROSCOPY

- 1. Effects of Gas Absorption and Increased Intraabdominal Pressure:** The physiological effects of laparoscopic surgery result from increased intraabdominal pressure, gas absorption (carbon dioxide) and patient positioning (Trendelenburg or reverse Trendelenburg)⁷⁻¹¹. The choice of gas used for pneumoperitoneum and the rate of insufflation, maximum intra-abdominal pressure, duration of surgery and patient's position further contribute to these effects.
- 2. Cardiovascular Effects:** Hemodynamic changes during laparoscopy involve a reduction in cardiac output, an increase in systemic vascular resistance and pulmonary vascular resistance. These changes can lead to tachycardia, hypertension and an increased myocardial oxygen requirement¹²⁻¹⁷. Special attention should be given to neonates and patients with pre-existing cardiovascular instability to prevent complications¹⁸.
- 3. Respiratory Effects:** Pneumoperitoneum affects thoraco-pulmonary compliance, functional residual capacity and can promote atelectasis. Children are particularly susceptible to small-airway collapse and impaired ventilation-perfusion ratios^{19,20}. Monitoring of end-tidal carbon dioxide levels is crucial and adjustments in ventilator settings may be required to optimize gas exchange.
- 4. Other Systemic Effects:** The increase in intraabdominal pressure during laparoscopy can affect renal, intracranial, and intraocular pressures, as well as hepatic blood flow and splanchnic circulation²¹. Attention should also be given to the risk of hypothermia, venous stasis, and deep vein thrombosis associated with increased intraabdominal pressure and patient positioning.

III. ANAESTHESIA MANAGEMENT

- 1. Pre-Anaesthesia Evaluation and Fasting:** A routine pre-anaesthesia evaluation should be performed following standard protocols and fasting guidelines from the American Society of Anaesthesiologists (ASA) should be followed.

- 2. Induction and Maintenance of Anaesthesia:** The choice of induction and maintenance agents should be based on patient age, pre-existing conditions and available resources. Endotracheal intubation is the standard practice, but supraglottic airway devices may be considered for specific surgeries²²⁻²⁵. Inhalational agents, total intravenous anaesthesia, or a combination of both can be used for maintenance.
- 3. Intraoperative Monitoring:** Standard monitoring techniques, including electrocardiography, pulse oximetry, non-invasive blood pressure monitoring, capnography and temperature monitoring, should be employed. Hemodynamic parameters, oxygenation, ventilation, end-tidal carbon dioxide levels and body temperature should be closely monitored.
- 4. Ventilation and Gas Exchange:** Lung-protective ventilation strategies should be used to maintain adequate oxygenation and prevent atelectasis. Adjustments in ventilator settings may be necessary and end-tidal carbon dioxide levels should be closely monitored. Attention should be given to complications such as carbon dioxide (CO₂) retention, hypercapnia and acidosis during laparoscopic procedures²⁶. The use of low-pressure pneumoperitoneum, intermittent release of gas, or controlled ventilation strategies can help minimize these complications. Monitoring of end-tidal carbon dioxide levels and arterial blood gas analysis should be performed regularly.

When considering intra-abdominal pressure (IAP) in laparoscopic surgery for paediatric patients, it is important to maintain a balance between achieving adequate visualization and minimizing potential complications. (Table 1):

Table 1: Intra-abdominal pressure recommended in laparoscopic surgery in paediatric patients in various studies

Studies	Recommendation
Sakka et al ²⁷ , 2000	IAP >12mmHg decrease Cardiac Index and causes left ventricular hypokinesia, IAP up to 12 mmHg is safe.
DE Wall et al ²⁸ ,2003	IAP=5 mmHg, does not decrease cardiac index.
De Keulenaer et al ²⁹ , 2009	IAP of 5-7 mm Hg.
Mishchuk et al ³⁰ , 2016	IAP levels within 8-12 mmHg for age >1yr.
Xiaomin et al ³¹ ,2020	IAP decided based on Index A (Index A=Age x BMI/duration).

Here are some recommendations regarding intra-abdominal pressure in laparoscopic surgery for paediatric patients.

- **Individualized Approach:** The IAP should be tailored to each patient's specific needs, taking into account their age, weight, underlying medical conditions and surgical procedure being performed. There is no universal optimal IAP for all paediatric patients, as it can vary depending on the case. A study has suggested to use index A (a ratio between duration of pneumoperitoneum (min), age (year) and BMI of patients (Index A=Age x BMI/duration). If Index A is more than 2.6, there are less

complication even at high (IAP=13) level for children. When Index A < 2.6, the risks of complications are more and lower IAP should be used³¹.

- **Lower IAP:** In general, it is recommended to use lower intra-abdominal pressures in paediatric laparoscopic surgery compared to adults. The lower pressure helps to minimize the adverse effects on cardiorespiratory function and reduces the risk of complications. A range of 8-12 mmHg is commonly suggested for most paediatric cases, but individualization is crucial²⁷⁻³¹.
- **Continuous Monitoring:** Continuous monitoring of the patient's vital signs, including blood pressure, heart rate, oxygen saturation and end-tidal CO₂, is essential during the procedure. This allows for prompt detection of any changes or complications related to intra-abdominal pressure.
- **Use of a Pneumoperitoneum Management System:** The use of a pneumoperitoneum management system, such as an insufflator with integrated pressure regulation and gas flow control, can help maintain and regulate the desired intra-abdominal pressure. These systems provide accurate and real-time pressure control, ensuring safety and preventing excessive pressure levels.
- **Optimal CO₂ Gas Flow Rate:** The CO₂ gas flow rate used for insufflation should be carefully controlled to avoid rapid increases in intra-abdominal pressure. A slow and controlled gas flow rate helps to minimize complications, particularly cardiovascular and respiratory effects.
- **Consideration of Patient Position:** The patient's position during surgery can affect intra-abdominal pressure. Optimizing the patient's position such as the head-up position or slight reverse Trendelenburg, can help reduce the pressure on the diaphragm and enhance respiratory mechanics.
- **Expertise and Experience:** Laparoscopic procedures in paediatric patients should be performed by surgeons with specialized training and experience in paediatric laparoscopy. The surgeon's expertise is crucial in maintaining appropriate intra-abdominal pressure and managing any complications that may arise.

It is important to note that these recommendations are general guidelines and individual patient factors may require adjustments or deviations from these guidelines. The surgeon should evaluate each case individually and make informed decisions regarding intra-abdominal pressure based on the patient's condition, the specific procedure being performed and the available resources and equipment.

5. **Fluid Management:** Appropriate fluid management is crucial during laparoscopic surgery in paediatric patients. Factors such as insensible losses, third space losses, fluid absorption and hemodynamic changes need to be considered. Individualized fluid therapy based on the patient's age, weight, comorbidities and surgical procedure is recommended. Close monitoring of fluid balance, urine output and electrolyte levels is essential to prevent complications like hypo/hypervolemia and electrolyte disturbances.

- 6. Analgesia and Pain Management:** Effective perioperative analgesia is vital to ensure optimal postoperative recovery in paediatric patients. Multimodal analgesic techniques, including the use of opioids, nonsteroidal anti-inflammatory drugs (NSAIDs), regional anaesthesia techniques (such as caudal or epidural analgesia) and local anaesthetics, should be considered. The choice of analgesic regimen should take into account the patient's age, weight, comorbidities and the expected duration and intensity of postoperative pain (Table2) ^{32,33}.

Table 2: Multimodal analgesic approaches for pain management

1. Intravenous paracetamol, nonsteroidal anti-inflammatories
2. Neuraxial (epidural, intrathecal morphine)
3. Port site local anaesthetic infiltration, intraperitoneal infiltration
4. Regional anaesthesia blocks (transverse abdominis block, rectus sheath block, or quadratus lumborum block, erector spinae block, transversus abdominis plane block, ilioinguinal and iliohypogastric block)
5. Opioids

- 7. Positioning and Safety Considerations:** Appropriate positioning of the patient is crucial for optimal surgical exposure and patient safety. Care should be taken to avoid excessive pressure on bony prominences, nerve compression and compromised ventilation. The use of appropriate padding and positioning aids can help minimize the risk of complications associated with patient positioning. The patient's position during laparoscopic surgery is determined by the specific procedure being performed and the surgeon's preference and associated with many physiological changes (Table 3). Here are some commonly used positions for laparoscopic surgery:

- **Trendelenburg Position:** This position involves tilting the patient's head downwards and elevating the feet higher than the head. It is commonly used in abdominal and pelvic procedures as it allows the intestines to fall away from the surgical field, providing better visualization and access. However, this position can increase intracranial pressure and may be unsuitable for patients with certain cardiovascular or respiratory conditions ^{10,34-36}.
- **Reverse Trendelenburg Position:** In contrast to the Trendelenburg position, the reverse Trendelenburg position involves tilting the patient's head upwards and lowering the feet. This position is often used for upper abdominal procedures and can help improve exposure of the liver, stomach and diaphragm. It may be preferred for patients with cardiovascular or respiratory concerns ^{10,35}.
- **Lateral Decubitus Position:** In this position, the patient is placed on their side, with one side of the body elevated. This position is commonly used for procedures involving the thoracic or retroperitoneal areas. It allows better access to the surgical site and avoids compression of the lungs and major vessels on the side being operated on.

- **Lithotomy position:** The lithotomy position is commonly used for gynaecological and urological laparoscopic procedures. It involves placing the patient in a supine position with the legs flexed and supported in stirrups. This position provides optimal access to the pelvic organs and allows for better visualization and manipulation.

Table 3: Effects of patient position on various cardiac and respiratory factors

	Trendelenburg (15°-20° head down)	Reverse Trendelenburg (20°-30° head up)
Venous return	↑	↓
Preload	↑	↓
Cardiac output	↑	↓
Airway pressures	↑	↓
Others	Endobronchial intubation	Deep venous thrombosis

8. **Emergence and Recovery:** After completion of the surgical procedure, the patient's emergence from anaesthesia should be smooth and uneventful. Extubation timing should be based on the patient's respiratory status, hemodynamic stability and readiness to protect their airway. Adequate postoperative monitoring, pain management, and early mobilization are essential for smooth recovery and timely discharge.

IV. SPECIFIC CONSIDERATIONS FOR PAEDIATRIC AGE GROUPS

1. **Neonates and Infants:** Neonates and infants have unique physiological considerations, including a higher metabolic rate, limited physiological reserve and increased susceptibility to fluid and heat loss. Extra attention should be given to maintaining normothermia, optimizing fluid management and preventing hypoglycaemia. Additionally, careful monitoring and management of cardiovascular stability and respiratory function are crucial in this age group.
2. **Toddlers and Pre-schoolers:** Toddlers and pre-schoolers may exhibit anxiety and fear related to the surgical experience. Proper preoperative counselling and parental involvement can help alleviate these concerns. Intraoperatively, maintaining a child-friendly environment, using age-appropriate distractions and considering the use of premedication may help reduce anxiety and facilitate smooth induction and maintenance of anaesthesia.
3. **School-Age Children and Adolescents:** School-age children and adolescents may require additional considerations regarding consent, autonomy and privacy. Open communication and age-appropriate explanations about the surgical procedure and anaesthesia can help alleviate anxiety. Involving them in decision-making, when appropriate, can help empower them and improve their overall experience.

V. COMPLICATIONS AND RISK MITIGATION

- 1. Surgical Complications:** Although laparoscopic surgery in paediatric patients is generally safe, there are potential complications associated with the procedure itself. These may include injury to abdominal viscera, vascular structures, or adjacent organs, as well as complications related to the pneumoperitoneum, such as subcutaneous emphysema or gas embolism³⁷⁻³⁹. Surgeons should be vigilant and take necessary precautions to prevent and promptly manage such complications (Table-4).

Table 4: Complications of laparoscopic surgeries

Venous gas embolism Pneumothorax, pneumomediastinum, pneumopericardium, Subcutaneous emphysema Trocar injuries Aspiration risk
--

- 2. Anaesthetic Complications:** Anaesthetic complications in paediatric patients can include adverse drug reactions, airway complications, hypothermia, malignant hyperthermia and anaphylaxis. Close monitoring, meticulous airway management, temperature regulation and the use of appropriate medications and techniques can help minimize the risk of these complications.
- 3. Postoperative Complications:** Postoperative complications in paediatric patients undergoing laparoscopic surgery can include pain, nausea and vomiting, respiratory complications, surgical site infections and thromboembolic events. Proper pain management, postoperative monitoring, early ambulation and prophylactic measures (such as administration of antiemetic medications and mechanical prophylaxis for thromboembolism) are essential for minimizing these complications.

VI. CONTRADICTIONS TO LAPAROSCOPIC SURGERY IN PAEDIATRIC PATIENTS

While laparoscopic surgery offers many benefits in adult patients, there are certain contradictions and considerations when it comes to performing laparoscopic procedures in paediatric patients. Here are some of the factors that can present challenges or contradictions to laparoscopy in paediatric patients (Table-5):

- 1. Size and Anatomical Differences:** Paediatric patients have smaller body sizes and anatomical structures compared to adults. This can make it technically challenging to access and manoeuvre within the limited space of the paediatric abdomen using laparoscopic instruments. The small size of paediatric instruments and the need for specialized ports and trocars designed for paediatric patients may limit the availability of certain laparoscopic techniques.
- 2. Limited Working Space:** The limited working space within the paediatric abdomen can restrict the movement of laparoscopic instruments and make complex procedures more

difficult. In some cases, it may be necessary to convert to an open surgical approach if laparoscopy cannot provide adequate exposure or access to the target area.

3. **Surgeon's Expertise:** Laparoscopic surgery in paediatric patients requires a high level of skill and experience due to the technical challenges involved⁴⁰. Surgeons who perform laparoscopic procedures in children should have specialized training and expertise in paediatric laparoscopy to ensure optimal outcomes and minimize the risks.

Table 5: Contraindications to laparoscopic surgeries

Pre-existing cardiovascular instability (hypotension), poor cardiovascular status
Patients with increased intracranial pressure
Right to left shut
Severe valvular heart disease
Retinal detachment

Despite these considerations and potential contradictions, laparoscopic surgery can still be performed in paediatric patients in many cases. The decision to proceed with laparoscopy should be made on a case-by-case basis, considering the specific surgical indication, the child's overall health status, the surgeon's expertise and the availability of appropriate equipment and resources.

VII. CONCLUSION

Laparoscopic surgery in paediatric patients requires careful consideration of various factors to ensure safe and successful outcomes. Preoperative assessment, optimization of patient condition and appropriate anaesthesia management are crucial steps in the perioperative period. Attention should be given to ventilation and gas exchange, fluid management, analgesia, patient positioning and safety considerations to minimize complications and promote smooth recovery.

Neonates, infants, toddlers, pre-schoolers, school-age children, and adolescents each have unique physiological and psychological considerations that need to be addressed to provide individualized care. Preoperative patients optimization should be done. It is recommended to use low gas insufflation rates (1 L/min) and a tailored intra-abdominal pressure (6-12mmHg) as described above. The effects of pneumoperitoneum and positioning are more deleterious to neonates and infants, proper precautions should be taken in these age group.

Anaesthetic technique preferred is general anaesthesia with endo- tracheal tube placement, however supraglottic devices have been successfully used. ASA standard monitoring should be done, early recognition and prompt management of hypotension, bradycardia, arrhythmias, venous air embolism, endobronchial intubation, pneumothorax and hypothermia should be done. Complications associated with the surgical procedure, anaesthesia and the postoperative period should be anticipated and managed promptly. Pain management using multimodal analgesia and use of antiemetics for management of PONV, is preferred should be planned accordingly.

By implementing appropriate strategies, vigilant monitoring and following best practices, healthcare providers can optimize the care of paediatric patients undergoing laparoscopic surgery and contribute to their overall well-being and successful surgical outcomes.

REFERENCES

- [1] Vecchio R, MacFayden BV, Palazzo F. History of laparoscopic surgery. *Panminerva Med.* 2000; 42:87-90.
- [2] Kelley WE Jr. The evolution of laparoscopy and the revolution in surgery in the decade of the 1990s. *JLSL.* 2008; 12:351-7.
- [3] Gupta R, Singh S. Challenges in paediatric laparoscopic surgeries. *Indian J Anaesth.* 2009;53(5):560–6.
- [4] Perrin M, Fletcher A. Laparoscopic abdominal surgery. *Contin Educ Anaesth Crit Care Pain.* 2004; 4:107-110.
- [5] Richardson JD, Trinkle JK. Haemodynamic and respiratory alterations with increased intra abdominal pressure. *J Surg Res.* 1976; 20:401–4.
- [6] Joris JL. Anesthesia for laparoscopic surgery. In: Miller RD, ed. *Miller's Anesthesia*, 7th ed. Philadelphia: Churchill Livingstone; 2010. pp. 21-95.
- [7] Perrin M, Frca A. FRCA, Laparoscopic abdominal surgery, Continuing Education in Anaesthesia Critical Care & Pain. 2004;4:107–10.
- [8] Hodgson G, Mc Clelland RM, Newton JR. Some effects of the peritoneal insufflation of carbon dioxide at laproscopy. *Anaesthesia.* 1970;25:382–90.
- [9] Blobner M, Felber AR, Gögler S, Weigl EM, Jelen ES. Carbon dioxide uptake from the pneumoperitoneum during laparoscopic cholecystectomy. *Anesthesiology.* 1992;77: A37–40.
- [10] Odeberg S, Ljungqvist O, Svenberg T, Gannedahl P, Bäckdahl M, von Rosen A, et al. Haemodynamic effects of pneumoperitoneum and the influence of posture during anaesthesia for laparoscopic surgery. *Acta Anaesthesiol Scand.* 1994; 38: 276–83.
- [11] Hirvonen EA, Nuutinen LS, Kauko M. Hemodynamic changes due to Trendelenburg positioning and pneumoperitoneum during laparoscopic hysterectomy. *Acta Anaesthesiol Scand.* 1995; 39: 949–55.
- [12] Takata M, Wise RA, Robotham JL. Effects of abdominal pressure on venous return: abdominal vascular zone conditions. *J Appl Physiol.* 1990; 69:1961-72.
- [13] Goodale RL, Beebe DS, McNevin MP, Boyle M, Letourneau JG, Abrams JH, Cerra FB. Hemodynamic, respiratory, and metabolic effects of laparoscopic cholecystectomy. *Am J Surg.* 1993; 166:533-7.
- [14] Kashtan J, Green JF, Parsons EQ, Holcroft JW. Hemodynamic effect of increased abdominal pressure. *J Surg Res.* 1981;30:249-55.
- [15] Giebler RM, Kabatnik M, Stegen BH, Scherer RU, Thomas M, Peters J. Retroperitoneal and intraperitoneal CO₂ insufflation have markedly different cardiovascular effects. *J Surg Res.* 1997; 68:153-60.
- [16] Ivankovich AD, Miletich DJ, Albrecht RF, Heyman HJ, Bonnet RF. Cardiovascular effects of intraperitoneal insufflation with carbon dioxide and nitrous oxide in the dog. *Anesthesiology.* 1975; 42:281-7.
- [17] Cunningham AJ, Turner J, Rosenbaum S, Rafferty T. Transoesophageal echocardiographic assessment of hemodynamic function during laparoscopic cholecystectomy. *Br J Anaesth.* 1993; 70:621-5.
- [18] Silveira LGT, Brocca IC, Moraes ES, Brandão MB, Nogueira RJN, de Souza TH. Hemodynamic effects of increased intra-abdominal pressure in critically ill children. *J Pediatr (Rio J).* 2021;97(5):564–70.
- [19] Lasersohn L. Anaesthetic considerations for paediatric laparoscopy. *S Afr J Surg.* 2011;49:22-26.
- [20] Marcinek B. Growth and development. In: Cote CJ, Lerman J, Anderson BJ, eds. *A Practice of Anesthesia for Infants and Children.* 6th ed. Philadelphia, Pennsylvania: Elsevier; 2019:8-24.
- [21] Ure BM, Suempelmann R, Metzelder MM, Kuebler J. Physiological responses to endoscopic surgery in children. *Semin Pediatr Surg.* 2007;16(4):217-223.
- [22] Sinha A, Sharma B, Sood J. ProSeal as an alternative to endotracheal intubation in pediatric laparoscopy. *Paediatr Anaesth* 2007;17(4):327-332.
- [23] Dave NM, Iyer HR, Dudhedia U, et al. An evaluation of the ProSeal laryngeal mask airway in paediatric laparoscopy. *J Anaesth Clin Pharmacol.* 2009;25(1):71-73.
- [24] Roth H, Genzwuerker HV, Rothhaas A, et al. The ProSeal laryngeal mask airway and the laryngeal tube suction for ventilation in gynaecological patients undergoing laparoscopic surgery. *Eur J Anaesthesiol.* 2005; 22:117-122.
- [25] Park SK, Ko G, Choi GJ, Ahn EJ, Kang H. Comparison between supraglottic airway devices and endotracheal tubes in patients undergoing laparoscopic surgery: a systematic review and meta-analysis.

- Med (Baltimore). 2016;95(33): e4598.
- [26] Ross PA, Lerman J Cote, CJ. Pediatric equipment. In: Cote CJ, Lerman J, Anderson BJ, eds. *A Practice of Anesthesia for Infants and Children*. 6th ed. Philadelphia, Pennsylvania: Elsevier; 2019:1175-1203.
- [27] Sakka SG, Huettemann E, Petrat G, Meier-Hellmann A, Schier F, Reinhart K. Transoesophageal echocardiographic assessment of haemodynamic changes during laparoscopic herniorrhaphy in small children. *Br J Anaesth*. 2000;84(3):330–4.
- [28] De Waal EE, Kalkman CJ. Haemodynamic changes during low-pressure carbon dioxide pneumoperitoneum in young children. *Paediatr Anaesth*. 2003 Jan;13(1):18-25
- [29] De Keulenaer BL, De Waele JJ, Powell B, Malbrain MLNG. What is normal intra-abdominal pressure and how is it affected by positioning, body mass and positive end-expiratory pressure? *Intensive Care Med*.2009;35(6):969–76.
- [30] Mishchuk V, Lerchuk O, Dvorakevych A, Khomyak V. Features of respiratory support during laparoscopic correction of inguinal hernias in children. *Wideochir Inne Tech Malo Inwazyjne*. 2016;11(2):55–9.
- [31] Hou X, Chen P, Jiang Y. How to choose a suitable intraabdominal pressure level during single-incision laparoscopic surgery in children. *Food Sci Technol*.2021;41(suppl 1):129–32
- [32] Macías AA, Finneran JJ. Regional anesthesia techniques for pain management for laparoscopic surgery: A review of the current literature. *Curr Pain Headache Rep*. 2022;26(1):33–42.
- [33] Tobias JD. Pain management following laparoscopy: Can we do better? *Saudi J Anaesth*. 2013;7(1):3-4
- [34] Hirvonen EA, Nuutinen LS, Vuolteenaho O. Hormonal responses and cardiac filling pressures in head-up or head-down position and pneumoperitoneum in patients undergoing operative laparoscopy. *Br J Anaesth*. 1997; 78:128-33.
- [35] Joris JL, Noirot DP, Legrand MJ, Jacquet NJ, Lamy ML. Hemodynamic changes during laparoscopic cholecystectomy. *Anesth Analg*. 1993; 76:1067-71.
- [36] Gannedahl P, Odeberg S, Brodin LA, Sollevi A. Effects of posture and pneumoperitoneum during anaesthesia on the indices of left ventricular filling. *Acta Anaesthesiol Scand*. 1996; 40:160-6.
- [37] Bax NMA, van der Zee DC. Complications in Laparoscopic Surgery in Children. In: *Endoscopic Surgery in Children*. Berlin, Heidelberg: Springer Berlin Heidelberg; 1999. p. 357–68.
- [38] Chen, M. K., Schropp, K. P., & Lobe, T. E. Complications of minimal-access surgery in children. *Journal of Pediatric Surgery*.1996; 31(8):1161-1165.
- [39] Esposito, C., Montupet, P., Amici, G., & Desruelle, P. Complications of laparoscopic antireflux surgery in childhood. *Surgical Endoscopy*.2000; 14(7): 622-624.
- [40] Srivastava A, Niranjana A. Secrets of safe laparoscopic surgery: Anaesthetic and surgical considerations. *J Minim Access Surg*. 2010;6(4):91-4.