Application of Video Laryngeal Mask in Laparoscopic Surgeries

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Abstract: Based on conventional laryngeal mask airways, the video laryngoscope features an integrated video module. This enhanced design allows real-time visualization during laryngeal mask placement, positioning, and endotracheal intubation guidance. It reduces reliance on auxiliary equipment like flexible fiberoptic bronchoscopes, significantly enhancing intraoperative airway management. This article elaborates on the clinical advantages of video laryngoscopes in laparoscopic surgeries through practical case analyses, providing valuable references for clinical implementation.

Keywords: Video Laryngoscope; Laparoscopic Surgery; Airway Management; Video-Assisted Technology; Carbon Dioxide Pneumoperitoneum; Special Patient Positioning

1. Introduction

The advent of laparoscopic surgery marked a fundamental shift in medical evolution. During the 1960s to 1980s, pioneers such as Palmer, Frangenheim, and Semm made outstanding contributions, transforming laparoscopy from a purely diagnostic procedure into a standalone surgical approach[1]. Laparoscopic surgery has advanced rapidly, fundamentally transforming surgical paradigms within a remarkably short time frame. It has now become the preferred surgical approach for various conditions across multiple medical specialties. Laparoscopy has emerged as a routine diagnostic and therapeutic approach in the 21st century. Its technological advancements are driving the development of robotic surgery, with future innovations poised to integrate artificial intelligence and precision surgical techniques[2-4].As a hallmark technique of minimally invasive surgery, laparoscopic surgery involves creating small incisions on the body surface to insert endoscopes and surgical instruments[5]. Equipped with technologies such as high-definition cameras, three-dimensional imaging, and robotic surgery systems, it enables surgeons to visualize lesions and surrounding structures with enhanced clarity, significantly improving the precision and safety of minimally invasive procedures, particularly critical in complex operations [6]. Compared with conventional surgery, laparoscopic surgery minimizes trauma to surrounding tissues and causes only mild postoperative pain, significantly reducing patients' need for analgesics and anti-infection medications—thereby effectively preventing excessive medication use[7,8].

In 1878, Macewen pioneered the use of tracheal intubation in anesthesia, while the laryngeal mask airways (LMAs) developed by Brain in 1981 stand as one of the most significant innovations in airway management tools in recent decades [8]. As a supraglottic airway device, the LMA is widely adopted in clinical practice due to its minimal hemodynamic stress, reduced postoperative complications, and ease of insertion. The feasibility of LMA application in laparoscopic surgery has been validated by multiple clinical studies, with demonstrated advantages in hemodynamic stability, reduced complication rates, procedural efficiency, and ventilatory efficacy. However, the application of LMAs in laparoscopic surgery remains challenging, primarily due to the risk of malposition during blind insertion, which may lead to intraoperative displacement, air leakage, and increased risks of reflux and aspiration—critical airway management safety concerns[9-10].

The third-generation laryngeal mask is equipped with a monitor screen and three channels (ventilation tube, esophageal drainage tube, and video endoscope channel), enabling continuous visual monitoring during insertion. This allows real-time detection of device displacement, cuff abnormalities, secretions, and reflux material—hence known as the visualized laryngeal mask. With a sealing pressure of 25–30 cm H_2O. It significantly enhances airway management safety-visualized laryngeal masks are recommended for patients requiring special positions, significant position changes, or prolonged surgeries to optimize airway management (Evidence Level II, Recommendation Grade B)[11, 12]. The application of visualized laryngeal masks expands the clinical applicability of LMAs, particularly in laparoscopic surgeries characterized by high pneumoperitoneum pressures and specific intraoperative positional demands. This challenges the conventional preference for endotracheal tubes (ETTs) over traditional LMAs in laparoscopic procedures.

2. Feasibility and Safety of LMAs Application in Laparoscopic Surgery

The application of LMAs in laparoscopic surgery demonstrates clear feasibility. Under positive pressure ventilation, its efficacy is comparable to ETTs, while adapting to the specific demands of laparoscopic procedures. Advantages include hemodynamic stability, reduced postoperative complications, and simplified operation. For eligible patients, LMAs serve as a viable alternative to ETTs, particularly excelling in gynecologic and cholecystectomy surgeries. However, individualized selection based on patient factors and surgical types is essential, with strict adherence to operational protocols to ensure safety.

2.1 Airway Management in Laparoscopy and Ventilation Effectiveness of LMA

Laparoscopic technology is increasingly becoming a primary modality in surgical treatment. Its minimally invasive incisions contribute to superior cosmetic outcomes, reduced postoperative pain, shortened hospital stays, and decreased healthcare costs. However, the anesthetic physiological dynamics and management in laparoscopic surgery are predominantly influenced by two primary factors: patient positioning and pneumoperitoneum.During laparoscopic procedures, carbon dioxide insufflation—essential for abdominal organ visualization—increases intra-abdominal pressure (IAP) by 10–20 mm Hg. Concurrent CO_2 absorption from the peritoneal cavity, combined with patient positioning (head-up or head-down tilt), elevates both intra-abdominal and intrathoracic pressures. This reduces pulmonary compliance, raises airway pressure, and increases airway resistance. Consequently, risks of atelectasis and ventilation-perfusion mismatch with hypoxemia arise, triggering hemodynamic, metabolic, and respiratory alterations[13-14].

LMAs ventilation under positive pressure ventilation is comparable to tracheal intubation and can be adapted to the specific needs of laparoscopic surgery. The experimental study by Miller DM comparing the effectiveness of the ProSeal LMA™, SLIPA™ supraglottic airway (SLA), and standard tracheal tube (TT) in 150 consecutive day-case laparoscopic gynaecological surgeries under general anaesthesia demonstrated that the TT provided significantly superior sealing efficacy to both SLAs. This was evidenced by lower minimum flow rates required to ventilate the lungs. However, the airway sealing pressure indicates that the sealing quality of the SLAs was nearly comparable to that of the TT. The required minimum flow rate was well below 1 $L \cdot min^{-1}$, thus enabling low-flow anaesthesia delivery. The difference between the two SLAs was not significant[15].The ProSeal PLMA is an evolution of the classic LMA™ design, featuring enhanced maximum sealing pressure and an integrated drainage tube. In contrast, the SLIPA™ is engineered as a single-use disposable device incorporating design features to minimize aspiration risk during regurgitation events, providing enhanced suitability for laparoscopic procedures[16].In a clinical evaluation of 300 patients undergoing laparoscopic surgery, Wei et al.[17] concluded that the LMA® Protector™ provides safe and effective airway management in laparoscopic procedures. While minor complications not requiring additional clinical intervention as postoperative sore throat-were reported, no clinically diagnosed aspiration events were observed throughout this prospective study. The 2024 Chinese Expert Consensus on Clinical Application and Management of Laryngeal Mask Airways established that second-generation laryngeal masks incorporate an esophageal drainage port as a key advancement over first-generation devices. These dual-lumen designs achieve oropharyngeal sealing pressures ≤ 30 cm H_2O while permitting insertion of gastric tubes (12-14 Fr) through the drainage channel for active suction, thereby reducing gastric insufflation and mitigating regurgitation/aspiration risks during laparoscopic procedures[18]. Recommendation: For patients undergoing prolonged surgical procedures or requiring non-standard positioning, gastric tube insertion with intermittent suction via the laryngeal mask airway drainage channel constitutes standard practice.

The above research and expert consensus indicate that although laparoscopic surgery may be affected by artificial pneumoperitoneum and special positioning, both traditional and cuffless laryngeal mask airways can maintain effective ventilation without significantly disrupting the surgical procedure. Their ventilation efficacy is comparable to endotracheal intubation. Featuring a dual-cuff design and drainage tube structure, the laryngeal mask effectively isolates the airway from the esophagus, reduces aspiration risks, and specifically meets the special requirements of laparoscopic surgery.

2.2 Advantages of Laryngeal Mask Airway in Laparoscopic Surgery

2.2.1 Hemodynamic Stability

ETTs and LMAs represent two commonly used airway management devices in clinical anesthesia. While ETTs offer superior sealing capacity and thus enhanced airway security, both intubation and extubation procedures may induce significant hemodynamic fluctuations (e.g., tachycardia, hypertension, arrhythmias)[20].The LMA is designed by positioning a silicone cuff above the glottis. Upon inflation, its cuff conforms to the pharyngeal anatomy, eliminating the need for tracheal insertion. This design results in reduced pharyngeal stimulation, an enhanced hemodynamic profile, and significantly attenuated cardiovascular stress responses. In a randomized trial by Miller DM et al. comparing the efficacy of ProSeal™ laryngeal mask airway (PLMA), SLIPA™ supraglottic airway (SLA), and standard tracheal tube (TT) in 150 consecutive day-case laparoscopic gynecological surgeries under general anesthesia, non-invasive systolic blood pressure (SBP) measurements were recorded: (1) pre-anesthesia, (2) immediately post-induction but pre-airway placement, and (3) within two minutes post-placement. Clinically significant SBP elevation (>15%) was observed post-placement when comparing TT with SLA. Conversely, SLIPA™ and PLMA demonstrated comparable hemodynamic responses [15]. Jarineshin et al. [19] detected that hemodynamic parameters were measured within 5 minutes after LMA or Endotracheal Tube (ETT) placement. The analysis revealed significantly smaller magnitudes of change in both systolic and diastolic blood pressure (SBP/DBP) in the LMA group compared to the ETT group at 5 min post-insertion ($P<0.01$). Additionally, heart rate (HR) demonstrated a statistically significant elevation in the ETT group versus the LMA cohort at 1 min post-insertion. It collectively demonstrated superior hemodynamic stability during LMA application in airway management[21]. Parallel findings were documented by Gülewald et al. [22], whose study concluded that ProSeal LMA (PLMA) serves as a clinically appropriate, effective, and safe alternative to endotracheal tubes (ETTs) for patients experiencing lower surgical stress. In the ETT group, hemodynamic parameters increased to 10%-15% above baseline values immediately post-intubation and subsequently stabilized at 5%-8% above baseline throughout the remaining surgical duration. These hemodynamic profiles demonstrated comparability between interventions.

2.2.2 Reduced Incidence of Postoperative Complications

The randomized comparative study investigating ProSeal laryngeal mask airways (PLMA) versus cuffed ETT during laparoscopic surgery under general anesthesia assessed postoperative complications in both cohorts (ETT and SLA groups), including nausea, vomiting, airway trauma, and pharyngolaryngeal pain. The incidence of nausea was 16.67% in the ETT group and 6.67% in the PLMA group. These values were statistically significant. The incidence of postoperative sore throat was 13.33% in the tracheal intubation group. No patients in the PLMA group suffered from this complication, which was statistically significant. Airway injury accounted for 1.67%. This was very statistically significant[15]. Higgins et al. [23] showed that ETT patients had the highest incidence of sore throat at 45.4%, followed by LMA patients. Saraswat et al. [24] found postoperative sore throat in 10% of PLMA patients and 20% of ETT patients, while postoperative airway injury occurred in 10% of PLMA patients and 16.67% of ETT patients. Postoperative vomiting was not observed in any group, which may be attributed to proper antiemetic prophylaxis and gastric tube aspiration before extubation.

2.2.3 Enhanced Procedural Efficiency and Cost-Effectiveness

PLMA and SLIPA™ were both easy to insert, with first-attempt insertion success rates of 96% and 98% respectively (the anesthesiologist performing airway insertions was a senior operator who had used each device type over 100 times prior to the beginning of the trial)[15].An independent study has shown that SLIPA™ can be a good success and easy to use, even in inexperienced hands[25].

Compared with traditional tracheal intubation, laryngeal mask, as a widely used supraglottic ventilator, has less damage to the airway, stable intraoperative haemodynamics, high patient comfort, and is able to reduce perioperative anaesthesia medication and postoperative complications such as postoperative sore throat, nausea and vomiting, shorten the length of hospital stay, reduce the cost of PACU postoperative monitoring and the use of postoperative analgesic and antiemetic medication, as well as inpatient bed costs, and reduce the overall medical costs of patients. patients' overall medical costs and reduce patients' financial burden.

3. The limitations of the conventional laryngeal mask in laparoscopic surgery

Obstructed ventilation is an important problem in the management of laryngeal mask anaesthesia due to the following: 1) a mismatch between the mask and the pharyngeal cavity resulting in poor sealing; 2) the epiglottis curling and folding, obstructing the vocal folds or the tip of the mask; 3) changes in position, including the position of the head and neck, as well as changes in intra-abdominal pressure. Shallow anaesthesia can result in the closure of the vocal folds or laryngeal spasm. Other causes include spontaneous respiration, swallowing, choking and head and neck extrusion.

The limitations of the traditional laryngeal mask in laparoscopic surgery mainly concern the incorrect placement of the blind probe. This can lead to complications or adverse events associated with ventilation using the laryngeal mask, such as poor alignment, insufficient ventilation, regurgitation, aspiration, a sore throat after surgery and injury to adjacent nerves[26-27].Anaesthetists need to assess the appropriateness of the mask type and position indirectly, based on a number of indicators[28-29].Following blind mask placement, 66% of mask openings were well aligned with the glottis. However, 33% showed epiglottic reflexion, which blocked the airway[30]. Regardless of the mask's make or model, between 50%~80% of masks do not fit in the ideal anatomical position, posing a safety hazard[28].

4. Visual laryngeal masks offer unique advantages in laparoscopic surgery

In recent years, the visual laryngeal mask (VLMA), which integrates video technology to significantly improve the accuracy of mask placement and intraoperative monitoring, has become a hot research topic in airway management for laparoscopic surgery. Using the visual method of placement, the alignment of the mask opening with the glottis can reach 94% by adjusting the laryngeal mask position under visualisation[30]. In laparoscopic surgery, high alignment of the laryngeal mask opening with the vocal folds offers multiple advantages.

4.1 Significantly elevated sealing pressure in the laryngeal mask

To cope with the higher pneumoperitoneal pressure of laparoscopic surgery and changes in respiratory mechanics caused by changes in body position during surgery, the laryngeal mask must be able to withstand a greater sealing pressure than that required for other conventional surgeries. The sealing pressure of the laryngeal mask reflects the degree of alignment of the larynx and pharynx, which varies between different masks. Leakage can occur when the upper limit of the sealing pressure is exceeded or the mask is not well aligned.To monitor and assess mask position and mechanical ventilation status, oropharyngeal leak pressure (OLP) is commonly used to assess mask seal. An adequate oropharyngeal seal and enhanced OLP improve the safety of preventing gastric aspiration. OLP is also used to evaluate the safety and efficacy of the device, as well as the degree of airway protection it provides. It can also indicate the positioning of the device after blind insertion[31-33].

However, the accuracy and usefulness of OPL as an indicator of airway leakage depends on the optimal placement of the SADs[34-35].Unlike current SAD blind insertion techniques, the use of finely controlled manoeuvres with the flexible end of a video mask to navigate it to the correct position ensures optimal gas exchange. This prevents oropharyngeal leakage pressure (OLP) recordings from being subject to inaccuracies caused by minor or severe SAD misalignment[5].

4.2 Continuous intraoperative ambulatory monitoring

Laparoscopic surgery requires adjustments to the patient's position during the procedure. For upper abdominal surgery (e.g. gallbladder or stomach), the patient is placed in a reverse Trendelenburg position (head elevated 15°-30°, tilted to the right), with the aim of making the liver droop and exposing the gallbladder triangle. For pelvic surgery (e.g. rectum or uterus), the patient is placed in a Trendelenburg position (head low 25°-35°, tilted to the left), with the aim of making the uterus droop and exposing the pelvic organs. This moves the bowel towards the epigastrium, exposing the pelvic structures. For renal surgery, the lateral position with the lumbar bridge elevated and the surgical bed flexed spreads the distance between the rib margins and the iliac crests. For combined surgery (e.g. gastric and pelvic), segmental adjustments are required and positions are switched as necessary during the operation to accommodate the multiregional procedure[13,36] .

Due to the factor of intraoperative position changes in laparoscopic surgery, the use of laryngeal masks in laparoscopic surgery requires dynamic monitoring tools rather than disposable fixtures. This is the key to ensuring the safety of laryngeal masks in laparoscopic surgery. Clinical signs of incorrect SAD positioning include 1. resistance to instrument insertion into the hypopharynx; 2. displacement of the trocar during blowing; 3. poor alignment of the bite block with the upper incisors; 4. poor seal of the oropharyngeal airway (first seal) increasing the risk of ineffective gas exchange; 5. poor seal of the oesophagus (second seal) increasing the risk of gastric insufflation and subsequent suctioning; 6. inability to insert gastric drains; 7. clinical Inadequate supraglottic ventilation (inadequate tidal volume, poor tracing of carbon dioxide tracings, air leaks, airway obstruction); 8. Air leaks or airway obstruction and low values of OLP, intrathecal pressure and oxygen saturation[10, 34].

Among these, situations 1, 3, 4, and 6 can be managed solely using devices such as a visual laryngeal mask; situations 7 and 8 can be resolved by analyzing parameters like respiratory dynamics and oxygen saturation monitored through devices including monitors and anesthesia machines; although situations 2 and 4 can be analyzed based on parameters from monitors and anesthesia machines, such analysis tends to be retrospective and carries irreversible risks. Therefore, continuous intraoperative monitoring for displacement and aspiration of refluxate remains necessary.

5. Conclusion

The visual laryngeal mask has been proven to be an effective and safe supraglottic ventilation tool in laparoscopic surgery. It can slow down haemodynamic fluctuations and allow a safe and reliable airway to be established rapidly, with continuous dynamic monitoring of ventilation status during the operation. Additionally, as the visual laryngeal mask eliminates the need for equipment such as visual flexible scopes, it is more cost-effective to promote its use in primary hospitals.

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