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LITERATURE REVIEW

Use of Laryngeal Mask Airway (LMA) in General Anesthesia for Elective Cesarean Section

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ABSTRACT

The Laryngeal Mask Airway (LMA) is a supraglottic airway device introduced by Archie Brain in 1988 and has become one of the most important innovations in anesthetic practice. The development of second-generation LMAs has demonstrated significant improvements in safety, particularly through the addition of gastric drainage channels and higher oropharyngeal seal pressures. These innovations aim to reduce the risk of aspiration and enhance the effectiveness of positive pressure ventilation. In obstetric practice, especially elective cesarean section, second- generation LMAs such as the ProSeal LMA (PLMA) and Supreme LMA (SLMA) have shown promising outcomes in patients with low aspiration risk. Multiple studies report high first-attempt insertion success rates (98–100%), rapid insertion times, and adequate ventilation and oxygenation. Additionally, LMA use is associated with more stable hemodynamic responses and a low incidence of complications, including aspiration, hypoxia, and airway spasm. However, the endotracheal tube remains the gold standard for airway management in obstetric anesthesia. Second-generation LMAs are recommended as an alternative in selected situations, particularly in cases of unexpected difficult or failed intubation. Their use requires careful patient selection, adherence to preoperative fasting guidelines, and operator experience to minimize potential complications. In conclusion, second-generation LMAs are effective and relatively safe airway devices for elective cesarean section in selected patients and play a crucial role in difficult airway management algorithms in modern anesthetic practice.

Keywords: Cesarean section, difficult airway, laryngeal mask airway

INTRODUCTION

Airway management is a crucial aspect in anesthetic practice, particularly in obstetric patients who exhibit significant physiological changes, such as reduced functional residual capacity and increased oxygen consumption. This condition renders pregnant patients more susceptible to desaturation during anesthetic induction, thereby necessitating effective and safe airway management strategies.[1]

Since its introduction in 1988, the Laryngeal Mask Airway (LMA) has evolved into one of the most widely used supraglottic airway devices. Second-generation LMA developments have introduced important innovations, including enhanced airway seal pressure and the presence of a gastric drainage channel that functions to reduce the risk of aspiration. These features make second-generation LMA an increasingly viable alternative in modern anesthetic practice.[1]

In obstetric anesthesia, the endotracheal tube remains considered the gold standard for airway management. However, difficult or failed intubation continues to be a clinical challenge that may potentially increase morbidity and mortality. Therefore, the use of second-generation LMA as an alternative, particularly in elective cesarean section with low aspiration risk, has become an important consideration. Various studies demonstrate that this device exhibits high success rates, low complications, and provides adequate ventilation. With evolving scientific evidence and recommendations from multiple organizations, second-generation LMA now plays a significant role in difficult airway management algorithms. Consequently, comprehensive understanding regarding the characteristics, safety, and effectiveness of its use in clinical practice, particularly in obstetric anesthesia, is warranted.[1,2]

Physiological Changes in Pregnant Mothers During Pregnancy

During pregnancy, various physiological changes occur in the gastroesophageal system, beginning with anatomical alterations. The stomach is displaced upward toward the left side of the diaphragm, and its axis rotates approximately 45 degrees to the right from its normal vertical position. This positional change of the stomach triggers displacement of the intra-abdominal esophageal segment into the thoracic cavity in most pregnant women. The new anatomical configuration results in decreased tonus of the lower esophageal high-pressure zone (LEHPZ), the area that normally functions to prevent gastric content reflux. In addition to mechanical factors, the hormone progestin also contributes to LEHPZ relaxation.[1]

In the first trimester of pregnancy, baseline LEHPZ pressure may not undergo significant changes, but the sphincter becomes less responsive to various physiological stimuli that typically increase pressure. Entering the second and third trimesters, LEHPZ pressure gradually decreases to approximately 50% of baseline values, reaching its lowest point at 36 weeks of gestation. This pressure gradually returns to pre-pregnancy normal levels within one to four weeks postpartum. Changes in sphincter tonus and gastric anatomical position directly impact the high incidence of Gastroesophageal Reflux Disease (GERD) in pregnant mothers.

Approximately 30% to 50% of women are estimated to experience GERD symptoms during pregnancy. The prevalence of this disorder continues to increase with advancing gestational age; prevalence is recorded at approximately 10% in the first trimester, rising to 40% in the second trimester, and peaking at 55% in the third trimester. Several major risk factors for GERD in pregnancy include gestational age itself, pre-pregnancy history of heartburn, and multiparity.[1] From a demographic perspective, maternal age demonstrates an inverse correlation with reflux occurrence, whereas other factors such as gravidity, pre-pregnancy body mass index (BMI), and weight gain during pregnancy have not been proven to correlate with reflux symptoms.

Regarding motor and secretory function, gastric emptying processes generally remain unchanged during pregnancy. However, esophageal peristaltic movements and intestinal transit time become slower. This slowing is often attributed to progesterone-mediated inhibition of gastrointestinal contractile activity, or possibly represents a secondary effect of

decreased plasma motilin concentration, which is also influenced by progesterin during pregnancy.[1]

Conversely, no significant differences exist in basal or peak gastric acid secretion rates during pregnancy. Although average gastric pH is found to be lower in pregnant women (2.4 versus 3.0), serum gastrin levels show no meaningful difference compared to non-pregnant women. Statistically, approximately 80% of women (both pregnant and non-pregnant) have gastric pH of 2.5 or lower. Additionally, approximately 50% of women are recorded to have gastric volume of 25 mL or greater, and 40% to 50% of them demonstrate combination of low gastric pH with gastric volume exceeding 25 mL. These gastrointestinal physiological changes undergo further dynamics during the labor process and puerperium period. During labor, gastric emptying rate becomes slower again, accompanied by increased average gastric volume. Conversely, gastric acid secretion may decrease during labor, as it has been reported that only approximately 25% of parturient patients are detected to have gastric pH of 2.5 or lower. After delivery, gastric emptying process remains delayed in the early period, but this function gradually normalizes and returns to pre-pregnancy levels at 18 hours postpartum. Fasting gastric volume and pH values also return to identical profiles as non-pregnant patients within 18 hours postpartum.[1]

History of Laryngeal Mask Airway Development

The classic Laryngeal Mask Airway (cLMA) was developed by Archie Brain and first introduced into clinical practice in 1988. In his original publication, Brain described cLMA as an alternative to both endotracheal tubes and face masks, usable for both spontaneous ventilation and positive pressure ventilation. More than three decades since its introduction, cLMA has been recognized as one of the most important innovations in airway management and has become the most frequently used airway device in general anesthesia across various countries. Furthermore, the existence of cLMA has stimulated further development in the design and use of supraglottic airway devices (SGA).[1] cLMA and its various variants (generally referred to as LMA) represent the most frequently used and extensively researched type of SGA. SGA technology continues to evolve through modifications and innovations, which generally produce safer and more effective devices. Conversely, some SGA types were introduced into clinical practice but subsequently withdrawn from circulation due to inadequate performance or low utilization rates.[1]

Over the past two decades, development of second-generation SGA has significantly improved the safety profile of these devices. Since 2015, the Difficult Airway Society (DAS) has recommended the use of second-generation SGA in difficult airway management algorithms, particularly in conditions of tracheal intubation failure. This approach has also been adopted by various other organizations.[1,3]

In the cLMA development process, Brain emphasized the importance of understanding the complex anatomical and physiological principles of the oropharyngolaryngeal region. The size and shape of the tube and maskcomponents in SGA vary considerably, especially when compared to non-LMA devices. These variations determine how the device is inserted through the oral cavity and influence nearly all functions of the device. With the development of second-generation SGA, such as ProSeal LMA (PLMA) and Supreme LMA (SLMA), new features were added including drainage channels, bite blocks, and fixation systems, with variations in manufacturing processes and materials used.[4]

From a safety perspective, the primary risks of LMA use include gastric content aspiration, airway trauma, ventilatory failure due to obstruction or leakage, and difficulty in maintaining airway access, particularly if device dislocation occurs during surgical procedures. Initial concerns regarding aspiration risk were related to the possibility of gag reflex stimulation and decreased upper esophageal sphincter tonus. However, extensive clinical experience demonstrates that aspiration risk is relatively low when appropriate patient selection is made and device insertion is performed correctly.[4]

Recent developments in SGA design focus on enhancing protection against aspiration. One important innovation is the addition of drainage channels in second-generation SGA, which provides protection through multiple mechanisms: reducing gastric insufflation by directing leaked gas to the upper esophagus, providing a pathway for gastric tube insertion, enabling drainage of air and fluids,directing regurgitation away from the larynx, and providing early detection of regurgitation through visualization of gastric contents within the channel.[4]

Use of Second-Generation LMA for Elective Cesarean Section

Key Characteristics of Second-Generation LMA

- Second-generation LMA is designed with a primary focus on enhancing patient safety profile, particularly in preventing airway complications.[4]
- Anti-Aspiration Design: This device features design elements specifically intended to reduce the risk of pulmonary aspiration from gastric contents.
- Drain Tube: This additional feature functions to remove gastric gas, drain regurgitated fluid away from the larynx, provide reliable access for gastric tube insertion, and provide early warning to the anesthesiologist if regurgitation occurs.
- Optimal Airway Seal: This generation of devices is capable of creating higher pharyngeal seal pressure, making it more reliable when used for controlled positive pressure ventilation.

Although the Endotracheal Tube (ETT) is often considered the gold standard, second-generation LMA (particularly PLMA and SLMA) has demonstrated promising results in obstetric practice.[4]

- Safety in Cesarean Surgery: Second-generation LMA has been reported successful and safe for use in both elective and emergency cesarean surgery cases.
- Patient Criteria: This device is predominantly used safely in pregnant mothers who have undergone adequate fasting and are not obese (low risk).
- High Success Rate: First-attempt insertion success rate is very high, ranging from 98% to 99%.
- Low Complication Incidence: In various reports, no cases of harmful aspiration were found (only one case of regurgitation was reported), and there were no reports of severe hypoxia or laryngeal/bronchial spasms.

Comparison with ETT: A meta-analysis in low-risk cesarean surgery patients demonstrated that Supraglottic Airway (SGA) use has comparable first-attempt success rates to ETT, with no difference in adverse event incidence. However, this analysis was noted to still be insufficiently robust to definitively detect adverse complication rates.[4-5]

The most critical point regarding second-generation LMA use in obstetrics is not to replace routine intubation, but rather as an emergency device. Although not yet standard routine practice for every obstetric surgery, existing clinical evidence strongly supports second-generation SGA use in airway management. This device is specifically recommended and highly important as an accepted management guideline for unexpectedly difficult intubation situations during cesarean surgery procedures.[4]

Evolution of Supraglottic Airway (SGA) devices has brought significant changes in airway management, particularly with the emergence of second-generation devices. Two most prominent devices marking design leaps in this category are ProSeal LMA (PLMA) and LMA Supreme (SLMA). Both were designed with the primary objective of addressing limitations of classic LMA, specifically by enhancing protection against pulmonary aspiration risk and optimizing positive pressure ventilation (PPV) function. The key safety feature distinguishing this generation is the presence of a drain tube to separate respiratory and gastrointestinal tracts, along with cuff design capable of providing high pharyngeal seal pressure, reaching 60–70 cm H_2O range.[1]

Although having similar safety profiles,

Figure 1. LMA Supreme is made from PVC material. This device has an integrated bite block and fixation tab at its proximal end. Two tubes extend from the manifold (connector base). The 15 mm diameter airway tube is designed to connect to the breathing circuit. The narrower tube is the proximal end of the drain tube. Two narrow airway channels extend on both sides of the drain tube, extending to the tip of the modified cuff. Unlike LMA ProSeal, this cuff lacks a posterior component. A pilot balloon is attached to the cuff inflation line.[2]

Figure 2. PLMA (ProSeal Laryngeal Mask Airway) is designed to separate the respiratory tract from the gastrointestinal tract and provide better seal around the glottis. This enables more reliable positive pressure ventilation compared to Classic LMA.[2]

Table 1. Technical Comparison between ProSeal LMA and LMA Supreme[2]

Aspect / Feature	ProSeal LMA (PLMA)	LMA Supreme (SLMA)
Material & Usage Type	Made of silicone with flexible airway tube. Generally designed for reusable use.	Made of PVC and specifically designed as single-use device.
Tube Characteristics	Has dual-tube design (airway channel and drain channel) making it more bulky. No rigid posterior plate.	Has built-in rigidity with sharper shaft curvature.
Cuff Design	Silicone cuff has dorsal (posterior) component enabling higher airway seal.	Cuff has been modified and lacks posterior component.
Esophageal Leak Pressure	60–70 cm H_2O	60–70 cm H_2O
Extra Features & Markers	Has bite block. Its bulky size makes it less practical for most intraoral surgical procedures.	Has internal bite block and proximal fixation tab functioning as insertion depth guide (ideally approximately 2 cm from upper lip).
Insertion Dynamics	Tends to be more difficult to insert and prone to posterior folding due to thick, large, soft cuff tip and absence of rigid plate.	Does not require additional introducer tool as it has inherent rigidity from material design.
Insertion Aid Technique	Can be inserted digitally (manual), using specialized introducer tool, or with bougie guide.	Curvature angle is too sharp for bougie guide insertion, but easily inserted over orogastric tube guide.

PLMA and SLMA differ in physical characteristics and insertion dynamics. PLMA offers flexibility and maximal seal through its silicone design, but requires more meticulous insertion technique. Conversely, SLMA is available as a single-use PVC solution integrating various

conveniences from previous generations, with rigid structure facilitating insertion without auxiliary instruments.[1,6]

Clinical Efficially Analysis of LMA in Elective Cesarean Section

A prospective randomized controlled study involving 60 obstetric patients with ASA I–II physical status undergoing elective cesarean section under general anesthesia compared ProSeal laryngeal mask airway (PLMA) with endotracheal tube. Patients with fasting duration less than 6 hours, suspected difficult airway, obesity, gastroesophageal reflux disease, and hypertensive disorders were excluded from the study.

All patients received aspiration prophylaxis and anesthetic induction using rapid sequence induction technique. PLMA placement was assessed as easy in nearly all patients, with insertion time comparable to endotracheal tube, and adequate ventilation achieved in all cases. Hemodynamic changes during device insertion and removal were more minimal in the PLMA group. No regurgitation or aspiration events were found, and postoperative throat pain incidence was lower compared to the endotracheal tube group. These results demonstrate that PLMA provides better hemodynamic stability with equivalent ventilation adequacy, along with additional advantage of gastric drainage channel for aspiration prevention. However, its use is recommended in selected obstetric patients with low aspiration risk and by experienced operators.[7]

Another study regarding Supreme laryngeal mask airway (SLMA) demonstrated first-attempt placement success rate of 98.3% with 100% overall success, and average time to effective ventilation approximately 15 seconds. No clinical evidence of regurgitation or aspiration was found, and intraoperative hypoxemia, laryngospasm, or bronchospasm events were not observed. Mild side effects such as throat pain and hoarseness were relatively low. Neonatal outcomes showed first-minute and fifth-minute APGAR scores within normal range and adequate umbilical venous pH, with no significant difference between categories 2 and 3. Maternal satisfaction was reported as high. This study concluded that SLMA is capable of providing adequate ventilation and oxygenation in category 2 and 3 cesarean section with strict patient selection. Nevertheless, tracheal intubation remains the gold standard, and SLMA is positioned as an alternative particularly in intubation failure. Study limitations include cohort design without control group and homogeneous population with low aspiration risk, thus results cannot be generalized to parturients with severe obesity, high aspiration risk, or difficult airway.[8]

Another prospective observational study involving 700 ASA I–II parturients, non-obese, fasting minimum four hours, and receiving antacid prophylaxis demonstrated all LMA Supreme™ placements were successfully performed, with approximately 98% successful on first attempt. Average time to effective ventilation was approximately 20 seconds, without aspiration or regurgitation events. Ventilation and oxygenation were well maintained during the procedure. Mild side effects such as throat pain and presence of blood on device during removal were reported with low incidence.

Neonatal outcomes remained good with APGAR scores and umbilical venous pH within normal limits, with no significant difference between elective and semi-emergency cases. This study concluded that in strictly selected parturients, LMA Supreme™ can become an alternative to tracheal intubation in general anesthesia for cesarean section. Low aspiration risk was likely influenced by appropriate patient selection, adherence to preoperative fasting, and operator experience. However, this device is not intended to replace tracheal intubation as the gold standard, but rather as an alternative option particularly in difficult or failed intubation conditions.[9]

Studies demonstrate that Supreme™ LMA is effective and safe as an alternative to endotracheal intubation in selected parturients undergoing cesarean section, although still having first-attempt insertion failure rate of approximately 2%.[10] According to previous studies, laryngeal mask airway (LMA) in

obstetric patients can be used as an alternative in elective cesarean section in patients with low aspiration risk and good airway conditions, particularly when performed by experienced operators.[11] Commonly used second-generation supraglottic airway devices—such as LMA ProSeal™, LMA Supreme™, and i-gel®—possess gastric drainage features and designs that enhance airway seal, with various studies demonstrating ease of insertion, reliability, and low morbidity rates.[12]

Although pulmonary aspiration is the most feared complication, clinical evidence demonstrates a very low incidence when second-generation LMAs are used appropriately. In one study involving 1,067 patients, no cases of aspiration or clinically evident regurgitation were reported.[13] Similarly, a 10-year retrospective study comparing the LMA Supreme with endotracheal intubation found no significant difference in the incidence of aspiration or aspiration pneumonia.[14]

Laryngeal Mask Airway (LMA) Insertion Steps in Obstetric Patients

Pregnant women experience more rapid arterial oxygen saturation decline compared to non-pregnant women. This is related to increased oxygen consumption and decreased functional residual capacity (FRC). Therefore, preoxygenation using 100% oxygen is a critically important step before anesthetic induction. In conditions of acute fetal distress, administration of four deep breaths with 100% oxygen may be sufficient. Pregnant women also experience faster denitrogenation during preoxygenation, but conversely will experience more rapid desaturation during apnea compared to non-pregnant women.[15]

Rapid sequence induction (RSI) with cricoid pressure administration (Sellick maneuver), followed by endotracheal intubation, is the standard procedure in anesthetic induction. American Society of Anesthesiologists (ASA) standard monitoring must be applied in every case, including capnography use. If intubation difficulty occurs after general anesthetic induction, oxygenation must be immediately maintained through mask ventilation. If no emergency conditions exist such as ongoing

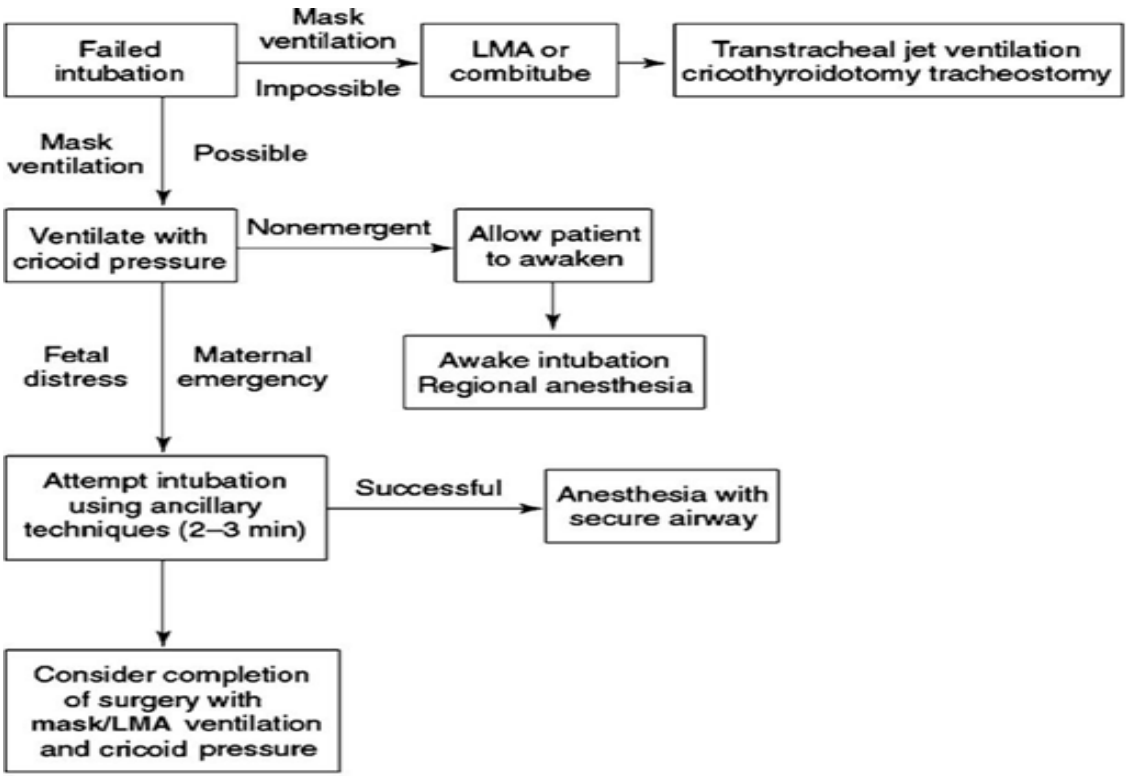

Figure 3. Steps in Standard Protocol when Difficult Intubation Occurs during Cesarean Section.[10]

fetal distress or antepartum hemorrhage, anesthesia can be discontinued and the patient allowed to regain consciousness for evaluation and determination of alternative anesthetic strategy. However, if anesthesia must continue, laryngeal mask airway (LMA) can be inserted to maintain airway.[15]

In certain conditions, endotracheal tube can be inserted through LMA with fiberoptic bronchoscope assistance to minimize airway trauma. LMA has also been proven effective in difficult intubation–difficult ventilation cases. Additionally, LMA can be inserted under local anesthesia as a conduit for awake endotracheal intubation before general anesthetic induction. Protocols for difficult or failed intubation management must be available at every institution before the event occurs. If intubation difficulty is anticipated, good communication between anesthesia team, obstetrics team, and patient is crucial in determining appropriate clinical decisions.[15-16]

CONCLUSION

Second-generation Laryngeal Mask Airway (LMA) is an increasingly relevant airway device in obstetric anesthesia, particularly in cesarean section. Physiological changes in pregnancy that increase hypoxia and intubation difficulty risk make the availability of safe airway alternatives crucial. With features such as gastric drainage channel and high pharyngeal seal pressure, second-generation LMA is capable of providing adequate ventilation while enhancing protection against aspiration in selected low-risk patients. Various evidence demonstrates that second-generation LMA use in elective cesarean section has high success rate, better hemodynamic stability, and low complication rates. However, endotracheal tube remains the gold standard in obstetric anesthesia.

Therefore, second-generation LMA is not used as routine replacement, but rather as an important alternative, particularly in difficult or failed intubation conditions. With appropriate patient selection and use by experienced operators, second-generation LMA plays a significant role in enhancing maternal and fetal safety, and serves as an integral part of airway management algorithms in modern obstetric anesthetic practice.

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