Comparison of the LMA Supreme™ with the LMA Proseal™ for airway management in patients anaesthetized in prone position†

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Editor’s key points

- The Proseal™ LMA (PLMA) and the single use Supreme™ LMA (SLMA) were compared during surgery in the prone position.
- Both devices were easy to insert with few complications.
- There was less need for manipulation to achieve optimal position, and seal pressure was higher with the PLMA.
- Both devices are suitable in selected patients but further data are required.

Background. The laryngeal mask airway (LMA) has been successfully used in patients in the prone position either for rescue or elective airway management. The reusable Proseal™ LMA (PLMA) and the single use Supreme™ LMA (SLMA) have been reported to be suitable for this purpose but few comparative data are available. In this study, we compared the clinical use of both devices in adult patients anaesthetized in the prone position.

Methods. One hundred and twenty patients undergoing surgery in the prone position were randomized to receive either the PLMA or the SLMA for airway management. Patients positioned themselves in the prone position and after pre-oxygenation, anaesthesia was induced using a target-controlled i.v. infusion of propofol and remifentanil. All PLMAs and SLMAs were inserted by experienced anaesthetists using a guided and a standard technique respectively. Ease of facemask ventilation, time and number of attempts needed for insertion, quality of ventilation, airway seal pressure, fibreoptic view, and complications were compared.

Results. There were no differences between groups in insertion time or first attempt success (100% vs 98%). The PLMA required fewer manipulations (3% vs 15%; P = 0.02) to achieve effective ventilation and provided a higher seal pressure (mean [SD] 31 [4] vs 27 [4] cm H₂O; P < 0.01). The fibrescopic view of the vocal cords was similar, although easier to achieve with the PLMA. The complication rate was low and similar between the groups. Blood was present on masks in 7% vs 8% and sore throat in 3% vs 5% of patients with the PLMA and SLMA, respectively.

Conclusions. Airway management in patients anaesthetized in the prone position was efficient with both devices, although the PLMA required fewer manipulations and achieved a higher seal pressure.

Keywords: airway equipment; complications; laryngeal mask airway; prone position

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The feasibility of inserting a laryngeal mask airway (LMA) in patients anaesthetized in the prone position for elective procedure has been reported in previous case series; only transient complications have been described and these were as easily treated as for in patients in the supine position.1–3 Furthermore, in ambulatory settings, the use of LMA to secure the airway in patients in the prone position has useful advantages, such as reductions in the induction to incision time, in the cardiovascular changes, and in manpower resources for positioning the patient, compared with the traditional approach of tracheal intubation in the supine position.4 Selected patients undergoing short surgical procedures may benefit from taking the prone position themselves to avoid the risk of adverse events derived from switching an anesthetized patient from the supine to the prone position.5 However, the use of supraglottic devices as the primary airway management technique for this purpose remains controversial. The potential risk of failed insertion or ventilation warrants safety precautions, such as the ready availability of difficult airway management equipment, the careful selection of patients and procedures, and the use of the most suitable device. New supraglottic devices with a drain tube, such as the reusable Proseal™ LMA (PLMA) or the single use Supreme™ LMA (SLMA) (Laryngeal Mask Co. Ltd, Le Rocher, Victoria, Mahe Seychelles), offer additional advantages over simple supraglottic devices, as they provide a more effective airway seal, allow evacuation of gastric contents, and facilitate repositioning in the case of displacement.

The PLMA is made of silicone, has a reinforced soft flexible airway tube, a second posterior cuff to increase the airway
The SLMA is made of polyvinyl chloride, has a firm airway tube shaped at a 90° angle to facilitate insertion, a modified conical cuff without posterior extension, and a gastric channel running along the posterior midline through the airway tube to facilitate the passage of a gastric tube. The cuff ends in a reinforced tip to prevent it from folding over during insertion.

The performance of the two devices in patients in supine position have been reported to be similar;6 7 however, slight differences in seal pressure favouring the PLMA8–10 or in ease of insertion favouring the SLMA10 have been demonstrated. Although the quality of ventilation was similar in these comparative studies, the SLMA was reported to require adjustments or repositioning to optimize ventilation in 13% and 20% of patients in two large series.11 12

The feasibility and efficacy of the PLMA inserted in the prone position has been reported in emergencies13 and in a retrospective audit of 245 patients.14 The SLMA has also been successfully used by experienced staff in patients in the prone position.15 16 However, the two devices have not been compared in the prone position in prospective trials. Our hypothesis was that the differences in shape and materials of the SLMA and the PLMA would result in differences in clinical performance in prone patients with the head rotated to one side. We conducted a randomized trial to compare the two LMAs in terms of ease of insertion, quality of ventilation, view through the fibrescope, and efficacy of seal in this setting.

**Methods**

After obtaining approval from the institutional review board for the study, we recruited adult patients with American Society Anesthesiologists physical status I–III, who were to undergo elective ambulatory procedures in the flat prone position or lumbar spine surgery in the modified knee-chest position under general anaesthesia. Exclusion criteria were obesity (body mass index >35 kg m⁻²), known or predicted difficult airway, reduced lung compliance, and high risk for pulmonary aspiration. After obtaining their written informed consent, 120 patients received artificial ventilation using the PLMA or SLMA according to randomly allocated sealed opaque envelopes (Fig. 1). The LMA size was selected according to the patient weight: size 3 for patients under 50 kg, size 4 for patients between 50 and 70 kg, and size 5 for patients heavier than 70 kg.

All insertions were performed by anaesthetists with extensive experience in using these supraglottic devices (≥100 PLMA insertions; ≥50 SMLA insertions) and with anaesthesia in the prone position.

Patients were premedicated with i.v. midazolam (0.02 mg kg⁻¹) and atropine (0.01 mg kg⁻¹) in the preanaesthesia room. Patients positioned themselves in the flat prone position with pillows under their thorax and pelvis, or in the knee-chest position on the Cloward frame with their hips and knees flexed and adequately protected. The head and neck was rotated to the left on a soft ring to provide access for airway management. Standard intraoperative monitoring included continuous electrocardiography, non-invasive blood pressure, pulse oximetry, capnography, spirometry, and the bispectral index. All patients’ lungs were preoxygenated with 100% oxygen delivered through a facial mask and anaesthesia was induced in the prone position with propofol (target-controlled infusion, 4–6 μg ml⁻¹) and remifentanil (target-controlled infusion, 2–4 ng ml⁻¹) targeting the effect site. Manual face mask ventilation was continued until the jaw was relaxed and the bispectral index was below 50. Ease of the face mask ventilation was graded in a 3-point scale: (1) correct thoracic movements and absence of leak; (2) resistance or leak requiring oropharyngeal cannula and cervical hyperextension; (3) two-handed mask ventilation needed.

All LMAs were inserted fully deflated and lubricated with a water-soluble gel, but using a different insertion technique. The PLMA was inserted after first advancing a suction catheter along the drain tube 8–10 cm beyond the distal end; the mask was then inserted using a digital technique, allowing the suction catheter to enter first in the oesophagus and guiding the tip of the cuff.15 16 The SLMA was inserted using the recommended standard rotational technique. The cuffs were inflated to achieve a pressure of 60 cm H₂O, measured with a manometer (VBM Medizintechnik GmbH, Sulz, Germany).

Anaesthesia was maintained with propofol and remifentanil target-controlled infusions. Neuromuscular blocking drugs were given if needed for the facilitation of surgery or the treatment of airway obstruction events. Doses, timing, and indication were recorded. Patients were allowed to breathe spontaneously or their lungs were mechanically ventilated with a tidal volume of 6–8 ml kg⁻¹, a frequency needed to maintain end-tidal carbon dioxide between 4.0 and 4.6 kPa, and the inspiratory flow adjusted to deliver the tidal volume. At the end of surgery, anaesthesia was discontinued and the LMA removed in the prone position after the return of airway reflexes and consciousness. Patients were helped to rotate into the supine position and were transferred to the recovery room.

An independent observer recorded the number of insertion attempts and the time needed for LMA placement, measured from when the LMA was picked up until the connection to the breathing circuit. In the case of a failed attempt, this was measured to the time the LMA was removed from the mouth. The maximum time allowed for each attempt was 60 s, and the final time was the sum of all attempts. The ease of insertion was graded on a 4-point scale: (1) no resistance; (2) mild resistance requiring additional manoeuvres (laryngeal mask rotation, neck hyper-extension, or jaw thrust); (3) high resistance requiring reinsertion; and (4) failure at second attempt. Ventilation quality with the LMA in position was scored on a similar 4-point scale: (1) optimal ventilation defined as normal thorax expansion and airway pressure without air leak; (2) suboptimal ventilation with minor air leak; (3) suboptimal ventilation with major air leak; and (4) failure requiring mask ventilation or reintubation.
(2) air leak or abnormal airway pressure necessitating manoeuvres (adjusting insertion depth, head–neck position, or cuff volume); (3) reinsertion of the LMA required; and (4) failed ventilation after two attempts. Type and number of manoeuvres were recorded. If the insertion or ventilation failed on the second attempt, one more try was allowed with the other device, provided correct facemask ventilation was maintained between attempts. Otherwise, the patient was turned into the supine position.

Airway seal pressure was measured by closing the expiratory valve of the breathing circuit and delivering a gas flow of 3 litre min⁻¹ until the seal pressure or a maximum pressure of 40 cm H₂O was reached. Peak inspiratory airway pressure was also recorded at the beginning of stable controlled ventilation. The difference between seal pressure and peak airway pressure for each patient was recorded.

A 16-gauge gastric tube was introduced via the drain tube of the SLMA to aspirate gastric contents. In the PLMA group, the suction catheter used to guide insertion was removed and a gastric tube inserted. The ease of insertion was scored as easy, difficult, or impossible. The gastric tube was left in place to aid the reinsertion of the LMA in case of displacement in those procedures expected to last more than 30 min or when a change in patient position was foreseen.

A 3.8 mm fibrescope (LF-2, Shirakawa, Olympus Co., Odakura, Nishigo-Mura, Japan) was introduced through the airway tube and advanced until the best possible view of the vocal cords was obtained. Ease of scope passage was graded by the operator as easy, if no resistance was found; fair, if manipulation of the tip was needed to deal with resistance; or difficult, if more than one obstacle was met. The view of vocal cords was scored as complete, when full vocal cords were visible; partial, when arytenoids or epiglottis covered part of the vocal cords, or no view at all.

Complications related to airway management, anaesthesia, and mechanical ventilation (teeth or mucosal trauma, cough, hiccup, laryngospasm, bronchospasm, leakage, high inspiratory pressure, arterial oxygen desaturation to \(\text{SpO}_2<95\%\), gastric distension, regurgitation, or aspiration), and the treatments were documented and the point of time was noted. Laryngospasm was treated by increasing the depth of anaesthesia and giving a neuromuscular blocking agent if required. In case of audible leak or displacement, manoeuvres to adjust the laryngeal mask or the pillows beneath the chest were attempted. Adverse events occurring
during awakening and in the postoperative period (blood on mask and sore throat) were recorded. Blood staining of the LMA at removal was classified as slight, moderate, or severe. Any sore throat, dysphonia, or dysphagia, classified as mild, moderate, or severe were investigated with a structured interview after 1 h in the recovery room and recorded by a blinded observer.

**Statistical analysis**

The primary outcome was the quality of ventilation in the prone position. The sample size was calculated to detect a 10% difference in the percentage of patients requiring manipulation of the LMA to obtain optimal ventilation (quality of ventilation assessed as 2, 3, or 4 on the scale), which was considered clinically relevant in this scenario. A previous study with the SLMA in prone position allowed us to expect an incidence of 12% need for LMA manipulation. For a type I error of 0.05 and a type II error of 0.2, 60 patients were required for each group. The secondary outcomes were the efficacy of seal and ease of insertion. Statistical analysis was performed using the Student's t-test for unpaired quantitative variables, and the χ² test and Fisher’s exact tests for qualitative variables as required.

**Results**

There were no differences between the groups regarding age, gender, weight, height, type, and duration of surgery (Table 1). All patients were included in the statistical analysis. Facemask ventilation was possible in all patients in the prone position and considered easy in most of them (Table 2). Only one patient required two-hand facemask ventilation owing to initial high resistance. There were no differences in the ease of insertion, time needed, or first attempt success rate (Table 2).

Optimal ventilation, defined as 1 on the scale, was achieved initially in 51 patients in the SLMA group and in 58 patients in the PLMA group (Table 2). Nine patients in the SLMA group (15%) required 15 adjustment manoeuvres...
(depth of insertion, up-down manoeuvre, head–neck extension, or repositioning the pillows) to solve gas leakage or high resistance to deliver the established gas flow; only two patients in the PLMA group (3%) required such manoeuvres. No cases of arterial oxygen desaturation <95% were detected during induction or maintenance or awakening from anaesthesia.

Airway seal pressure was higher with the PLMA [31 (4) mm Hg; 95% confidence interval (CI): 29.1–31.6 mm Hg] than with the SLMA [27 (4) mm Hg; 95% CI: 25.7–28.2 mm Hg (P<0.01)]. Peak inspiratory airway pressure and the difference between seal pressure and peak airway pressure did not differ between the groups. After evaluation, spontaneous ventilation was allowed to resume in eight patients in the PLMA group and in six in the SLMA group.

Gastric tube insertion was easy and successful in all patients in both groups.

The position of the LMAs was assessed fibreoptically in 44 patients in the PLMA group and in 45 in the SLMA group. In the remaining 31 patients, position could not be evaluated because the equipment was unavailable. Advancement of the scope was rated as easy more often in the PLMA group. There were no differences between the groups regarding the alignment of the LMA with glottic structures (Table 2).

The rate of intraoperative complications was low in both the groups (Table 2). Transient episodes of laryngospasm were effectively treated by increasing the depth of anaesthesia, although five patients in the SLMA group, and two in the PLMA needed low doses of rocuronium (0.1–0.2 mg kg⁻¹). All cases of audible leak or displacement were resolved by manoeuvres to adjust the mask or the pillows. One case of regurgitation flowing out of the drain tube occurred in the SLMA group. This patient did not develop any clinical sign of aspiration during or after the procedure.

The most frequent postoperative complication was the presence of blood on the LMA at removal, considered slight in all patients (Table 2). The rate of sore throat or discomfort after 1 h in the postanaesthesia care unit was low in both the groups. A transient episode of mild dysphonia was registered in one patient in the PLMA group (Table 2).

**Discussion**

Under the conditions of our study, both the PLMA and SLMA were successfully inserted and provided each patient with an effective airway with low rate of complications, results that are in line with previous series reporting the feasibility of the PLMA or the SLMA in patients anaesthetized in prone position. However, we found slight but significant differences in clinical performance between the two devices. The PLMA required fewer adjustment manoeuvres to achieve optimal ventilation and reached higher airway seal pressures than the SLMA.

Our data show that after successful insertion of the SLMA, the device had to be adjusted in 15% of patients to optimize the ventilation, in agreement with our previous report using the SLMA in patients in prone position. Sharma and colleagues also reported adjustment manoeuvres or reinsertion of a different size of SLMA in 9% of 205 patients anaesthetized in the prone position to obtain an acceptable airway. Our data are consistent with the results of two series evaluating the SLMA in patients in supine position. Timmerman and colleagues reported air leak in the drain tube in 13 out of 100 female patients, requiring repositioning of the SLMA. Cook and colleagues reported manipulations in 22 out of 100 patients and three reinsertions to obtain a patent airway. In contrast, only 3.3% of our patients required manipulations of the PLMA after successful insertion. Adjustment manoeuvres were effective to optimize ventilation with both devices in all patients in agreement with comparative studies evaluating the adequacy of ventilation in supine position, although details of such manoeuvres were not provided in the comparative studies. The preformed curve of the airway tube of the SLMA may limit the insertion depth of the cuff in some patients. The anatomic fit may also be impaired if the airway axes are not aligned with the sagittal plane, as when the neck of a patient in the prone position is rotated to one side. In contrast, the flexibility of the PLMA tube, seems to allow for a better fit, as reported in a comparative study of different head and neck positions.

The PLMA achieved a slight but significantly higher airway seal pressure (32 vs 27 cm H₂O achieved by the SLMA). These results are in line with the seal of 32 cm H₂O reported for the PLMA in a retrospective series of 245 patients and the seal of 27 cm H₂O that we reported previously for the SLMA in the prone position. Our data are also in agreement with three randomized trials comparing the two devices used in patients in the supine position. Eschertzhuber and colleagues reported a seal pressure of 34 cm H₂O for the PLMA vs 28 cm H₂O for the SLMA in a cross-over study in female patients. Lee and colleagues reported a similar difference between the two devices (31.7 vs 27.9 cm H₂O). However, Verghese and colleagues, in a cross-over study, and Hosten and colleagues observed similar seal pressure for these devices. Of note, no study has reported a higher seal pressure when using the SLMA, suggesting that the conical shape of its cuff does not compensate for the absence of the posterior cuff of the PLMA. This subtle advantage of the PLMA had no clinical significance in our patients, however, as peak airway pressure values were well below seal pressure in both the groups.

We found no differences in the ease of insertion between the two groups, in line with the results of most comparative studies in patients in supine position. Reported first-pass success rates in these trials range from 88% to 97% for the PLMA, and from 90% to 98% for the SLMA. Only a single study found the SLMA easier to insert than the PLMA. We attribute our high success rate in the PLMA group (100%) to the use of a guided insertion technique, which has been demonstrated to be superior to both the standard digital and the introducer tool techniques.

We found that the insertion of a gastric tube was easy at first attempt in both groups, in contrast to the results of two
comparative studies, which reported a more difficult or failed gastric tube insertion through the PLMA gastric channel. The double bend in the drain tube inside the cuff of the laryngeal mask may make the passage of the gastric tube difficult in some patients. The use of a suction catheter to facilitate the insertion of the PLMA in our study protocol probably circumvented this problem. The passage of a gastric tube has also been proved useful to detect malpositioning of the cuff tip during insertion or manipulation of the PLMA, which could lead to aspiration of gastric fluids. Even though the insertion of a gastric tube in fasted patients may not be necessary for elective procedures, there is agreement that it could be useful to aid the repositioning of the LMA in case of accidental displacement. Thus, the advantage of an LMA with a drain channel may contribute to the safety of both laryngeal masks, in comparison with simpler devices without gastric access for challenging indications such as the prone position.

The fibreoptic view was similar in both groups as reported in comparative studies in which patients were in supine position, although the passage of the scope to reach the vocal cords required more manipulations when the SLMA was used. The airway tube of the SLMA is partially divided by the gastric channel, making access more difficult than with the single flexible tube of the PLMA. Should fibreoptic-guided tracheal intubation be needed at any moment during the procedure, the PLMA would be an easier airway conduit than the SLMA.

The rate of complications recorded during the maintenance phase of anaesthesia, such as episodes of airway obstruction, was similar to rates reported for patients in supine position. All episodes were easily treated without turning the patient and without significant arterial oxygen desaturation, as reported in large series of patients managed in the prone position with both devices. Postoperative morbidity, such as blood on the mask or sore throat, was also within the range reported previously.

This study has certain limitations. It was blinded only for postoperative complications, although we stress that an independent observer recorded most of the variables studied and care was taken to clearly define the criteria to grade each item on a simple scale.

The PLMA was inserted with a guided technique to increase the likelihood of first-attempt insertion and avoid potential malpositioning of the tip, for safety reasons; we did not use the same technique to insert the SLMA because its design overcomes these problems. The firm elliptical and fixed curved tube facilitates the insertion of the SLMA and the reinforced tip prevents the cuff from folding over. Although all operators had experience with both devices in patients in the prone position, they were more used to PLMA (at least 100 uses) than SLMA (at least 50 uses) insertion at the beginning of the study. Finally, postoperative complication assessment was performed 1 h after awakening from anaesthesia, but always by the same observers and in similar conditions. Results obtained afterwards could be biased by different patient pathways and analgesia protocols corresponding to the variety of surgical procedures.

As design improvements in supraglottic airway devices are introduced and anaesthetists gain experience, the spectrum of applications continues to expand. In many ambulatory settings, the use of these devices has come to include anaesthesia in the prone position. Success and safety in advanced indications require selection of the device best suited to the patient and clinical situation. Previous series have reported the feasibility of all available laryngeal masks for artificial ventilation in the prone position with few complications; however, slight advantages in performance may further reduce the need to manipulate the airway and the risk of suboptimal ventilation in more challenging patients.

In conclusion, both the PLMA and the SLMA are suitable for managing the airway in selected patients anaesthetized in the prone position, based on the high rates of successful insertion, effective ventilation, and low incidences of complications in our study. The PLMA, inserted using a guided technique, required fewer adjustments to obtain optimal ventilation and provided a higher seal pressure. These subtle advantages, which remain to be confirmed in larger studies, would make the PLMA our first choice for patients with any potential risk of difficult ventilation in the prone position.

Conflict of interest
None declared.

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