Original Article

Comparative Evaluation of the i-gel and ProSeal Laryngeal Mask Airway on Respiratory Mechanics During Laparoscopic Surgery – A Randomized Controlled Trial

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Abstract

Background: Supraglottic airway devices (SADs) have emerged as effective alternatives to endotracheal intubation for airway management during laparoscopic surgery. Among second-generation SADs, the i-gel and ProSeal laryngeal mask airway (PLMA) are widely used. However, differences in their respiratory mechanics and clinical performance remain a subject of interest. The aim is to compare the i-gel and PLMA with respect to respiratory mechanics, ease of insertion, airway trauma, and oropharyngeal leak pressure in adult patients undergoing elective laparoscopic surgery. **Material and Methods:** This prospective randomized controlled study was conducted on 100 adult patients undergoing elective laparoscopic surgery who were randomly allocated to either the i-gel (n=50) or the PLMA (n=50) groups. Dynamic compliance, peak airway pressure, airway resistance, heart rate, and mean arterial pressure were recorded at predefined intraoperative time points. Ease of insertion, blood staining of the device following removal, and oropharyngeal leak pressure were also assessed. Statistical analysis was performed using IBM SPSS Statistics v20. **Results:** Baseline demographic and clinical characteristics were comparable between the groups. The i-gel demonstrated significantly higher dynamic compliance and lower peak airway pressure at all measured time points (all $p < 0.01$). Airway resistance was significantly lower with the i-gel at 10 minutes after pneumoperitoneum ($p = 0.021$). First-attempt insertion success was higher with the i-gel (92% vs. 84%), although the difference was not statistically significant. Blood staining of the device was significantly less frequent with the i-gel (12% vs. 30%; $p = 0.027$). In contrast, the PLMA achieved a significantly higher oropharyngeal leak pressure, indicating a superior airway seal. **Conclusion:** The i-gel provided superior respiratory mechanics, lower airway trauma, and comparable ease of insertion compared with the PLMA during laparoscopic surgery. However, the PLMA offered a superior oropharyngeal seal. Both devices are effective for airway management, with the choice depending on the clinical priority between ventilatory performance and airway sealing.

Keywords: Airway devices, i-gel, laryngeal masks, dynamic compliance, airway resistance, peak airway pressure.

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Introduction

Supraglottic airway devices (SADs) have become an established alternative to tracheal intubation for airway management in selected patients undergoing laparoscopic surgery.[1] Cuffed endotracheal intubation with controlled mechanical ventilation remains the standard of care during laparoscopic surgery.[1-3] Compared with the endotracheal tube (ETT), SADs offer several advantages, including easier insertion, greater haemodynamic stability, favourable respiratory mechanics, a lower incidence of airway-related morbidity, and the potential to reduce intubation-related complications.[4,5] Second-generation SADs with higher oropharyngeal seal pressure (OSP) and a gastric drain channel are particularly suited to laparoscopic surgery because they facilitate effective positive-pressure ventilation while minimizing gas leak.[6]

Laparoscopic surgery offers several advantages over open procedures, including reduced intraoperative blood loss, less postoperative pain, fewer pulmonary complications, and faster recovery. However, pneumoperitoneum alters respiratory mechanics by decreasing pulmonary compliance and increasing airway resistance, resulting in elevated airway pressures and the need for higher inspiratory pressures to achieve adequate tidal volume and minute ventilation.[7,8] An intra-abdominal pressure of 15-20 mmHg is associated with a 50% increase in peak airway pressure, a 25% decrease in lung compliance, and a 10% increase in $PaCO_2$, leading to inadequate ventilation, gastric insufflation, an increased risk of regurgitation, and subsequent pulmonary

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aspiration.[1,2] In addition, transperitoneal absorption of insufflated carbon dioxide increases end-tidal CO2 (EtCO2), often necessitating up to a 30% increase in minute ventilation to maintain normocapnia.[9-11]

The ProSeal laryngeal mask airway (PLMA) (Intavent Orthofix, Maidenhead, UK) and the i-gel airway (Intersurgical Ltd., Wokingham, Berkshire, UK) are second-generation SADs that provide higher OSP than the classic laryngeal mask airway (LMA). Both devices incorporate a separate gastric drain channel and are designed for use during both spontaneous and positive-pressure ventilation (PPV).[12]

The PLMA incorporates a dorsal cuff in addition to the peripheral cuff of the classic LMA, resulting in an improved airway seal and allowing ventilation at higher airway pressures. However, studies in adults have shown that higher LMA cuff pressures are associated with an increased incidence of postoperative airway morbidity, including sore throat, hoarseness, and cranial nerve palsies.[13,14] Differences in cuff design, airway tube dimensions, and gastric drain channel may influence airway sealing, airflow resistance, and respiratory mechanics.[15,16] The size of the gastric drain channel indirectly influences the dimensions of the airway tube and may also affect protection against regurgitation and pulmonary aspiration. Unlike the PLMA, which relies on an inflatable cuff to achieve an airway seal, the i-gel incorporates a non-inflatable thermoplastic elastomer cuff that conforms to the perilaryngeal anatomy, potentially facilitating easier insertion while avoiding cuff-related morbidity. Furthermore, as the manufacturer's weight-based recommendations for device size selection differ between the two SADs, these differences may influence OSP and respiratory mechanics.[16]

Despite the widespread use of both devices, it remains unclear whether their structural differences translate into clinically meaningful differences in respiratory mechanics during laparoscopic surgery. A direct comparison of the PLMA and i-gel may therefore help identify the device that provides more favourable ventilatory characteristics while maintaining effective airway sealing and safety. Accordingly, this randomized controlled trial was designed to compare the respiratory mechanics of the PLMA and i-gel during laparoscopic surgery and to evaluate their ease of insertion and associated airway-related complications.

Aims and Objectives

Aim: To compare the clinical performance of the ProSeal laryngeal mask airway (PLMA) and the i-gel during elective laparoscopic surgery.

Primary Objective: To compare the respiratory mechanics associated with the PLMA and the i-gel during elective laparoscopic surgery by assessing dynamic compliance, airway resistance, and peak airway pressure.

Secondary objectives:

1. To compare the ease of insertion of the PLMA and the i-gel based on the number of insertion attempts.
2. To compare device-related airway trauma.

Materials and Methods

This prospective, randomized controlled study was conducted at a tertiary care centre over a period of 18 months after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrolment. Adult patients, aged 18 to 60 years, with American Society of Anesthesiologists (ASA) physical status I or II, scheduled to undergo elective laparoscopic abdominal surgery under general anaesthesia were included in the study. Patients with anticipated difficult airway, body mass index > 30 kg/m², upper respiratory tract infection, gastro-oesophageal reflux disease (GERD), hiatus hernia, or any contraindication to the use of supraglottic airway devices were excluded. Patients with uncontrolled systemic illnesses were also excluded. A detailed pre-anaesthetic evaluation was performed on the day preceding surgery. Upon arrival in the operating theatre, standard ASA monitors, including electrocardiography, non-invasive blood pressure, and pulse oximetry, were applied. Intravenous access was secured using an appropriately sized peripheral venous cannula. Participants were randomly allocated in a 1:1 ratio to one of two groups using a computer-generated randomization sequence. Allocation concealment was ensured using sequentially numbered, sealed, opaque envelopes, which were opened immediately before induction of anaesthesia.

- Group A: Airway management using the i-gel.
- Group B: Airway management using the PLMA

Owing to the nature of the intervention, the anaesthesiologist inserting the airway device could not be blinded. However, postoperative assessment of device-related adverse events was performed by an investigator blinded to group allocation.

All patients were preoxygenated with 100% oxygen for 3 minutes. Intravenous glycopyrrolate (0.01 mg/kg) and midazolam (0.05 mg/kg) were administered as premedication. Anaesthesia was induced with fentanyl (2 μg/kg) and propofol (2 mg/kg). After 3 minutes of mask ventilation, an appropriately sized i-gel or PLMA, according to the assigned group and the manufacturer's recommendations, was inserted by the same experienced anaesthesiologist. Correct placement of the SAD was confirmed by adequate chest expansion, bilateral air entry on auscultation, the absence of an audible air leak at an airway pressure of 25 cm of H2O, and the presence of a square-wave capnographic trace. OSP was measured by closing the adjustable pressure-limiting (APL) valve with a fixed fresh gas flow and recording the airway pressure at which an audible leak was first detected. If satisfactory placement was not achieved, the device was repositioned or reinserted. Failure to achieve successful placement after three attempts was considered a failed insertion, and the patient underwent endotracheal intubation and was excluded from the study. Following successful insertion, patients were mechanically ventilated using a tidal volume of 7 mL/kg ideal body weight, respiratory rate of 12–14 breaths/min, and PEEP of 5 cm of H2O. Anaesthesia was maintained with a 50% oxygen-air mixture, sevoflurane (1.5–2.4%), and intermittent vecuronium boluses (0.02 mg/kg). Ventilator settings were adjusted as required to maintain EtCO2 between 30 and 45 mmHg. The primary outcome measures were dynamic compliance, airway resistance, and peak airway pressure. Secondary outcomes included the number of insertion attempts, oropharyngeal seal pressure, and device-related adverse events, including mucosal injury and postoperative sore throat. Data were analysed using IBM SPSS Statistics for Windows, Version

15.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Between-group comparisons of continuous variables were performed using the independent-samples Student's t-test, while categorical variables were compared using the Chi-square test. All statistical tests were two-tailed, and a P value <0.05 was considered statistically significant.

Results

A total of 100 patients were enrolled and randomly allocated to the i-gel group (n = 50) or the PLMA group (n = 50). The baseline demographic and clinical characteristics of the two groups are summarized in Table 1. Laparoscopic cholecystectomy and laparoscopic appendicectomy were the most commonly performed procedures.

Table 1: Baseline characteristics of participants

Characteristic	PLMA (n=50)	i-gel (n=50)	p value
Age (years), mean ± SD	38.8 ± 11.1	**34.2 ± 10.5**	0.37
Sex, n (%)			0.313
Male	26 (52.0)	31 (62.0)	
Female	24 (48.0)	19 (38.0)	
ASA physical status, n (%)			0.529
ASA I	31 (62.0)	34 (68.0)	
ASA II	19 (38.0)	16 (32.0)	
Surgical procedure, n (%)			0.689
Laparoscopic appendicectomy	24 (48.0)	26 (52.0)	
Laparoscopic cholecystectomy	26 (52.0)	24 (48.0)	

The i-gel demonstrated significantly better respiratory mechanics than the PLMA throughout the study. Dynamic compliance was significantly higher with the i-gel at all measured time points (all $p < 0.001$), while peak airway pressure was consistently lower before pneumoperitoneum ($p < 0.001$), at 10 minutes ($p = 0.005$) and 30 minutes ($p = 0.002$) after pneumoperitoneum, and after release of pneumoperitoneum ($p < 0.001$). Airway resistance was significantly lower with the i-gel only at 10 minutes after pneumoperitoneum ($p = 0.021$), with no significant between-group differences at the remaining time points.

Haemodynamic variables remained clinically stable in both groups. Mean arterial pressure was comparable throughout the study, with a small but statistically significant difference observed only after release of pneumoperitoneum ($p = 0.048$). Heart rate was comparable at baseline and 30 minutes after pneumoperitoneum but was significantly lower in the i-gel group before pneumoperitoneum ($p < 0.001$), at 10 minutes after pneumoperitoneum ($p < 0.001$), and after release of pneumoperitoneum ($p = 0.011$) [Table 2].

Table 2: Comparison of haemodynamic variables and respiratory mechanics between the i-gel and PLMA groups at predefined intraoperative time points

Parameter	Time Point	i-gel	PLMA	p value
Heart rate (beats/min)	Baseline	69 ± 6.7	71 ± 5.2	0.099
	Before pneumoperitoneum	66 ± 6.6	71 ± 5.4	< 0.001
	10 min after pneumoperitoneum	69 ± 6.1	78 ± 5.3	< 0.001
	30 min after pneumoperitoneum	70 ± 5.6	71 ± 5.2	0.357
	After release of pneumoperitoneum	68 ± 6.4	71 ± 5.1	0.011
Mean arterial pressure (mm Hg)	Baseline	87 ± 4.6	88 ± 5.4	0.321
	Before pneumoperitoneum	88 ± 4.2	89 ± 4.8	0.270
	10 min after pneumoperitoneum	87 ± 4.8	87 ± 5.2	1.000
	30 min after pneumoperitoneum	85 ± 5.0	87 ± 5.4	0.058
	After release of pneumoperitoneum	87 ± 4.4	89 ± 5.5	0.048
Dynamic compliance (mL/cm H2O)	Before pneumoperitoneum	50.1 ± 1.3	43.6 ± 2.3	< 0.001
	10 min after pneumoperitoneum	38.5 ± 1.6	35.2 ± 1.8	< 0.001
	30 min after pneumoperitoneum	40.8 ± 1.4	32.1 ± 2.4	< 0.001
	After release of pneumoperitoneum	45.6 ± 1.9	40.2 ± 1.8	< 0.001
Peak airway pressure (cm H2O)	Before pneumoperitoneum	18 ± 1.1	20 ± 1.7	< 0.001
	10 min after pneumoperitoneum	22 ± 1.7	24 ± 1.8	0.005
	30 min after pneumoperitoneum	21 ± 1.5	22 ± 1.7	0.002
	After release of pneumoperitoneum	19 ± 1.1	21 ± 1.2	< 0.001
Airway resistance (cm H2O/L/s)	Before pneumoperitoneum	10.0 ± 0.8	10.5 ± 1.6	0.052
	10 min after pneumoperitoneum	14.3 ± 1.6	15.1 ± 1.8	0.021
	30 min after pneumoperitoneum	13.6 ± 1.7	14.1 ± 1.5	0.122
	After release of pneumoperitoneum	9.9 ± 0.8	10 ± 1.4	0.662

Ease of insertion was comparable between the two groups, although a higher proportion of patients in the i-gel group achieved successful insertion on the first attempt compared with the PLMA group (92% [46/50] vs. 84% [42/50]); however, this difference was not statistically significant ($\chi^2 = 2.00$, $p = 0.368$). Blood staining of the airway device following removal was significantly less frequent in the i-gel group than in the PLMA group (12% vs. 30%; $\chi^2 = 4.882$, p

= 0.048).

The oropharyngeal leak pressure was significantly higher in the PLMA group than in the i-gel group. In the PLMA group, 42 of 50 patients achieved an oropharyngeal leak pressure of 35 cm H_2O, whereas the i-gel group demonstrated lower leak pressures ranging from 27 to 31 cm H_2O. These findings indicate that the PLMA provided a superior oropharyngeal seal compared with the i-gel [Table 3].

Table 3: Comparison of ease of insertion and blood staining of airway device between i-gel and PLMA groups

Variable	i-gel (n = 50)	PLMA (n = 50)	χ^2	df	p value
Ease of insertion					
First attempt	46 (92%)	42 (84%)	1.998	2	0.368
Second attempt	4 (8%)	7 (14%)			
Third attempt	0	1 (2%)			
Blood staining of device					
No	44 (88%)	35 (70%)	4.882	1	0.027
Yes	6 (12%)	15 (30%)			

Discussion

This prospective randomized study was conducted at a tertiary care centre to compare i-gel and PLMA in adult patients undergoing elective laparoscopic surgery, with particular emphasis on respiratory mechanics, ease of insertion, airway trauma, and oropharyngeal leak pressure. We hypothesised that the i-gel would provide superior respiratory mechanics, lower peak airway pressures, and easier insertion than the PLMA, whereas the PLMA would achieve a higher oropharyngeal leak pressure. The findings of the present study support this hypothesis. Compared with the PLMA, the i-gel was associated with significantly higher dynamic compliance, lower peak airway pressure, reduced blood staining of the airway device, and comparable ease of insertion, while the PLMA provided a superior oropharyngeal seal.

Respiratory mechanics: In the present study, dynamic compliance decreased following pneumoperitoneum in both groups, consistent with the expected reduction in lung compliance associated with increased intra-abdominal pressure. However, dynamic compliance remained significantly higher in the i-gel group than in the PLMA group at all measured time points. At 30 minutes after pneumoperitoneum, the mean dynamic compliance was 40.8 ± 1.4 mL/cm H_2O in the i-gel group compared with 32.1 ± 2.4 mL/cm H_2O in the PLMA group ($p < 0.001$). These findings are consistent with those reported by Sharma and Sehgal et al., who demonstrated significantly higher dynamic compliance with the i-gel than with the PLMA during laparoscopic surgery.[17] Similarly, R. Nisarga, D. A. Bhavana et al. observed significantly greater dynamic compliance in the i-gel group than in the PLMA group before pneumoperitoneum ($p < 0.001$).[18] The present study extends these findings by demonstrating that the superiority of the i-gel in terms of dynamic compliance was maintained throughout pneumoperitoneum.

Airway resistance was consistently higher in the PLMA group than in the i-gel group throughout the study. However, a statistically significant between-group difference was observed only at 10 minutes after pneumoperitoneum, with mean airway resistance of 14.3 ± 1.6 cm H_2O/L/s in the i-gel group and 15.1 ± 1.8 cm H_2O/L/s in the PLMA group ($p = 0.021$). Although airway resistance remained numerically lower in the i-gel group after release of pneumoperitoneum (9.9 ± 0.8 vs. 10.0 ± 1.4 cm H_2O/L/s), the difference was not statistically significant ($p = 0.662$). These findings are consistent with those of R. Nisarga, D. A. Bhavana et al,[18] and Sharma and Sehgal et al,[17] who also reported lower airway resistance with the i-gel than with the PLMA. Similarly, Fahy, Barnas et al. demonstrated an increase in airway resistance with the PLMA compared with other supraglottic airway devices.[19]

Peak airway pressure was lower in the i-gel group than in the PLMA group at all measured time points. Before pneumoperitoneum, the mean peak airway pressure was 18.0 ± 1.1 cm H_2O in the i-gel group compared with 20.0 ± 1.7 cm H_2O in the PLMA group ($p < 0.001$). At 30 minutes after pneumoperitoneum, the corresponding values were 21.0 ± 1.5 cm H_2O and 22.0 ± 1.7 cm H_2O, respectively ($p = 0.002$). Peak airway pressure also remained significantly lower in the i-gel group at 10 minutes after pneumoperitoneum ($p = 0.005$) and after release of pneumoperitoneum ($p < 0.001$). These findings are in agreement with those of Fahy, Barnas et al., who reported that peak airway pressure and resistive load were greater with the PLMA than with the classic laryngeal mask airway, attributed to the relatively narrower airway tube of the PLMA.[19] The lower peak airway pressures observed with the i-gel in the present study may similarly be explained by its wider airway lumen, resulting in lower airflow resistance. Sharma and Sehgal et al. also reported lower peak airway pressures with the i-gel than with the PLMA before and after pneumoperitoneum, although the differences were not statistically significant in their study.[17]

Another important finding of the present study was that the PLMA provided significantly higher oropharyngeal leak pressure than the i-gel, indicating a superior airway seal. In the PLMA group, 42 of 50 patients achieved an oropharyngeal leak pressure of 35 cm H_2O, whereas the i-gel group demonstrated lower leak pressures ranging from 27 to 31 cm H_2O. These findings are consistent with those reported by Sharma and Sehgal et al., who observed significantly higher oropharyngeal leak pressures with the PLMA than with the i-gel (38.9 vs. 35.6 cm H_2O; $p = 0.007$).[17] A higher oropharyngeal seal pressure may provide better protection against gastric insufflation and aspiration and facilitate positive-pressure ventilation, particularly in patients with reduced pulmonary compliance or increased airway resistance. The superior sealing characteristics of the PLMA are likely attributable to its larger inflatable cuff with dorsal and ventral components, deeper mask bowl, proximal wedge-shaped design, and greater cuff surface area, all of which promote a more effective peri-laryngeal seal than the cuffless, anatomically shaped thermoplastic elastomer cuff of the i-gel.

Insertion Characteristics and Airway Morbidity: With respect to insertion characteristics, the i-gel demonstrated a higher first-attempt insertion success rate than the PLMA (92% vs. 84%), although the difference was not statistically significant. Nevertheless, fewer insertion attempts were required with the i-gel, suggesting that it is easier to insert in routine clinical practice. Blood staining of the airway device following removal, a surrogate marker of airway trauma, was significantly less frequent with the i-gel than with the PLMA (12% vs. 30%), indicating reduced airway trauma with the i-gel. These findings are consistent with those of Ishwar Singh et al., who reported easier insertion, higher insertion success rates, better drain tube positioning, and less airway trauma with the i-gel than with the PLMA.[20] Similarly, Sun Kyung Park et al. found that although the i-gel and PLMA were comparable with respect to ease of insertion, the i-gel was associated with fewer postoperative airway complications, including blood staining, sore throat, and dysphagia.[21]

The present study has several limitations. First, obese patients and those with restrictive lung disease or other significant pulmonary disorders were excluded, limiting the generalizability of the findings to these patient populations. Second, owing to resource constraints, not all respiratory mechanical parameters could be measured. Third, postoperative airway morbidity, including sore throat, dysphagia, and hoarseness, was not systematically evaluated beyond the assessment of blood staining of the airway device. Finally, this was a single-centre study with a relatively modest sample size, and larger multicentre studies are warranted to validate these findings and determine the applicability of the results across broader surgical populations.

Conclusion

In adult patients undergoing elective laparoscopic surgery, the i-gel demonstrated superior respiratory mechanics compared with the ProSeal laryngeal mask airway, with significantly higher dynamic compliance, lower peak airway pressures, lower airway resistance during pneumoperitoneum, and reduced airway trauma as evidenced by less blood staining of the device. Although first-attempt insertion success was higher with the i-gel, ease of insertion was comparable between the two devices. In contrast, the PLMA provided a significantly higher oropharyngeal leak pressure, indicating a superior airway seal during positive-pressure ventilation. Overall, the findings suggest that the i-gel offers favourable ventilatory performance and atraumatic insertion while maintaining effective airway management in laparoscopic surgery, whereas the PLMA may be preferred when achieving a higher airway seal is of primary importance. Larger, multicentre randomized studies are warranted to validate these findings and further define the optimal role of each device in different surgical and patient populations.

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Conflicts of interest

There are no conflicts of interest.

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