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A Comparative Evaluation of Respiratory Mechanics with I-Gel or ProSeal LMA as Airway Device in Laparoscopic Surgeries

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Abstract

Objectives: The study was designed to compare the respiratory mechanics of the patients with either I-Gel or ProSeal LMA as airway device during positive pressure ventilation while undergoing laparoscopic hernia repair surgeries. The other parameters compared are ease of insertion and airway trauma. *Methodology*: This randomized control study was conducted in our tertiary care hospital. 110 patients of ASA PS class 1-2 were randomly divided into 2 groups of 55 each. Premedication and anesthesia technique were standardized in both the groups. One group had PLMA as their airway device and the other group had I-gel as their airway device. We compared the respiratory mechanics (dynamic compliance, airway resistance and peak airway pressure) of these patients during positive pressure ventilation. The other parameters compared were ease of insertion and airway trauma. *Results*: I-Gel is a better device compared to PLMA in terms of dynamic compliance, peak airway pressure, airway resistance and ease of insertion was higher with PLMA. There was no significant difference in blood staining after removal of the device or trauma to lips, tongue and teeth between two groups. *Conclusion*: From our study, we concluded that I-Gel is a better device compared to PLMA in terms of dynamic compliance, peak airway pressure, airway resistance and ease of insertion. There was no significant difference in blood staining after removal of the device or trauma to lips, tongue and teeth between two groups.

Keywords: I-gel; Proseal LMA; Laparoscopic hernia repair; Compliance; Resistance; Peak airway pressure.

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Introduction

With the advancement of technology compiled with availability of special instruments and high definition cameras, laparoscopic surgery has gained wide popularity among general population. It is also known as minimally invasive surgery and is the most important revolution in surgical techniques. Laparoscopic surgeries have been employed for procedures ranging across multiple

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surgical specialities. Its advantages compared to open procedures include less intraoperative pain and haemorrhage, fewer postoperative pulmonary complications and a shorter recovery time which allows a shorter hospital stay. Anaesthetic management of these cases poses special challenge due to creation of carbon dioxide pneumoperitoneum and extreme degrees of positioning with its own effect on cardiovascular system and respiratory system.

Laparoscopy is associated with problems such as increased risk for aspiration, endobronchial intubation, pneumothorax and gas embolism amongst many others. Endotracheal intubation and controlled mechanical ventilation were considered the gold standards in the anaesthetic management of laparoscopic procedures [1,2]. Hemodynamic response, chance of failed intubation, increased airway morbidity due to trauma are a few serious concerns with endotracheal tube (ETT). Introduction of supralaryngeal airway devices overcomes most of the above draw backs of ETT. Supraglottic airway devices have several advantages compared to endotracheal intubation, particularly avoidance of complications associated with endotracheal intubation, quick and easy placement of airway device itself, lesser requirement of neuromuscular blocking drugs as well as lower incidence of postoperative sore throat, dysphagia and dysphonia. Currently supralaryngeal airway devices (PLMA, I-gel) are increasingly being used instead of the tracheal tube for planned anaesthesia in laparoscopy.

Laryngeal Mask Airway ProSeal (PLMA) and I-Gel are supraglottic airway devices which produce high oropharyngeal seal pressure and have the facility for gastric decompression. I-Gel was developed in 2007 to overcome the limitations of PLMA. It utilizes a thermoplastic elastomer (Styrene butadiene styrene ethylene) which has a gel-like feel [3]. It was designed to create a non-inflatable anatomical seal of the pharyngeal, laryngeal and perilaryngeal structures while avoiding compression trauma. The shape, softness and contour accurately mirror the perilaryngeal anatomy to create the perfect fit so that compression and displacement trauma are significantly reduced. I-Gel also has a gastric drainage tube integrated to the upper tube for stomach decompression which reduces the risk of reflux and pulmonary aspiration. It has a semirigid stem to aid with insertion and prevents kinking. It has an intrinsic bite block to prevent compression of the airway tube, misplacement in the mouth and axial rotation. It is not necessary to insert fingers into the mouth of the patient for full insertion.

Pneumoperitoneum created during laparoscopic surgeries decreases thoracopulmonary compliance by 30% to 50% approximately. Reduction in functional residual capacity and development of atelectasis due to elevation of the diaphragm and changes in the distribution of pulmonary ventilation and perfusion from increased airway pressure can be expected. Decreased thoraco pulmonary compliance during pneumoperitoneum frequently results in increased airway pressures.

The study was designed to compare the respiratory mechanics of the patients with either I-Gel or ProSeal LMA as airway device during positive pressure ventilation while undergoing laparoscopic hernia repair surgeries. The other parameters compared are ease of insertion and airway trauma.

Methodology

After obtaining ethical clearance and informed written consent, this randomized control study was conducted in 110 patients of ASA class I and II, aged 18-60 years, of both sexes scheduled for laparoscopic hernia repair at our hospital over a period of 2 years. Patients with anticipated difficult airway, mouth opening <2.5 cm, upper respiratory tract infections, BMI> 30 kg/m^2, risk of aspiration (full stomach, hiatushernia, GERD), restrictive/ obstructive lung disease, cervical spine deformity, cardiovascular diseases, neurological diseases were excluded from the study.

Each participant was randomly assigned either of the two groups.

Group 1-- ProSeal Laryngeal Mask Airway as the airway device.

Group 2 -- I-Gel as the airway device.

All participants in both groups were advised to fast overnight. Each of them was given Tab. Alprazolam 0.25 mg at bedtime on the day before surgery. Baseline vital signs (peripheral O_2 saturation, ECG, Pulse rate, Respiratory rate, Blood pressure) were noted before surgery. All patients were given Tab. Ranitidine 150 mg and Tab. Metoclopramide 10 mg 2 hrs before surgery. After preoxygenation, each of them was given Midazolam 1mg, Glycopyrrolate 0.2 mg and Fentanyl 1.5 mcg/kg intravenously. Anesthesia was induced with Propofol 2 mg/kg. Neuromuscular blockade was achieved with Vecuronium 0.1 mg/kg. Patients were ventilated using face mask with N_2O, O_2, Isoflurane before the insertion of the chosen airway device.

After mask ventilation appropriate sized airway device (Proseal LMA in Group 1 patients and I-gel in Group 2 patients) was inserted. Cuff of the Proseal LMA was inflated to 60 cm H_2O and maintained at the same pressure throughout anaesthesia. In both groups the device was fixed by taping it to the chin.

An effective airway was confirmed by bilateral symmetrical chest movements, a square wave form of capnography and no audible leak of gases. If an effective airway could not be achieved the device was removed and reinserted and 3 attempts are allowed before failure of insertion is recorded.

Ease of insertion of the device was also recorded in both groups as easy/difficult/failure. Ease is defined as no resistance to insertion in the pharynx in a single manoeuvre. Difficult category includes those cases in which more than one attempt is needed for insertion/ there is resistance to insertion in the pharynx. If more than 3 attempts were needed, the participant was excluded from the study.

For comparing *respiratory mechanics*, dynamic compliance, peak airway pressure and airway resistance were noted at different points of time—before pneumoperitoneum, 10mts after pneumoperitoneum, 30 mts after pneumoperitoneum and at the release of pneumoperitoneum.

Compliance of the lungs is defined as a change in lung volume per unit changein airway pressure ($\Delta V/\Delta P$). In mechanically ventilated patients dynamic compliance can be calculated as:

$C = V_t / (P_{peak} - PEEP)$

C = dynamic compliance; V_t– tidal volume; P_{peak} –peak airway pressure; PEEP-positive end expiratory pressure.

Airway resistance is the pressure required to deliver a given flow of gas to the alveoli.It is expressed as change in pressure/flow.

$R = (P_{peak}-P_{plat}) /$Mean inspiratory flow rate.

After completion of the procedure anesthesia was discontinued. Blood staining of the device, tongue, lip and teeth trauma were noted.

Observations and Results

Statistical Analysis

Quantitative variables were expressed in mean and standard deviation. Qualitative variables were expressed infrequency distribution. Between groups comparison of quantitative variables were analysedby 't' test and Chi-square test. A p value of 0.05 was taken as the level of significance. SPSS version 17.0 was used for statistical analysis.

Before pneumoperitoneum dynamic compliance was 44.20 ± 3.27 for PLMA and 50.67 ± 3.46 for I-Gel. 10 minutes after pneumoperitoneum, the value was 35.03 ± 2.93 for PLMA and for I-gel, it was 38.76 ± 2.77. 30 minutes after pneumoperitoneum, dynamic compliance was 36.81 ± 2.16 for PLMA and 40.87 ± 3.11 for I-gel. After release of pneumoperitoneum, dynamic compliance improved to 41.09 ± 2.61 for PLMA and 46.48 ± 3.67 for I-gel. Thus, dynamic compliance was found to be higher with I-gel at all points of study (before pneumoperitoneum, 10 mts after pneumoperitoneum, 30 mts after pneumoperitoneum and at the release of pneumoperitoneum) with a p value <0.001 (Table 1).

Airway resistance was slightly higher in PLMA group than I-gel group at all points of study, but was not statistically significant (Table 2).

Before pneumoperitoneum peak airway pressure was 20.38 ± 1.67 for PLMA and 18.58 ± 1.66 for I-gel. 10 minutes after pneumoperitoneum, the value was 24.20 ± 1.98 for PLMA and for I-gel, it was 22.76 ± 2.19. 30 minutes after pneumoperitoneum, peak airway pressure was 23.42 ± 1.77 for PLMA and 21.45 ± 2.12 for I-gel. After release of pneumoperitoneum, peak airway pressure was 21.51 ± 1.61 for PLMA and 19.75 ± 1.87 for I-gel. Peak airway pressure was significantly higher in PLMA group than I-gel group at all points of study with a p value <0.001 (before pneumoperitoneum, 10 mts after pneumoperitoneum, 30 mts after pneumoperitoneum and at the release of pneumoperitoneum) with a p value <0.001 (Table 3).

Table 1: Dynamic Compliance

Dynamic Compliance	Proseal LMA (N=55)		I-Gel (N=55)		t	p
	mean	sd	Mean	Sd		
Before pneumoperitoneum	44.20	3.27	50.67	3.46	-10.086	<0.001
10 minutes after pneumoperitoneum	35.03	2.93	38.75	2.77	-6.841	<0.001
30 minutes after pneumoperitoneum	36.81	2.16	41.87	3.11	-9.898	<0.001
After release of pneumoperitoneum	41.09	2.61	46.48	3.67	-8.882	<0.001

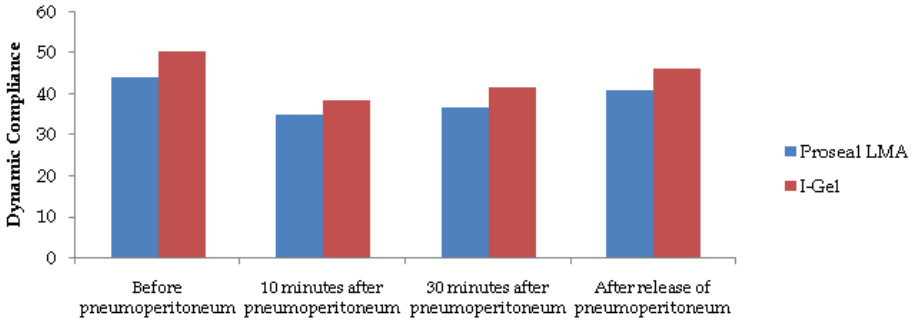

Chart 1: Dynamic compliance

Table 2: Airway Resistance

Airway Resistance	Proseal LMA(N=55)		I-Gel(N=55)		t	p
	Mean	SD	Mean	SD		
Before pneumoperitoneum	10.48	1.93	10.58	6.04	-.117	.907
10 minutes after pneumoperitoneum	15.32	1.82	14.63	3.99	1.161	.248
30 minutes after pneumoperitoneum	13.39	1.81	13.15	4.16	.402	.689
After release of pneumoperitoneum	11.08	1.74	10.60	5.14	.659	.511

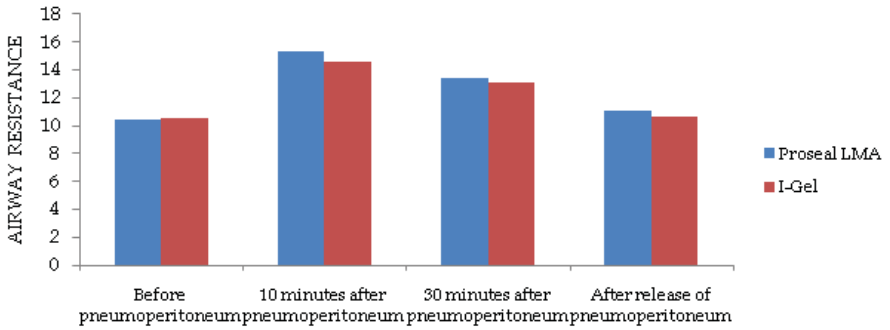

Chart 2: Airway Resistance

Table 3: Peak Airway Pressure

Peak Airway Pressure	Proseal LMA (N=55)		I-Gel (N=55)		t	p
	Mean	SD	Mean	SD		
Before pneumoperitoneum	20.38	1.67	18.58	1.66	5.660	<0.001
10 minutes after pneumoperitoneum	24.40	1.98	22.76	2.19	4.109	<0.001
30 minutes after pneumoperitoneum	23.42	1.77	21.45	2.12	5.278	<0.001
After release of pneumoperitoneum	21.51	1.61	19.75	1.83	5.371	<0.001

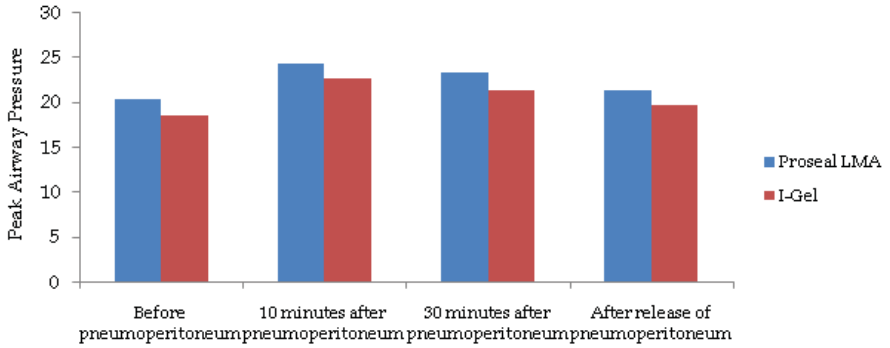

Chart 3: Peak Airway Pressure

Table 4: Grading of ease of insertion

Ease of Insertion	Airway Device				Total		χ^2	df	p
	Proseal LMA		I-GEL						
	N	%	N	%	N	%			
Easy	45	81.8	51	92.7	96	87.3	2.946	1	0.086
Difficult	10	18.2	4	7.3	14	12.7			
Total	55	100	55	100	110	100			

Table 5: Blood Staining

Blood Staining	Airway Device				Total		χ^2	df	p
	Proseal LMA		I-GEL						
	N	%	N	%	N	%			
No	48	87.3	52	94.5	100	90.9	1.760	1	0.185
Yes	7	12.7	3	5.5	10	9.1			
Total	55	100	55	100	110	100			

Table 6: Trauma Totongue, Lips, Teeth

Trauma Totongue, Lips, Teeth	Airway Device				Total		χ^2	df	p
	Proseal LMA		I-GEL						
	N	%	N	%	N	%			
No	52	94.5	52	94.5	104	94.5	0.000	1	1.000
Yes	3	5.5	3	5.5	6	5.5			
Total	55	100	55	100	110	100			

Ease of insertion was found to be higher in I-gel group, but was not statistically significant (Table 4).

There was no significant difference in blood staining after removal of the device or trauma tolips, tongue and teeth between two groups (Table 6).

Discussion

Laparoscopy has several advantages compared to open procedures including less intraoperative pain and haemorrhage, fewer postoperative pulmonary complications and a shorter recovery time. Principal *respiratory complications [4]* during laparoscopic surgeries include CO_2 subcutaneous emphysema, Capnothorax, Capnomediastinum, Capnopericardium, Endobronchial intubation, Gas embolism and risk of aspiration. During laparoscopic surgeries, pulmonary compliance is decreased and resistance is increased leading to high airway pressures.

Supraglottic airway devices are nowadays a standard modality in airway management, filling a niche between the face mask and tracheal tube considering both anatomical position and degree of invasiveness. These devices are placed outside the trachea and provide a means of achieving a gas-tight airway. The laryngeal mask, as a new concept in airway management was first introduced by Archie Brain in 1983. Although it is an acceptable device in airway management, the issues with positive pressure ventilation (PPV), particularly in obese patients with decreased pulmonary compliance led to the design and development of the Pro Seal LMA (PLMA) in the late 1990's with modified cuff and drain tube, thereby offering protection against regurgitation of gastric contents and gastric insufflation and providing improved ventilatory characteristics.

Currently supralaryngeal airway devices (PLMA, I-Gel) are increasingly being used instead of the tracheal tube for planned anaesthesia in laparoscopy. Supra glottic airway devices have several advantages including lower incidence of sore throat, less hemodynamic upset during induction and maintenance of anesthesia and better oxygenation during emergence

The PLMA is the most complex of the specialized laryngeal mask devices. It was designed by Archie Brain in the late 1990s and released in 2000 [5]. The primary aim was to construct a supraglottic airway device with improved ventilatory characteristics that also offered protection against regurgitation and gastric insufflation. The major new features are a modified cuff and a drain tube.

I-Gel was developed in 2007 to overcome the limitations of PLMA. It utilizes a thermoplastic

elastomer (Styrene butadiene styrene ethylene) which has a gel-like feel. It creates a non inflatable anatomical seal of the pharyngeal, laryngeal and perilaryngeal structures while avoiding compression trauma.

PLMA and I-Gel have separate channels for gastric tube insertion and can be used for both spontaneous and controlled ventilation. There are certain differences in the fundamental design of thsetwo. I-gel is cuffless, made of a thermoplastic elastomer which creates an anatomical seal of pharyngeal laryngeal and perilaryngeal structures. The airway tube of I-Gel is bigger, where as PLMA hasa narrow reinforced airway tube with a large wedge shaped inflatable cuff and a larger drain tube. The cuff size and design influence the ease of insertion and oropharyngeal seal pressure, where as the diameter and length of airway tube determines its resistance. A cuffless supraglottic airway device offers some potential advantages with regards to ease of insertion and tissue compression. A supraglottic device with inflatable cuff absorbs anesthetic gases leading to increased mucosal pressure [6].

In our study, we tried to compare the respiratory mechanics (dynamic compliance, airway resistance, peak airway pressure) of patients undergoing laparoscopic hernia repair with I-Gel or ProSeal LMA as airway device. We also compared I-Gel and ProSeal LMA in terms of ease of insertion and airway trauma. 110 patients of ASA class 1-2 aged 18-60 yrs of both sexes scheduled to undergo laparoscopic hernia repair were included in the study. The study population was randomly divided into two groups with 55 patients in each. Premedication and anesthesia technique were standardized in both the groups. Group 1 had PLMA as their airway device and group 2 had I-gel as their airway device.

For comparing respiratory mechanics, we recorded tidal volume, peak airway pressure, plateau pressure and mean inspiratory flow rate at four points of time – before pneumoperitoneum, 10 minutes after pneumoperitoneum, 30 minutes after pneumoperitoneum and after release of pneumoperitoneum.

In mechanically ventilated patients dynamic compliance can be calculated as:

$C = V_t / (P_{peak} - PEEP)$

[C = dynamic compliance; Vt– tidal volume; P_{peak} –Peak airway pressure; PEEP-Positive end expiratory pressure].

Airway resistance is expressed as change in pressure/flow

$R = (P_{peak} - P_{plat}) /$ Mean inspiratory flow rate

In our study using volume controlled ventilation, we found that dynamic compliance was significantly higher with I-gel at all 4 points of study ($p<0.001$). Peak airway pressure was significantly higher in PLMA group at all points of study. Airway resistance was slightly higher in PLMA group than I-gel group at all points of study, but was not statistically significant.

The inference from our study is that dynamic compliance is higher with I-gel and peak airway pressure was higher with PLMA. Airway resistance was lower with I-gel, though not statistically significant. I-gel was better when ease of insertion were compared.

Limitations of the study

Our study was not blinded since the researcher could not be blinded during airway management. Thus a question of observer bias can arise. Only ASA 1-2 patients with a BMI<30 kg/m^2 were included. So the data cannot be extrapolated to use of these devices in other groups. Also, we didn't perform fibreoptic evaluation to assess the positioning of the devices.

Conclusion

From our study, we concluded that I-gel is a better device compared to PLMA in terms of dynamic compliance, peak airway pressure, airway resistance and ease of insertion. Therewas no significant difference in blood staining after removal of the device or trauma tolips, tongue and teeth between two groups.

Conflict of interest: None

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