Chapter

# Second Generation Supraglottic Airway (SGA) Devices

*Kriti Singh*

## Abstract

Supraglottic Airways (SGAs) are an integral part of anaesthetic care. Since their introduction, several modifications, additions, and variations have been developed and are currently in clinical practice since the last 25 years. Not only are they useful for difficult ventilation during both in-hospital and out-of-hospital difficult airway management, they also act as a conduit for tracheal intubation. The newer or second-generation SGAs have been designed to provide a better seal of the airway and are relatively safer since they allow gastric aspiration. Thus, the SGAs may be the most versatile component in the airway management cart. Existing literature on SGAs tends to focus on first generation SGAs and their use in OT only. However, the scope and use of these devices is vast. Knowledge regarding specific devices and supporting data for their use is of utmost importance to patient's safety. This chapter addresses various types of commercially available novel SGAs and their use in and out of hospital settings.

**Keywords:** airway, supraglottic airway devices, laryngeal mask airway, laryngeal tubes, rescue airway

## 1. Introduction

In spite of tremendous advances in contemporary anaesthetic practice, advances in airway management continue to be of paramount importance to anaesthesiologists. Till some time ago, the cuffed tracheal tube was considered as the gold standard for providing a safe glottic seal [1]. The disadvantages of tracheal intubation, which involves rigid laryngoscopy, are the concomitant hemodynamic responses and damage to the oropharyngeal structures. Postoperative airway morbidity is also a serious concern. This precluded the global utility of the tracheal tube and there was a perceived need for better alternatives [2].

Dr. Archie Brain, a British anaesthesiologist, introduced the laryngeal mask airway (LMA) in 1983 for the first time, designed to be positioned around the laryngeal inlet. LMA is a supraglottic airway (SGA) device with an inflatable cuff forming a low-pressure seal around the laryngeal inlet and permitting ventilation.

Supraglottic Airways (SGAs) have revolutionised the airway management [3]. Besides serving as a rescue device in the difficult airway, and as a conduit for the endotracheal tube insertion, SGAs provide a less invasive and less traumatic means of securing the airway in surgical patients [4, 5].

Careful observations and clinical experience have led to several modifications of the LMA leading to development of newer supraglottic airway devices with better features for airway maintenance [3]. Over a period of time, new airway devices

have been added to the anaesthesiologist's armamentarium to address specific needs. A wide variety of airway devices are available today which are employed to protect the airway in both elective as well as emergency situations [6].

In 2001, Dr. Archie Brain came up with a modification of the LMA. This device was called the Proseal-Laryngeal mask airway™ (Teleflex®, USA) [7]. This double lumen, double cuff LMA has some clear advantages over its predecessor. The double tube design separated the respiratory and alimentary tracts, providing a safe escape channel for the regurgitated fluids.

Since then, several devices that are able to accommodate nasogastric tubes have been invented. Newer features like better sealing pressures, reduced risk of pulmonary aspiration by stomach contents, single use devices, integrated bite blocks, and the ability to act as conduits for endotracheal tube (ETT) placement have rendered these devices more reliable for routine use. The last decade has seen a rapid rise in the number of clinical studies evaluating these second-generation SGAs.

## 2. Clinical indications of LMA

### 2.1 As a substitute for a facemask

LMAs are especially useful when mask fit is difficult as in edentulous or bearded patients. It also frees the hands of the anaesthesia care giver.

### 2.2 As an alternative to tracheal intubation for routine anaesthesia

The LMA may be used in the spontaneously breathing patient with adequate sedation and topical anaesthesia, or the paralysed, anaesthetised patient with assisted mechanical ventilation.

#### *2.2.1 Laparoscopic surgery*

The indications for use of the supraglottic airway devices are expanding. Their routine use in laparoscopic surgeries has almost replaced the endotracheal tubes. Second generation SGAs have proved to provide adequate sealing pressure required to provide adequate ventilation and maintain airway safety [8]. Also, pharyngolaryngeal morbidity (sore throat, dysphagia, dysphonia) are less as compared to endotracheal tube [9, 10].

#### *2.2.2 Obese patients*

In today's era, the number of obese patients undergoing surgeries is increasing. Intubation is known to be more difficult in obese patients [11, 12]. Closed claims analysis shows that obesity, difficult intubation and intubation by inexperienced personnel are risk factors for severe airway injuries and pharyngo-oesophageal perforation [13].

In such cases, SGAs after successful placement can provide better postoperative pulmonary performance if used in very well selected patients. Hence, SGAs may be a simple alternative to intubation in short-term elective surgery in obese patients, as suggested by some randomised controlled trials (RCTs) [14]. These maybe used as conduits for tracheal intubation in obese patients with failed laryngoscopy and expected/unexpected difficult airways [15].

*2.2.3 Pregnancy*

Maternal morbidity from failed intubation and aspiration remains the biggest concern with general anaesthesia. SGAs can be lifesaving in caesarean deliveries where scenarios of cannot ventilate and cannot intubate is faced. Second generation SGAs have become the gadget of choice in such scenarios [16–18].

*2.2.4 Paediatric age group*

Being user-friendly, SGAs are now more commonly used in children. They obviate the use of ETTs and avoid many complications associated with endotracheal intubation [19, 20]. The LMA Classic™ and the LMA Proseal™ have established their safety and efficacy for routine as well as in emergency cases in paediatric patients [21–25]. The presence of a drain tube, which helps to empty the stomach in the Second-generation SGAs, has removed the fear of distension of the stomach with gas during controlled or spontaneous ventilation, leading to impairment of respiration, especially in a smaller child.

*2.2.5 Prone position*

Surgery performed in the prone position require significant OT time and necessitate additional manpower for proper positioning of the patient. Induction and device placement in the prone position avoids the displacement of OT personnel from other tasks as significantly less number of people is required in shifting the patient. Anaesthetic induction of the patient and SGA insertion can be done in prone position, unlike endotracheal intubation. A large cohort study included 1000 patients undergoing surgery under general anaesthesia in prone position where SGAs were safely used to secure the airway [26].

## 2.3 Aiding blind and fiberoptic-guided endotracheal intubation

SGAs can be used as a conduit for blind and fiberoptic-guided intubation for rescue of failed direct laryngoscopy or failed intubation [27–29]. After inserting the LMA, a well lubricated ETT with deflated cuff is passed over the fiberscope. The fiberscope is then advanced through the LMA. The ETT is advanced around 1.5 cm past the mask aperture. The tip of the ETT lifts the fiberscope away from the bowl of the mask and exposes the glottis. The fiberoptic scope is then advanced up to the distal end of the tracheal tube. The ETT is advanced until the glottis is brought into view and then further advanced into the trachea.

A specific advantage of using an SGA is the ability to continue ventilating and anaesthetising the patient through the SGA until formal tracheal intubation is achieved. The Aintree catheter, a modification of the Cook's airway exchanger may be used to intubate through the SGA. It is loaded over a fiberoptic bronchoscope (FOB) and the trachea is visualised through the SGA [30, 31]. Leaving the Aintree catheter in place, the SGA is then removed. The ETT is then loaded over the catheter and advanced into the trachea.

## 2.4 Rescue airway

The difficult airway algorithm made by the American Society of Anesthesiologists (ASA) has a prominent place for the use of SGAs in airway rescue [32]. The Difficult Airway Society (DAS) 2015 guidelines suggests the use of SGAs as first line

rescue airway for management of a failed intubation [33]. Several case reports support the use of SGAs for supporting ventilation in difficult airways with failed intubation [34–37]. SGAs also aid successful tracheal intubation in situations in which conventional methods have failed.

## 2.5 Procedures in the critical care units

### *2.5.1 Paediatric bronchoscopies*

Flexible bronchoscopies comprise the major airway procedures performed including bronchoalveolar lavage, transbronchial biopsies, and foreign body removal [38]. LMA use during paediatric bronchscopies is associated with ease of insertion during general anaesthesia with spontaneous or assisted ventilation, as well as a net decrease in procedure time.

### *2.5.2 Adult bronchoscopies*

Certain patients who cannot tolerate the procedure with conscious sedation (i.e., excessive gag response or discomfort) may require general anaesthesia. An LMA is an ideal device in such a scenario.

### *2.5.3 Percutaneous tracheostomies*

Percutaneous tracheostomies are increasingly performed in the critical care setting. It is indicated in patients who are ventilator dependent due to acute illnesses, or if duration of ETT use is expected to exceed 2 weeks [39]. Cattano et al. conducted a study on patients undergoing percutaneous tracheostomy using dilating forceps approach where ETT was replaced by an SGA [40]. They concluded that intubation through SGAs offered a superior view of the trachea without the risk of the bronchoscope or the ETT getting needle punctured.

## 2.6 Aide to tracheal extubation

Since SGAs cause less cough and rise in intracranial or intraocular pressures compared to the ETT, they may be used for smooth emergence from anaesthesia. The device may be placed after removal of the ETT. This is helpful in situations in which airway and hemodynamic reflexes are undesirable.

## 2.7 Pre or outside the hospital airway

In the field, securing an airway is of paramount importance. SGAs are lifesaving in the “can’t ventilate, can’t intubate” situation. An SGA can be used for transport until a definitive airway can be obtained [41]. The placement of an SGA is easily mastered by the inexperienced hands with minimal training.

During cardio pulmonary resuscitation (CPR), the first part of the secondary survey includes securing an airway device as soon as possible [42]. SGA use during CPR has increased since SGA insertion is easier to learn than tracheal intubation and feasible with fewer and shorter interruptions in chest compression [43]. Use of SGAs during CPR is associated with a lower incidence of regurgitation of gastric contents than bag-mask ventilation [44].

## 3. Contraindications

- Patients with risk of gastric aspiration (non-fasted, Gastro Oesophageal Reflux Disease, hiatus hernia)
- Patients with airway morbidities (Respiratory tract infections, COPD etc.)
- Restricted mouth opening (< 2.5 cm)
- Distorted airway anatomy and airway obstruction
- Prolonged duration of surgery (>2 hrs)
- Surgery involving the upper airway
- Maxillo facial trauma
- Morbidly obese patients

### 3.1 Complications

- Regurgitation and aspiration
- Misplacement of mask and airway obstruction
- Malposition or dislodgement of LMA
- Upper airway trauma
- Inadequate sealing of airway and leaks
- Cough and laryngospasm
- Gastric insufflation
- Vocal cord palsy and nerve injuries (Lingual nerve, Recurrent Laryngeal Nerve, Hypoglossal Nerve, Glossopharyngeal Nerve)

## 4. Insertion technique

All LMAs consist of four parts, a hollow tube (shaft) continuous with a hollow mask or cuff, inflation line with pilot balloon and drain (gastric access) tube. The broad elliptical inflatable cuff has a smooth upper surface that prevents pharyngeal secretions from entering the airway and an under surface that sits over the larynx to create a seal.

The patient's neck is flexed and head is extended (sniffing position) (**Figure 1**). The LMA is partially deflated and the backside of the LMA is lubricated. The shaft is grasped with the dominant hand like a pen, as near to the mask as possible. The deflated flattened mask is inserted against the hard palate downward into the mouth along the curvature of the back of the pharynx. The index finger follows the tube into the mouth to keep pressing "back" and "down" until the aperture faces the laryngeal inlet. If at any time during insertion the mask fails to stay flattened or starts to fold back, it should be withdrawn and reinserted. Another technique is to

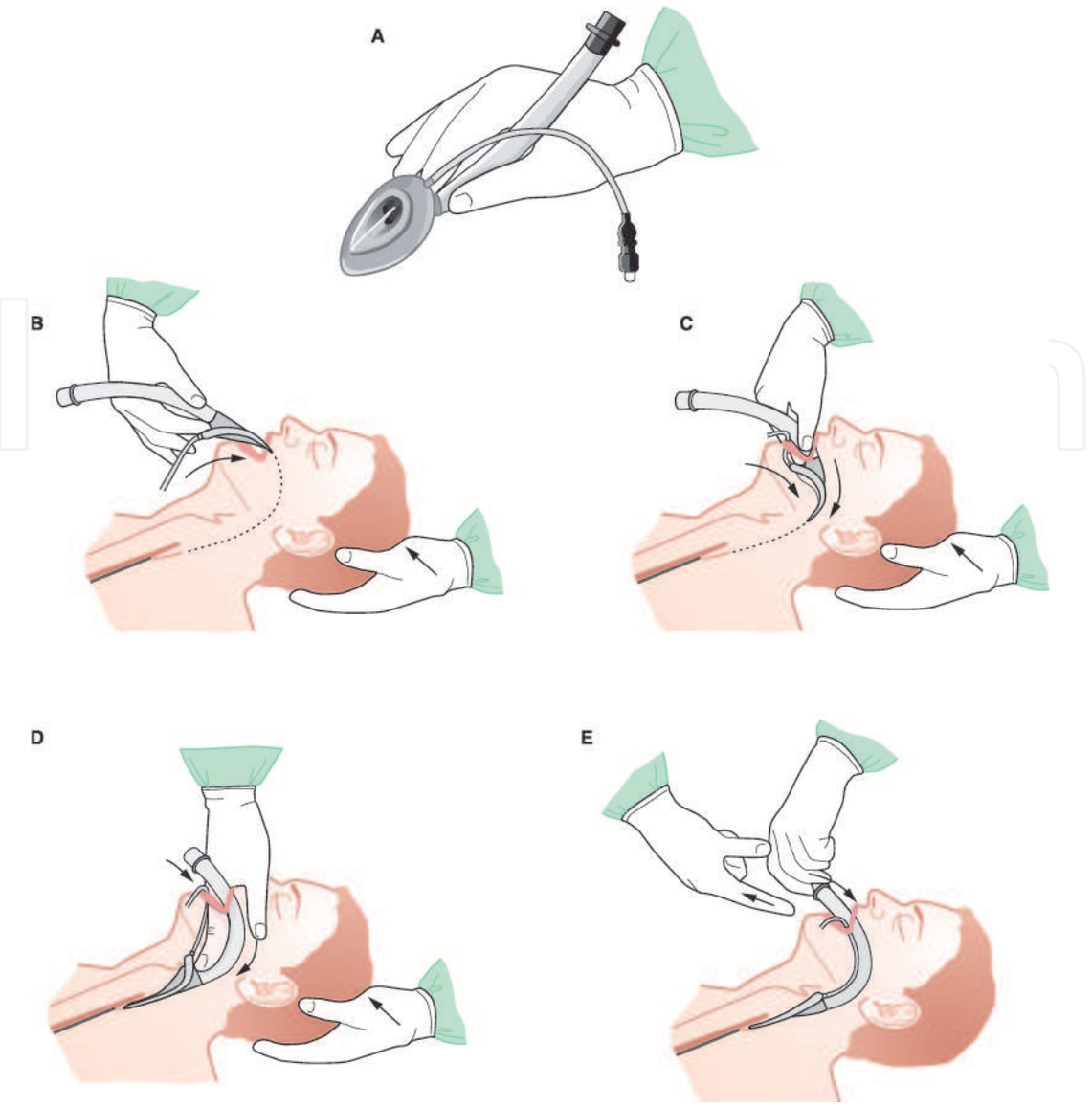


**Figure 1.**
*Technique of LMA insertion. (a) The deflated and lubricated LMA is held by the index finger and thumb of right hand. (b) The left hand stabilizes the occiput. LMA is inserted in the mouth pressed against the hard palate. (c) Using the index finger, it is advanced behind the tongue. (d) It is further pushed into the hypopharynx with the index finger. (e) After removing the index figure, the airway tube of the LMA is pushed further inside with the left hand till a resistance is felt.*

allow the dominant hand to guide the shaft and use the nondominant hand to push the tube with or without an introducer [45–47].

Proper placement of the airway is prudent. Cuff should be inflated to achieve adequate tidal volumes with minimal leaks. The cuff inflation pressure should never exceed 60 mm Hg. Higher Cuff pressures may lead to increased pharyngeal mucosal pressures which may lead to mucosal ischemia and airway morbidities [48].

Marjot showed that intracuff pressure increased as cuff volume increases [49]. The pressure exerted on the pharynx by the SGA is usually higher than that of mucosal capillary perfusion pressure when the cuff is inflated with the recommended maximum volume of air.

However, if the cuff is deflated excessively, it may not protect the airway from soiling, due to the regurgitated fluid from the stomach [50]. Therefore. it is desirable to inflate the cuff of the SGA with minimum volume of air which provides a seal around the mask.

In case of malpositioning of the mask, it may have to be replaced or other manoeuvres may have to be tried. A partially or fully inflated SGA cuff may ease insertion [8–10]. Wakeling et al. claim that inserting an SGA with a fully inflated cuff

causes less mucosal trauma and leads to fewer airway morbidities. If an assistant is available, he can apply a jaw thrust manoeuvre which moves the tongue forward and prevents compression of the epiglottis [14]. In case of a single operator, a tongue depressor or a laryngoscope may be used to assist insertion of the LMA [15].

## 5. Size selection

Weight-based selection as per the manufacturer's guideline is done. If unsure, check the package cover for size information. More than one size should always be available, because the correct size cannot always be predicted. Weight-based selection has given way to sex-based selection, especially in adults. The consensus seems to be that the correct size would be a size 4 for most adult women and a size 5 for most adult men [51–57]. Whatever the initial size selected, if malposition or an inadequate seal is present, a larger size LMA should be considered. Alternative formulas based on weight have been proposed [58, 59]. For children, the width of the second to fourth fingers can be matched to the widest part of the mask [60]. If repeated attempts with one type of LMA are unsuccessful, changing to another type may help.

## 6. Removal technique

Wait for full recovery from anaesthesia. Do not try to pull out the SGA if the patient is biting down on the shaft. Usually, patients emerge smoothly with SGAs.

It is recommended to use a bite block with the LMA in order to prevent damage to the airway tube or pilot balloon during emergence. Manufacturers usually recommend using a wad of gauze swabs rolled into a cylindrical shape and placed along the LMA. Some anaesthesiologists prefer to place the Guedel's airway. The LMA should never be removed if patient is in a light plane of anaesthesia as it may precipitate a laryngospasm.

## 7. Classification

SGAs have been conventionally classified based on the following characteristics by Miller [61].:

- Whether it is inflatable or anatomically pre-shaped
- Where in the hypopharynx it provides a seal
- Whether or not the sealing effect is directional and
- Whether or not oesophageal sealing occurs

In recent years, devices with oesophageal sealing (Second Generation SGAs) have gained popularity due to presence of a gastric port which allows drainage of stomach contents and reduces the incidence of regurgitation and aspiration pneumonitis.

Modern classification of SGAs is given in **Table 1**.

### 7.1 Sealing pressure

The airway sealing pressure or the oropharyngeal leak pressure (OLP) is the pressure at which gas leak occurs around the device. It indicates the degree of airway protection. After the successful placement of airway device, OLP can be determined

| Oesophageal sealing | Pharyngeal sealer | Perilaryngeal sealers |
|---|---|---|
| None (1st generation) | VBM Laryngeal Tube (VBM, Germany) | LMA Classic (Teleflex, USA) |
| | Cobra PLA (Pulmodyne, USA) | LMA Unique (Teleflex, USA) |
| | | LMA Flexible (Teleflex, USA) |
| | | AuraOnce LMA (Ambu, Denmark) |
| | | Aura-i LMA (Ambu, Denmark) |
| | | Air-Q ILA (Mercury Medical, USA) |
| Gastric channel (2nd generation) | Combitube (Covidien-Nellcor USA) | LMA ProSeal (Teleflex, USA) |
| | Rusch Easy Tube (Teleflex, USA) | LMA Supreme (Teleflex, USA) |
| | VBM LTS II (VBM, Germany) | LMA Guardian (Teleflex, USA) |
| | King LTS-D (Ambu, Denmark) | LMA Protector (Teleflex, USA) |
| | | AuraGain LMA (Ambu, Denmark) |
| | | i-gel (Intersurgical, UK) |
| Gastric channel + self-energising mechanism of seal | | Baska mask (Baska Versatile Laryngeal Mask Pvt. Ltd., Australia) |

*LMA: laryngeal mask airway, ILA: intubating laryngeal airway, LTS: Laryngeal Tube Suction, LTS-D: Laryngeal Tube Suction disposable, PLA: perilaryngeal airway.*

**Table 1.**
*Classification of supraglottic airways.*

by turning off the ventilator and closing the adjustable pressure limiting valve of the circuit. A fixed gas flow of 3 L/min is started and the pressure allowed to rise.

There are various methods of assessment of OLP [62].:

a. Audible noise over the patient's mouth

b. Auscultation just lateral to the thyroid cartilage for an audible noise

c. Manometer stability test- The fresh gas flow is set at 3 l/minute of oxygen and the adjustable pressure limiting valve of the circle system is closed. As the pressure from the breathing system increases, the aneroid manometer dial is observed to note airway pressure at which the dial attains stability and no further rise in pressure is seen. A maximum pressure of 40 cm H2O is allowed.

Correct placement of the LMA can be checked by a simple test. A soap bubble solution is placed over the tip of the drain tube. If the tip of the LMA is in the laryngopharynx, bubbling or bursting of soap solution column will occur during positive pressure ventilation.

## 7.2 First generation SGA

### *7.2.1 LMA classic ™ (cLMA)*

The original Laryngeal Mask Airway (cLMA, Intavent Direct, Maidenhead, UK) was the first SGAs introduced into clinical practice. It was invented by Dr. Archie Brain in the United Kingdom 1981 and was introduced into clinical practice in 1988.

In 1992 a task force was commissioned by the ASA to establish practice guidelines for management of difficult airway scenarios. In 1993, the ASA published the algorithm for difficult airways. They stressed on an early attempt at LMA insertion in case of inadequate face mask ventilation. cLMA has revolutionised anaesthetic practice ever since [63].

### *7.2.2 Device description, technical aspects*

The cLMA consists of the following parts (**Figure 2**):

- Curved airway tube (shaft)
- Pilot tube
- Elliptical mask

The angle between the mask and shaft is 30°. The machine end of the shaft has a standard 15-mm adapter. Two flexible vertical bars at the junction of the shaft and mask prevent obstruction of the ventilating lumen by the epiglottis (**Figure 3**). Reusable devices are constructed of medical grade silicone designed to provide an oval seal around the laryngeal inlet and act as a sleeve joint at the upper oesophagus. The single use devices have a cuff constructed of polyvinyl-chloride.

The classic laryngeal mask is available in eight sizes, as shown in **Table 2**.

### *7.2.3 Limitations of the LMA classic™*

Although the cLMA is used in a large number of cases requiring airway management, it has some limitations

- It has a moderate pharyngeal seal (~20 cm $H_2O$)
- It may be associated with pulmonary aspiration of regurgitated fluid

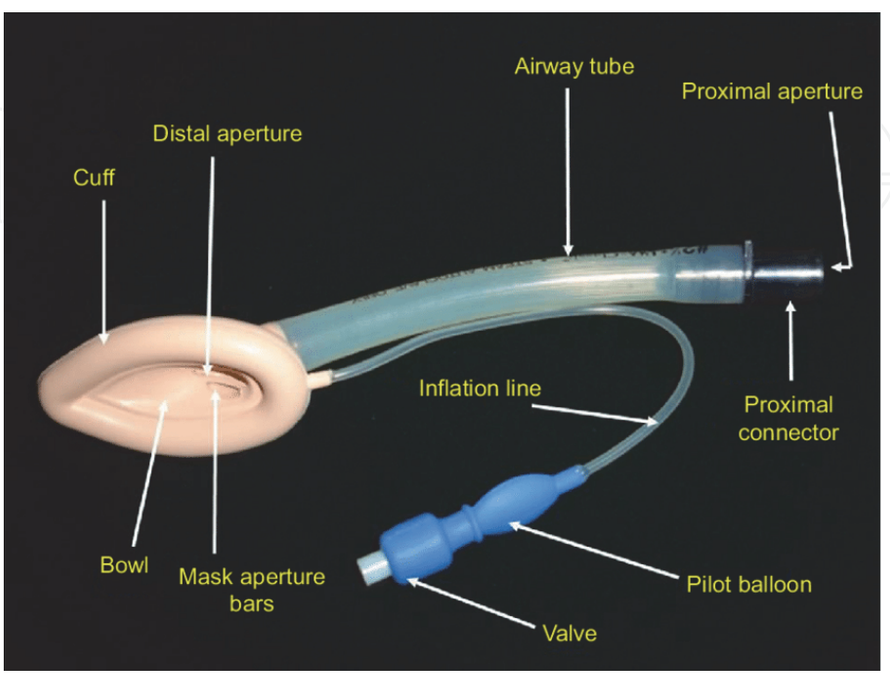


**Figure 2.**
*Classic LMA.*

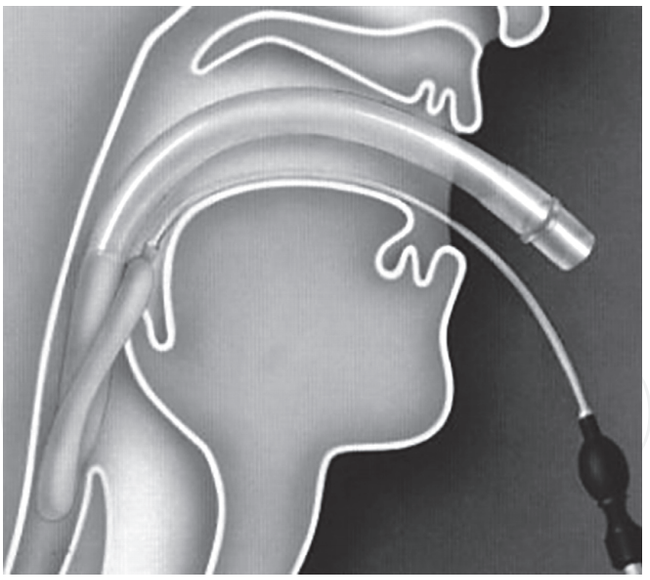

**Figure 3.**
*Classic LMA in-situ.*

| Mask size | Patient weight | Maximum cuff volume of air (ml) |
|---|---|---|
| 1 | Neonates/infants up to 5 kg | 4 |
| 1.5 | Infants 5–10 kg | 7 |
| 2 | Infants/children 10–20 kg | 10 |
| 2.5 | Children 20–30 kg | 14 |
| 3 | Children 30–50 kg | 20 |
| 4 | Adults 50–70 kg | 30 |
| 5 | Adults 70–100 kg | 40 |
| 6 | Large adults over 100 kg | 50 |

**Table 2.**
*Available classic LMAs.*

First generation SGAs have only a single lumen for ventilation. There is risk of regurgitation of gastric contents and aspiration with positive pressure ventilation. To combat this risk, a separate channel was incorporated into this design to allow for gastric drainage and provide better seal. Several modifications of the Classic LMA were done and lead to the invention of second-generation SGAs.

## 7.3 Second generation SGA

A second-generation SGA is one with design features (higher oropharyngeal seal pressures and oesophageal drain tubes) specifically intended to reduce the risk of aspiration [33].

### *7.3.1 LMA Proseal™ (pLMA)*

#### *7.3.1.1 Introduction*

The Proseal LMA™ (Teleflex®, USA) designed by Dr. Archie Brain, is based on the cLMA. It was introduced in the year 2001. In comparison to the cLMA, it has a

larger and deeper bowl without aperture bars, second drainage tube placed lateral to the airway tube that ends at the tip of the mask, posterior extension of the mask cuff, integral silicone bite block, and an anterior pocket for seating an introducer or finger during insertion.

*7.3.1.2 Device description, technical aspects and practicalities of use*

The pLMA has four main components (**Figure 4**):

- Mask
- Inflation line with pilot balloon.
- Airway tube
- Drain tube.

The mask conforms to the contours of the hypopharynx. The mask has a main cuff that seals around the glottic aperture. The rear cuff pushes the mask anteriorly which helps to increase the seal. A pilot balloon with valve is used to inflate or deflate the device.

A drain tube (DT) passes parallel and lateral to the airway tube. It continues to enter the cuff bowl and terminates at the mask tip. Cuff tip lies at the origin of the upper oesophageal sphincter if device is positioned correctly. The wire reinforced airway tube prevents collapse and terminates with a standard 15 mm connector [7]. The pLMA can also be used for FOB guided intubation.

*7.3.1.3 Size selection, practical aspect, adjuncts*

Sizes 3 to 5 were introduced in 2000 and sizes 1½-2½ in 2004. Sizes 1½-2½ have no dorsal cuff. Device properties and recommendations for use are given in **Table 3**. The pLMA is reusable and recommended product life is 40 sterilisations. Not all protein material can be removed by routine cleaning of laryngeal masks and this raises theoretical concerns over cross-infection risk, hence steam autoclaving is the recommended method of sterilising this device.

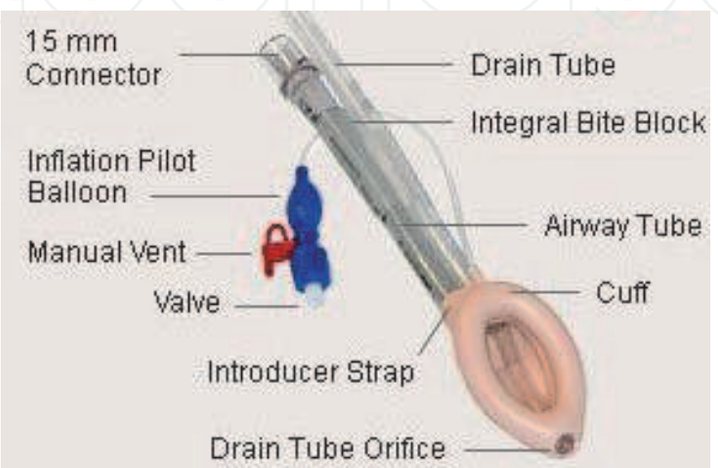


**Figure 4.**
*Parts of Proseal LMA.*

| Mask size | Patient weight | Maximum cuff volume of air (ml) | Gastric tube size (French) | Largest ETT ID (mm) |
|---|---|---|---|---|
| 1 | Neonates/infants up to 5 kg | 4 | 8 | 3.5 |
| 1.5 | Infants 5–10 kg | 7 | 10 | 4 |
| 2 | Infants/children 10–20 kg | 10 | 10 | 4.5 |
| 2.5 | Children 20–30 kg | 14 | 14 | 5 |
| 3 | Children 30–50 kg | 20 | 16 | 6 |
| 4 | Adults 50–70 kg | 30 | 16 | 6 |
| 5 | Adults 70–100 kg | 40 | 18 | 7 |

**Table 3.**
*Available Proseal LMAs.*

The pLMA is accompanied by a cuff deflator (**Figure 5**) and insertion tool (**Figures 6** and **7**). The cuff deflator assists complete deflation and flattening the device tip before insertion to improve insertion success.

### *7.3.2 The LMA-supreme™ (SLMA)*

#### *7.3.2.1 Introduction*

LMA Supreme™(Teleflex®, USA) is a second generation, single use, SGA device which facilitate ease of placement and in-situ airway stability. It forms an effective seal first with the oropharynx (oropharyngeal seal) and a second seal with the upper oesophageal sphincter (the oesophageal seal). This devise is designed incorporating features of a cLMA, pLMA, and LMA Fastrach [64–66]. SLMA delivers measured oropharyngeal leak pressures up to 37 cm H2 O [67].

#### *7.3.2.2 Device description, technical aspects and practicalities of use*

The SLMA has following components (**Figure 8**):

- Modified cuff
- Elliptical airway tube
- Drain tube

**Figure 5.**
*PLMA cuff deflator.*

**Figure 6.**
*pLMA with insertion tool.*

**Figure 7.**
*Insertion tool.*

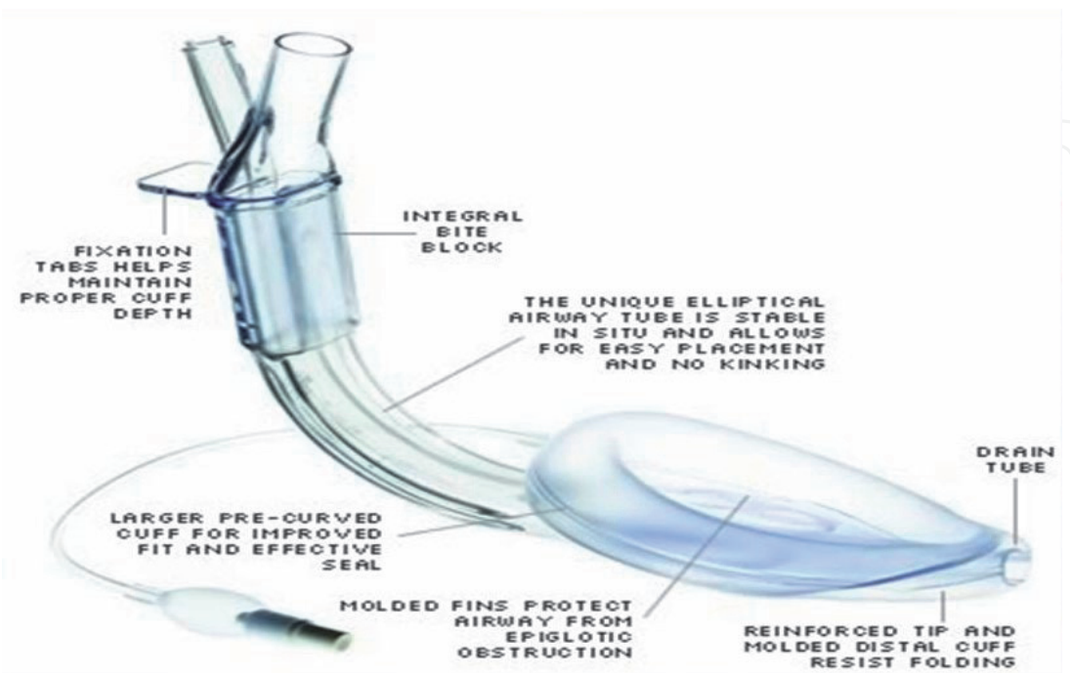


**Figure 8.**
*Parts of LMA supreme.*

- Integrated bite block
- Inflation line with pilot balloon
- Fixation tab

The device is preformed and anatomically shaped. The stiffness of SLMA is intended to guide the airway into the correct position during insertion (**Figure 9**). This also eliminates the need for placing the clinician's fingers into the patient's mouth. Also, rotational mal-positioning of the airway becomes unlikely owing to this feature. The integrated bite block reduces the potential for damage to, or obstruction of the airway tube in the event of biting. The airway also has a fixation tab designed to facilitate easy fixation and improve drain tube position. These improvisations render it suited for inexperienced users in an emergency situation.

Primarily, the SLMA has been recommended for securing airway in routine and emergency surgical procedures. It may also be used to secure an immediate airway when tracheal intubation is precluded by lack of available expertise or equipment, or when attempts at tracheal intubation have failed.

There is increasing evidence that suggests that it may be used for airway rescue in emergency situations and in hostile environments, particularly when tracheal intubation may be challenging or may delay oxygenation [68–70].

*7.3.2.3 Size selection, practical aspect, adjuncts*

Size 1 to 5 are commercially available (**Table 4**). A weight-based size selection is suggested by the manufacturer. The cuff is inflated with air as recommended for that specific size. The intra-cuff pressure should never exceed 60 cm $H_2O$. The cuff should be inflated with just enough air to achieve a seal sufficient to permit ventilation without leaks, if no manometer is available.

Some studies advocate an anatomical-related size selection method. The patient's thyromental distance is measured by the palm side of patient's hand. If it is four

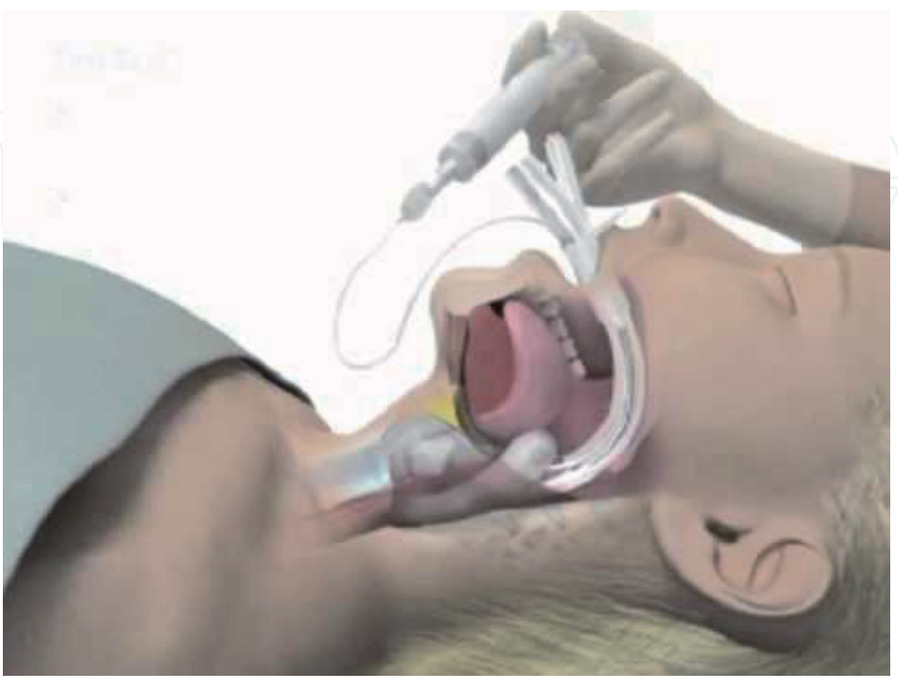

**Figure 9.**
*LMA supreme in-situ.*

| Mask size | Patient weight | Maximum cuff volume of air (ml) | Gastric tube size (French) |
|---|---|---|---|
| 1 | Neonates/infants up to 5 kg | 5 | 6 |
| 1.5 | Infants 5–10 kg | 8 | 6 |
| 2 | Infants/children 10–20 kg | 12 | 10 |
| 2.5 | Children 20–30 kg | 20 | 10 |
| 3 | Children 30–50 kg | 30 | 14 |
| 4 | Adults 50–70 kg | 45 | 14 |
| 5 | Adults 70–100 kg | 45 | 14 |

**Table 4.**
*Available supreme LMAs.*

fingers wide (index, middle, ring and little fingers), they suggest size 4 SLMA; If it is three fingers wide (index, middle, ring fingers), they suggest size 3 SLMA [71].

### *7.3.3 The LMA Guardian™ (GLMA)*

The Guardian laryngeal mask airway™ (GLMA) (Teleflex®, USA) is a new disposable silicone SGA device. The cuff forms a seal with the glottis for ventilation, and with the hypopharynx for airway protection. The gastric drainage port helps to suction the stomach contents. Also, it has a port for suctioning material from the hypopharynx. The pilot balloon valve with pressure logo indicates visual intracuff pressure (Yellow <40 cmH2O, Green 40–60 cmH2O and Red >60 cmH2O) (**Figure 10**). A study suggests that it provides sealing pressures as high as 32 cm H2O [72, 73].

### *7.3.4 LMA protector and LMA protector™ cuff pilot™*

#### *7.3.4.1 Introduction*

The LMA-Protector™ (Teleflex®, USA) is a novel SGA made of medical-grade silicone (**Figure 11**). In comparison to other devices made of

**Figure 10.**
*LMA guardian.*

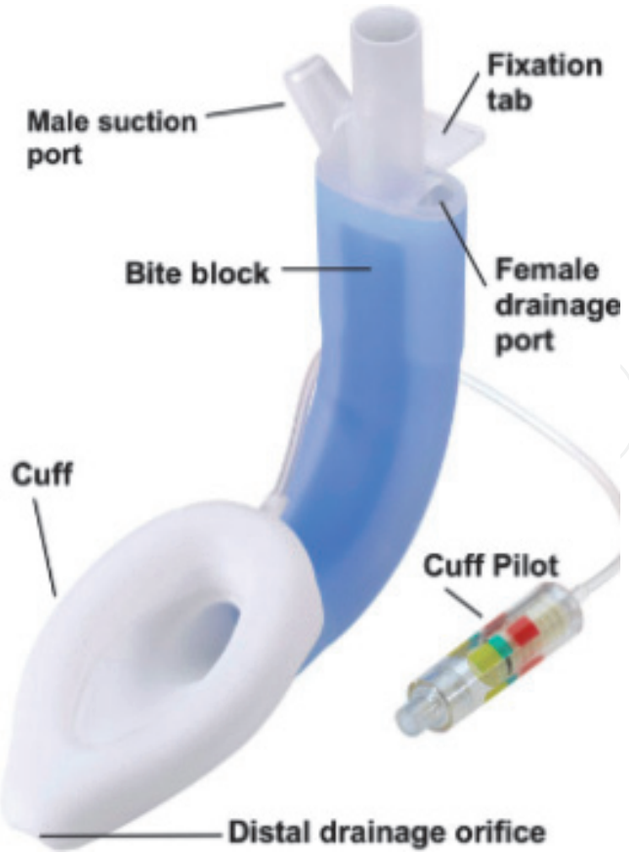


**Figure 11.**
*LMA protector cuff pilot.*

polyvinylchloride, it is more flexible and less traumatic. Its fixed, anatomically curved shape is elliptical in cross section and aids easier insertion. It has two separate drain channels. At the machine end, they begin as the male and female suction ports. The channels then enter a chamber behind the cuff bowl. At the patient end, the chamber ends at the tip of the cuff. The device is flexible and stays in place if the patient's head is mobilised. A built-in bite block reduces the potential for damage to, or obstruction of the airway tube in the event of biting. Additionally, the LMA-Protector™ is available with a pilot balloon or the integrated Cuff Pilot™. The Cuff Pilot™ enables constant visualisation of intracuff pressure inside the mask cuff that provides easier adjustment and is colour coded for inflation pressure [74].

*7.3.4.2 Size selection, practical aspect, adjuncts*

It is commercially available in size 3, 4 and 5. The manufacturer recommends using a size 4 device for normal adults. After insertion, the device is fixed in place and inflated to the recommended pressure. There should be a minimum of a 1 cm gap between the fixation tab and the patient's upper lip. The cuff should be inflated with sufficient air to prevent a leak with positive pressure ventilation, but it must not exceed either a pressure of 60 cm H2O or the specific device cuff volume maxima. If no manometer is available, inflate with just enough air to achieve a seal sufficient to permit ventilation without leaks. It provides high first attempt and overall insertion success rate. It helps rapidly achieve effective ventilation with reliable airway seal. Additionally, it acts as a conduit for FOB guided intubation [75, 76].

### *7.3.5 Ambu AuraGain*

#### *7.3.5.1 Introduction*

The AuraGain™ (Ambu®, Denmark) is intended for use as an alternative to a face mask for achieving and maintaining control of the airway during routine and emergency anaesthetic procedures. The gastric channel of AuraGain™ may be used as a conduit for passing a gastric tube into the stomach for removal of air and gastric fluids.

It is intended for use as a conduit for an endotracheal tube in "can't intubate – can't ventilate" scenarios. It may also be used to establish a clear airway during resuscitation in profoundly unconscious patients with absent glossopharyngeal and laryngeal reflexes who may need artificial ventilation [77].

#### *7.3.5.2 Device description*

The parts of AuraGain are as follows (**Figures 12** and **13**):

- Inflatable Mask
- Inflation line with pilot balloon.
- Airway tube with integrated bite block
- Gastric channel

The mask is designed to conform to the contours of the hypopharynx with its lumen facing the laryngeal opening. When correctly inserted, the distal tip of the cuff rests against the upper oesophageal sphincter. It is anatomically shaped with an integrated bite block.

#### *7.3.5.3 Size selection, practical aspect*

The AuraGain™ comes in eight different sizes for use in patients of different weight (**Table 5**). This device is meant to be used only once. Studies suggest that AuraGain™ provides adequate sealing of the airway [78–80].

**Figure 12.**
*Ambu AuraGain.*

**Figure 13.**
*FOB guided intubation.*

| Mask size | Patient weight | Maximum cuff volume of air (ml) | Gastric tube size (French) | Largest ETT ID (mm) |
|---|---|---|---|---|
| 1 | Neonates/infants up to 5 kg | 4 | 6 | 3.5 |
| 1.5 | Infants 5–10 kg | 7 | 8 | 4 |
| 2 | Infants/children 10–20 kg | 10 | 10 | 5 |
| 2.5 | Children 20–30 kg | 14 | 10 | 5.5 |
| 3 | Children 30–50 kg | 20 | 16 | 6.5 |
| 4 | Adults 50–70 kg | 30 | 16 | 7.5 |
| 5 | Adults 70–100 kg | 40 | 16 | 8 |
| 6 | Adults more than 100 kg | 50 | 16 | 8 |

**Table 5.**
*Available Auragain LMAs.*

### *7.3.6 i-gel®*

#### *7.3.6.1 Introduction*

The i-gel® (Intersurgical®, UK) is the innovative second generation supraglottic airway device from Intersurgical launched in 2007. Made from a medical grade thermoplastic elastomer, i-gel has been designed to create a

non-inflatable, anatomical seal of the pharyngeal, laryngeal and perilaryngeal structures whilst avoiding compression trauma.

*7.3.6.2 Device description*

The igel has the following parts (**Figure 14**):

- Soft non-inflatable cuff
- Gastric channel
- Epiglottic rest
- Buccal cavity stabiliser
- Airway tube
- Gastric tube

A horizontal line (Adult sizes 3,4 and 5 only) at the middle of the integral bite-block represents the correct position of the teeth. The soft design of the i-gel is able to retain its shape to facilitate ease of insertion. In a known difficult or unexpectedly difficult intubation, for intubating the patient, by passing an ETT through the device under fibre optic guidance.

*7.3.6.3 Size selection, practical aspect, adjuncts*

Size selection is done on a weight basis (**Table 6**). However, individual anatomical variations should always be considered. Patients with cylindrical necks or wide thyroid/cricoid cartilages may require a larger size i-gel than would normally be recommended on a weight basis [81, 82].

The i-gel can be used in difficult or unanticipated difficult intubations. Owing to its ease of insertion, it can quickly establish and maintain a clear airway in a pre-hospital setting [83, 84]. In a study it was observed that hemodynamic parameters, ease of insertion and postoperative complications were comparable among the i-gel, pLMA and cLMA but airway sealing pressure was significantly higher with i-gel [85].

A modification of this device is the i-gel O2. It contains a supplementary oxygen port for passive oxygen administration. It may be utilised for cardiopulmonary resuscitation. The i-gel O2 Resus Pack is a resuscitation pack provided by the manufacturer. It contains the i-gel O2 LMA, an airway support strap to fix and secure the device in place, a suction tube (12 Fr) and a pack of lubricant. The Resus Pack is available in three adult sizes (3, 4 and 5). The presence of a colour coded hook ring on the LMA allows easy identification of the size during resuscitation.

*7.3.7 Combitube®*

*7.3.7.1 Introduction*

The Combitube® (Covidien-Nellcor®, Pleaseton, USA) is a single use, double-lumen tube that combines the features of a conventional ETT with those of an oesophageal obturator airway.

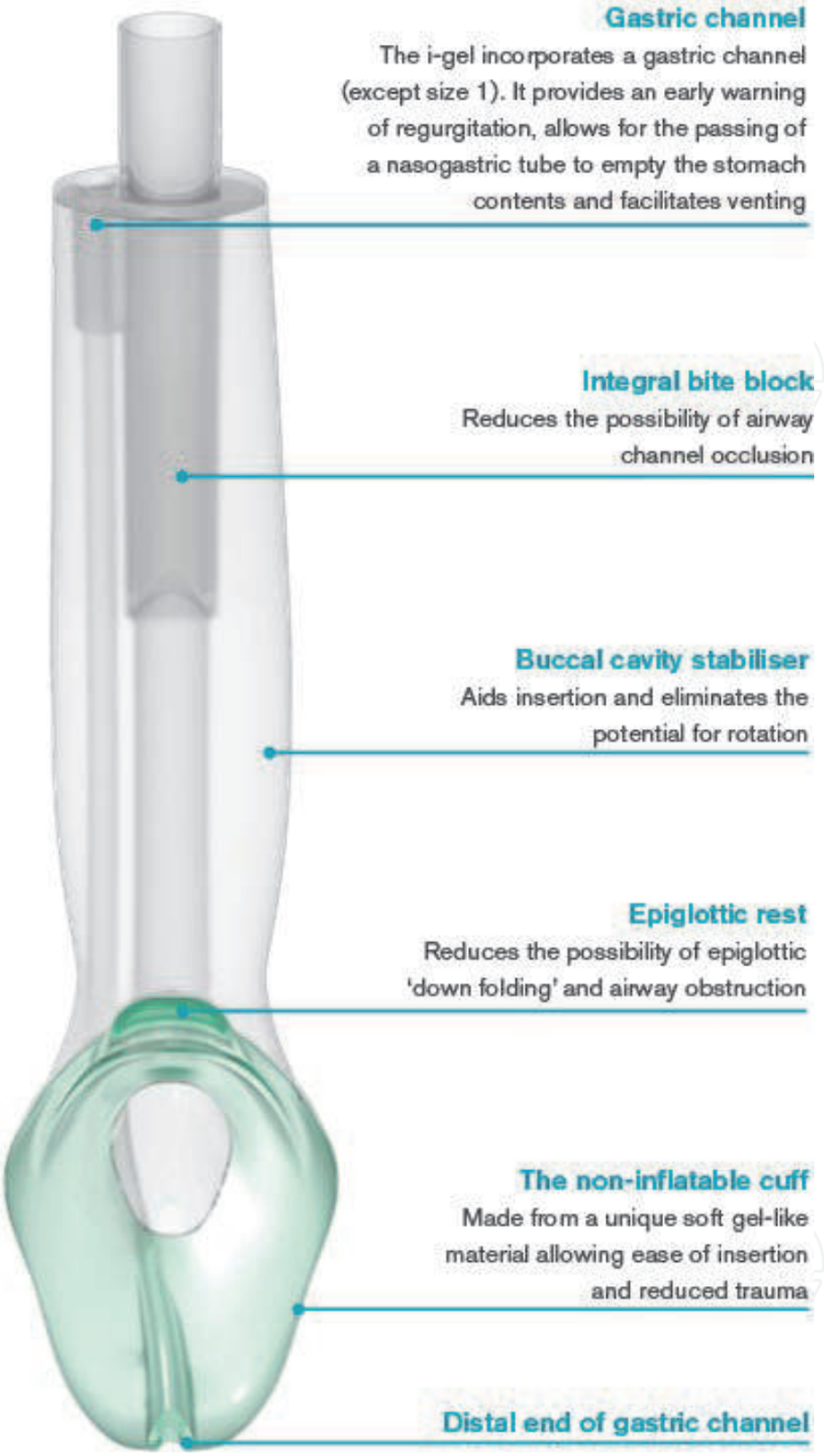


**Figure 14.**
*Parts of i-gel.*

*7.3.7.2 Device description*

The Combitube® has the following parts (**Figure 15**):

- A large proximal balloon cuff seals the hypopharynx
- A ventilating, proximal lumen terminates at side ports overlying the laryngeal inlet

| Mask size | Patient weight | Largest ETT ID (mm) | Gastric tube size (French) |
|---|---|---|---|
| 1 | Neonates 2-5 kg | 3 | NA |
| 1.5 | Infants 5–12 kg | 4 | 10 |
| 2 | Infants/children 10–25 kg | 5 | 12 |
| 2.5 | Children 25–35 kg | 5 | 12 |
| 3 | Children, Small adult 30–60 kg | 6 | 12 |
| 4 | Adults 50–90 kg | 7 | 12 |
| 5 | Adults >90 kg | 8 | 14 |

**Table 6.**
*Available i-gel LMAs.*

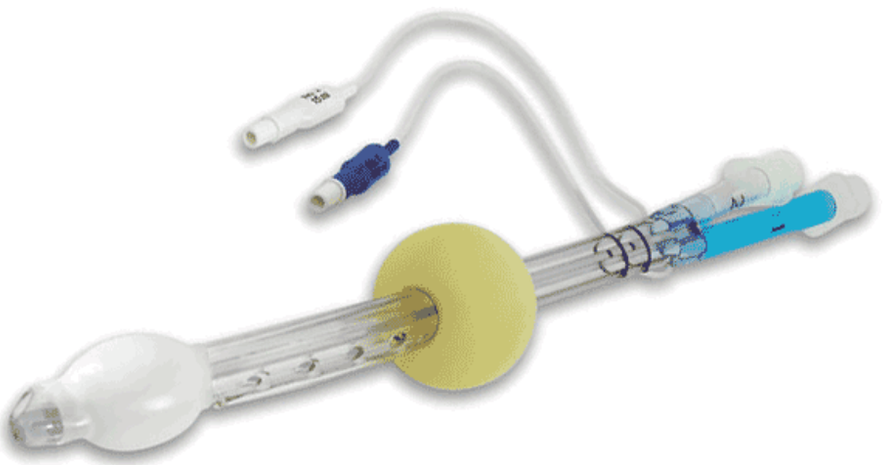

**Figure 15.**
*Combitube.*

- A distal lumen and its smaller balloon cuff terminate in and seal the upper oesophagus (in >90% of insertions)

The device commonly enters the oesophagus on insertion. Ventilation is achieved through multiple proximal apertures situated above the distal cuff (**Figure 16**). Both the proximal and distal cuffs have to be inflated to prevent air from escaping through the oesophagus. If the tube enters the trachea, ventilation is achieved through the distal lumen.

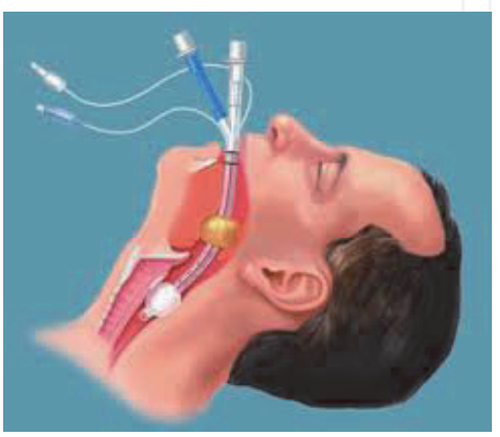

**Figure 16.**
*Combitube in-situ.*

*7.3.7.3 Size selection, practical aspect, adjuncts*

Combitube® is commercially available in two sizes (**Table 7**). It has a major advantage over conventional ETT as it can be inserted without head and neck movement, which may be an important consideration in trauma patients [86]. Situations where ETT placement is not immediately possible, it is used for emergency airway control [87]. The Combitube® has been used effectively in cardiopulmonary resuscitation [88, 89]. It has been used successfully in difficult airway situations owing to severe facial burns, trauma, upper airway bleeding and vomiting where there was an inability to visualise the vocal cords [90–92].

*7.3.8 Ambu® king LTS-D™ (disposable laryngeal tube)*

*7.3.8.1 Introduction*

The King Laryngeal Tube Suction-D™ (Ambu®, Denmark) is a disposable, double-lumen, supralaryngeal device for airway management introduced in 2005. A single pilot tube can be used to inflate both oropharyngeal and oesophageal soft silicon cuff. A ventilating outlet opens in front of the vocal cords. It is present between these cuffs. It is available in six sizes to fit patients from neonates to large adults.

*7.3.8.2 Device description*

Parts of the LTS-D (**Figures 17** and **18**):

- Proximal cuff.
- Distal cuff
- Inflation line with pilot balloon
- Ventilation holes
- Drain tube

The Proximal cuff stabilises the device and seals the oropharynx. Distal cuff blocks entry of the oesophagus, reducing the possibility of gastric insufflation. Multiple distal ventilatory openings and bilateral ventilation eyelets facilitate air flow. The device has a curvature of 60 degrees. Sealing pressures of 30 cm H20 or more are achievable.

*7.3.8.3 Size selection, practical aspect*

Size selection is done on a weight basis (**Table 8**). The slim profile allows easy insertion; thus, it can be considered for airway management in patients with

| Patient's height | Combitube size |
|---|---|
| 4 to 6 feet tall | 37 French |
| 5 feet and above | 41 French |

**Table 7.**
*Available combitube.*

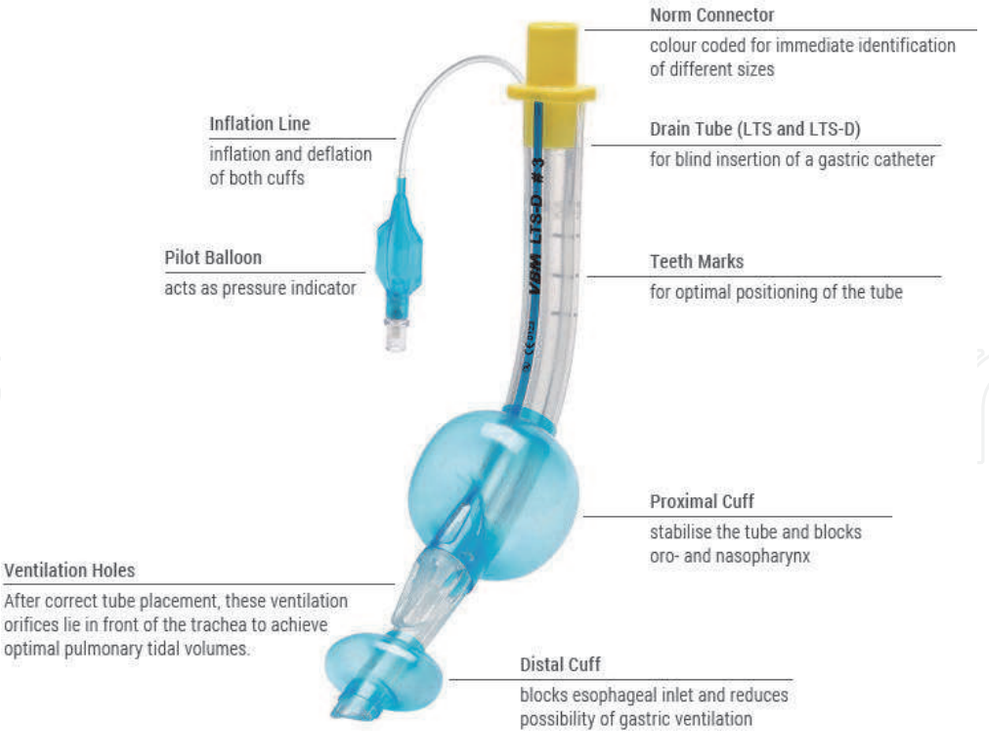


**Figure 17.**
*Parts of LTS-D.*

**Figure 18.**
*LTS-D drain tube.*

restricted mouth opening. Since insertion is relatively easy and guarantees a clear airway in most patients on the first attempt extensive training is not necessary [93].

It can be used during spontaneous or controlled ventilation. The LTS-D has been recommended as an emergency device to be used in cases of difficult intubation and cannot intubate, cannot ventilate situations while one is preparing to perform a surgical airway [94–96]. A modification of this device, the Intubating Laryngeal Tube Suction-D(iLTS-D™) is a novel device which may also be used as a conduit for intubation.

| Size | Patient weight | Maximum cuff volume of air (ml) | Colour of Connector |
|---|---|---|---|
| 0 | Neonates < 6 kg | 15 | TRANSPARENT |
| 1 | Infants 6–15 kg | 40 | WHITE |
| 2 | Children 15–30 kg | 60 | GREEN |
| 3 | Small Adult 30–60 kg | 120 | YELLOW |
| 4 | Medium Adult50–90 kg | 130 | RED |
| 5 | Large Adults >90 kg | 150 | VIOLET |

**Table 8.**
*Available LTS-D tubes.*

### *7.3.9 Baska mask®*

#### *7.3.9.1 Introduction*

The Baska Mask® (Baska Versatile Laryngeal Mask Pty Ltd., Australia) has been designed by Australian anesthesists, Kanag and Meenakshi Baska. It obviates the need of an orogastric tube and replaces this with a sump and two drains. It brings together features of PLMA, SLMA, SLIPA and i-gel. The biggest advantage of Baska mask lies in the fact that cuff deflation or inflation is not required prior to insertion [97].

#### *7.3.9.2 Device description*

Parts of the Baska mask® (**Figures 19** and **20**):

- Self-sealing variable pressure cuff
- Insertion tab
- Integrated bite block
- Airway tube
- Suction attachment
- Sump area

It is made of medical grade silicone. It differs in several ways from the conventional LMA, including; a cuff-less self-sealing membranous bowl which inflates and deflates with each positive pressure inspiration and expiration respectively, an inbuilt "tab" that permits to increase its angulation for easy negotiation of the oropharyngeal curve during placement, a bite block. It has a dual high flow suction drainage system. The distal aperture at oesophageal end is aspirated using two vents running along the entire length of the stem. One tube is connected to high pressure suction whereas the other is left open.

#### *7.3.9.3 Size selection, practical aspect*

Size selection is given below (**Table 9**). Zundert *et al*. in their study concluded that Baska mask® improves safety when used in both intermittent positive pressure

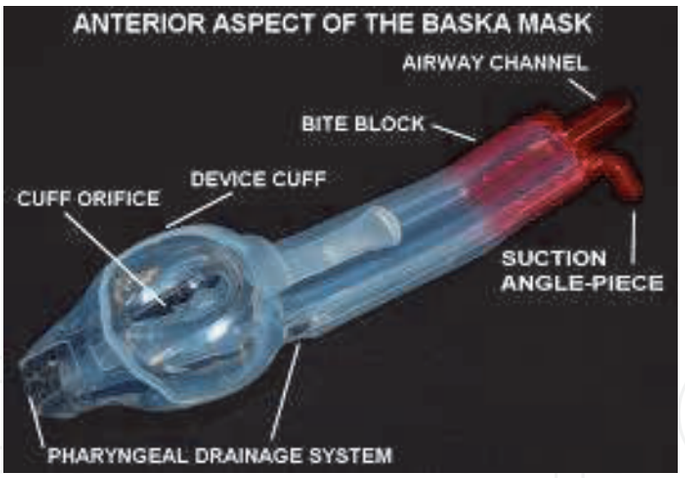


**Figure 19.**
*Baska mask-anterior.*

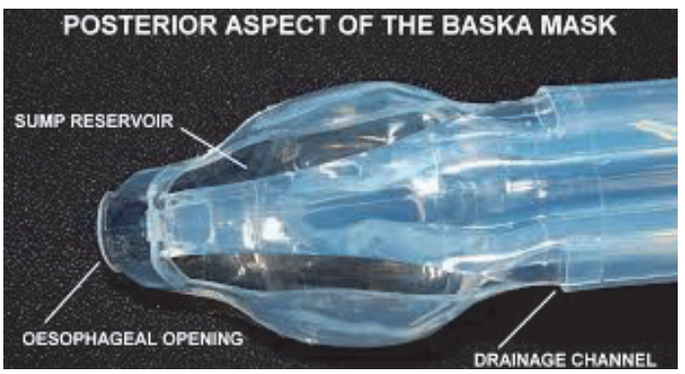


**Figure 20.**
*Baska mask-posterior.*

| Mask size | Patient | Colour coded connector |
|---|---|---|
| 1 | Neonates | PURPLE |
| 1.5 | Infants 1–2 yrs | ORANGE |
| 2 | Children 2-5 yrs | DARK BLUE |
| 2.5 | Large child or small female | WHITE |
| 3 | Large female or small man | GREEN |
| 4 | Average adult man | YELLOW |
| 5 | Large man | RED |

**Table 9.**
*Available Baska LMAs.*

ventilation (IPPV) and spontaneous breathing [98]. Another study found its safety profile comparable to i-gel [99].

### *7.3.10 Air-Q® blocker™ intubating laryngeal airway*

#### *7.3.10.1 Introduction*

The Air-Q® Blocker™ ILA (Cookgas® LLC, Mercury Medical, USA) was introduced by Daniel Cook in 2005. It is a disposable, anatomically shaped device ideal for use in pre-hospital and critical care settings.

*7.3.10.2 Device description*

Parts of the Air-Q® Blocker™ ILA (**Figure 21**):

- Inflatable cuff with elevation ramp
- Built up mask heel
- Airway tube
- Integrated bite block
- Blocker Channel
- Thethered Colour Coded connector

The Air-Q® Blocker™ airway outlet is keyhole-shaped. The anatomical shape facilitates ease of insertion. The soft blocker channel accepts naso-gastric tube to suction stomach contents. Alternatively, a blocker tube may be inserted through the blocker channel and helps to suction the pharynx or suction and block the upper oesophagus. The tethered colour coded connector avoids misplacements. In a known difficult or unexpectedly difficult intubation, it may be used as a conduit for intubation. The elevation ramp directs ETT midline and upward toward the laryngeal inlet. The Air-Q Removal Stylet helps easily remove the Air-Q® Blocker™ after intubation without ETT dislodgement.

*7.3.10.3 Size selection, practical aspect, adjuncts*

Size selection is done on a weight basis (**Table 10**). It is available in three sizes. Device placement is easy and offers less resistance. The major advantage of the device design is

**Figure 21.**
*Air-Q blocker.*

that conventional PVC endotracheal tube can be passed through it without the use of conventional laryngoscope. It is useful in delivery of anaesthesia, resuscitation, critical care and difficult airway management in and out of hospital. It has a self-pressurising cuff which inflates to adequate pressure during positive pressure ventilation. This prevents airway trauma and morbidity associated with excessive cuff inflation [100].

### *7.3.11 LMA gastro™ airway*

#### *7.3.11.1 Introduction*

The LMA® Gastro™ Airway with Cuff Pilot™ Technology (Teleflex®, USA) is the first SGA designed to enable active management of the airway while facilitating direct endoscopic access via the integrated endoscope channel. It is a soft, disposable, anatomically shaped device made up of silicone.

#### *7.3.11.2 Device description*

Parts of the LMA® Gastro™ Airway (**Figure 22**):

- Inflatable cuff
- Gastric drain tube or Endoscope channel
- Silicone airway tube
- Integrated bite block
- Adjustable holder and strap
- Cuff pilot

Being anatomically shaped, it conforms to the patients's airway creating a better seal. Cuff Pilot™ Technology prevents cuff over inflation and reduces airway morbidity. The gastric channel provides as a conduit for passage of gastroduodenoscope.

#### *7.3.11.3 Size selection, practical aspect*

Size selection is done on a weight basis (**Table 11**). It is available in three sizes. Moderate to deep sedation if often required for endoscopic procedures. This can lead to hypoxemia and warrants the need of rescue airway. LMA® Gastro™ can be successfully employed as a primary airway technique for such procedures [101].

| Mask size | Patient ideal body weight(kg) | Internal cuff volume (ml) | Cuff inflation volume (ml) | Largest ETT ID (mm) |
|---|---|---|---|---|
| 2.5 | 30–50 | 12 | 2–3 | 6.5 |
| 3.5 | 50–70 | 18 | 3–4 | 7.5 |
| 4.5 | 70–100 | 25 | 4–5 | 8.5 |

**Table 10.**
*Available air-Q blocker LMAs.*

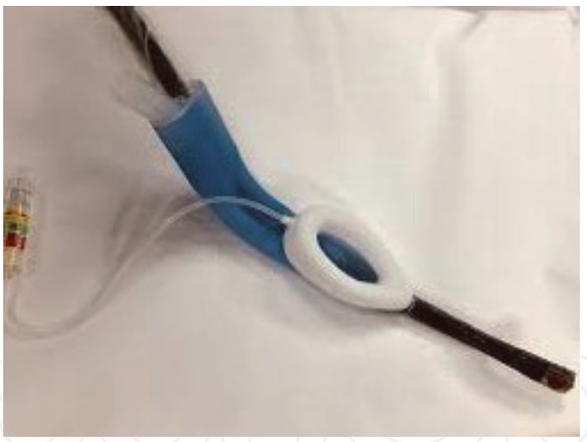

**Figure 22.**
*Gastro LMA.*

| Mask size | Patient weight (kg) | Maximum intracuff pressure (cm H2O) | Maximum endoscope size (mm) |
|---|---|---|---|
| 3 | 30–50 | 60 | 14 |
| 4 | 50–70 | 60 | 14 |
| 5 | 70–100 | 60 | 14 |

**Table 11.**
*Available gastro LMAs.*

## 8. Conclusion

The first clinically useful SGA was introduced more than 3 decades ago.

The clinical utility of various SGAs has significantly increased over this period. Different designs have specific advantages in different clinical scenarios. Insertion is easy to learn, and with adequate training nonphysicians are capable of securing an airway.

The use of SGAs for expanded indications has been described in many ways. The expanded spectrum of indications including airway instrumentation, surgeries in prone position, paediatric age group and use in critical care settings. The position of SGAs for rescue airway management is prominent in guidelines issued by various authorities. SGAs continue to be an important mode of rescue ventilation in patients in "can't ventilate can't intubate" scenarios. The ability to aspirate gastric contents renders them a safe alternative to the conventional ETTs. The ability to act as a conduit for intubation in elective and emergency patients is a valuable rescue technique.

Knowledge about the indications and contraindications of using an SGA is prudent for its appropriate use. SGAs with enough documented evidence of safety and efficacy should be used. Increasing recognition of an SGA's applications should expand its role in airway management for the anesthesiologist.

## Conflict of interest

The author declares no conflict of interest.

*DOI: http://dx.doi.org/10.5772/intechopen.93947*

## Abbreviations

| | |
|---|---|
| SGA | Supraglottic Airway |
| LMA | Laryngeal Mask Airway |
| ETT | Endotracheal Tube |
| OT | Operation Theatre |
| FOB | Fibreoptic Bronchoscopy |
| CPR | Cardiopulmonary Resuscitation |
| ID | Internal Diameter |
| mmHg | millimetres of mercury |
| L | Litre |
| Min | Minute |
| mm | millimetre |
| cmH2O | centimetre of water |
| Kg | kilogramme |
| ml | millilitre |





## Author details

Kriti Singh
ESIC Hospital and PGIMSR, Basaidarapur, New Delhi, India

*Address all correspondence to: drkritisingh@gmail.com

## References

[1] Sharma B, Sahai C, Bhattacharya A, Kumar VP, Sood J. ProSeal laryngeal mask airway: A study of 100 consecutive cases of laparoscopic surgery. Indian J Anaesth. 2003;47:467–72.

[2] Misra MN, Ramamurthy B. The Pro-Seal LMATM and the tracheal tube: A comparison of events at insertion of the airway device. Internet J Anesthesiol. 2008;16.

[3] Pennant JH,White PF. The laryngeal mask airway. Its uses in anesthesiology. Anesthesiology. 1993;79:144–63.

[4] Kovac AL. Controlling the hemodynamic response to laryngoscopy and endotracheal intubation. J Clin Anesth. 1996;8:63–79.

[5] Prys-Roberts C, Greene LT, Meloche R, Foëx P. Studies of anaesthesia in relation to hypertension. II. Haemodynamic consequences of induction and endotracheal intubation. Br J Anaesth. 1971;43:531–47.

[6] Helmy AM, Atef HM, El-Taher EM, Henidak AM. Comparative study between i-gel, a new supraglottic airway device, and classical laryngeal mask airway in anesthetized spontaneously ventilated patients. Saudi J Anaesth. 2010;4(3):131–6.

[7] Brain AIJ, Verghese C, Strube PJ. The LMA 'Proseal' – A laryngeal mask with an oesophageal vent. Br J Anaesth. 2000; 84:650–654.

[8] Wakeling HG, Butler PJ, Baxter PJ. The laryngeal mask airway: a comparison between two insertion techniques. Anesth Analg. 1997; 85:687–690.

[9] Matta BF, Marsh DS, Nevin M. Laryngeal mask airway: a more successful method of insertion. J Clin Anesth. 1995; 7:132–135

[10] Brimacombe J. Laryngeal mask insertion techniques. Anesth Analg. 1998;86:1337–38.

[11] Gonzalez H, Minville V, Delanoue K, Mazerolles M, Concina D, Fourcade O. The importance of increased neck circumference to intubation difficulties in obese patients. Anesth Analg.2008; 106: 1132–6.

[12] Lavi R, Sega l D, Ziser A. Predicting difficult airways using the intubation difficulty scale: a study comparing obese and non-obese patients. Journal of Clinical Anesthesia. 2009; 21: 264–7.

[13] Domino KB, Posner K, Caplan RA, Cheney FW. Airway injury during anesthesia: a closed claims analysis. Anesthesiology. 1999; 91: 1703–11.

[14] Aoyama K, Takenaka I, Sata T, et al. The triple airway manoeuvre for insertion of the laryngeal mask airway in paralyzed patients. Can J Anaesth. 1995; 42:1010–16.

[15] Campbell RL, Biddle C, Assudme N, et al. Fiberoptic assessment of laryngeal mask airway placement: blind insertion versus direct visual epiglottoscopy. J Oral Maxillofac Surg. 2004; 62:1108–13.

[16] Brain AJ. The Intavent Laryngeal Mask Instruction Manual. London: Intavent; 1991.

[17] Awan R, Nolan JP, Cook TM. Use of a ProSeal laryngeal mask airway for airway maintenance during emergency Caesarean section after failed tracheal intubation. Br J Anaesth 2004; 92:144–6.

[18] Cook TM, Brooks TS, Van der Westhuizen J, Clarke M. The Proseal LMA is a useful rescue device during failed rapid sequence intubation: Two additional cases. Can J Anaesth. 2005; 52:630–3.

[19] Brimacombe J, Holyoake L, Keller C, et al. Emergence characteristics and postoperative laryngopharyngeal morbidity with the laryngeal mask airway: a comparison of high versus low initial cuff volume. Anaesthesia. 2000; 55:338–343.

[20] Cook T, Howes B. Supraglottic airway devices: recent advances. Continuing Educ Anaesth Crit Care Pain 11(2): 56–61.

[21] Carron M, Veronese S, Gomiero W, Foletto M, Nitti D, et al. Hemodynamic and hormonal stress responses to endotracheal tube and ProSeal Laryngeal Mask Airway TM for laparoscopic gastric banding. J Am Soc Anesthesiol. 2012; 117(2): 309–20.

[22] Ulrich-Pur H, Hrska F, Krafft P, Friehs H, Wulkersdorfer B, et al. Comparison of mucosal pressures induced by cuffs of different airway devices. J Am Soc Anesthesiol. 2006; 104(5): 933–938.

[23] Nicholson A, Cook TM, Smith AF, Lewis SR, Reed SS. Supraglottic airway devices versus tracheal intubation for airway management during general anaesthesia in obese patients. Cochrane Database Syst Rev. 2013. 9(9): CD010105.

[24] Henderson JJ, Popat MT, Lotto IP, Pearce AC. Difficult Airway Society guidelines for management of the unanticipated difficult intubation. Anaesthesia. 2004. 59(7): 675694.

[25] Verghese C, Brimacombe JR.Survey of laryngeal mask airway usage in 11,910 patients: safety and efficacy for conventional and nonconventional usage. Anesth Analg. 1996. 82(1): 129–133.

[26] Gable A, Whitaker E. E, Tobias J. D. Use of the laryngeal mask airway in the prone position. Pediatric Anesthesia and Critical Care Journal.2015; 3(2):118–123.

[27] Sinha PK, Misra S. Supraglottic airway devices other than laryngeal mask airway and its prototypes. Ind J Anaesth.2005 ;49:281–92.

[28] Luba PP, Brain AI. The laryngeal mask—a new concept in airway management. Br J Anaesth.1983;55: 801–5.

[29] Dorsch JA, Dorsch SE. Supraglottic airway devices. In: Dorsch JA, Dorsch SE editors. Understanding Anesthesia Equipment. 5th ed. Philadelphia: Williams L, Wilkins; 2008. p. 491s

[30] Atherton DP, O'Sullivan E, Lowe D, Charters P. A ventilation exchange bougie for fibreoptic intubations with the laryngeal mask airway. Anaesthesia. 1996;51(12):1123–26.

[31] Higgs A, Clark E, Premraj K. Low-skill fibreoptic intubation: use of the Aintree Catheter with the classic LMA. Anaesthesia. 2005;60(9): 915–920.

[32] Practice Guidelines for Management of the Difficult Airway: An Updated Report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology.2003;98(5):1269–1277.

[33] Frerk C, Mitchell VSS, McNarry AFF, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. British Journal of Anaesthesia.2015; 115: 827–48.

[34] Augoustides JG, Groff BE, Mann DG, Johansson JS. Difficult airway management after carotid endarterectomy: utility and limitations of the Laryngeal Mask Airway. J Clin Anesth. 2007;19(3):218–221.

[35] Fundingsland BW, Benumof JL. Difficulty using a laryngeal mask airway in a patient with lingual tonsil hyperplasia. Anesthesiology.1996;84(5): 1265–6.

[36] Kidani DC, Shah NK. The use of a laryngeal mask airway after a prolonged suspension laryngoscopy to preserve a vocal cord fat graft. Anesth Analg.2007; 105(6):1753–4.

[37] Parmet JL, Colonna-Romano P, Horrow JC, Miller F, Gonzales J, Rosenberg H. The laryngeal mask airway reliably provides rescue ventilation in cases of unanticipated difficult tracheal intubation along with difficult mask ventilation. Anesth Analg.1998;87(3):661–5.

[38] Swanson KL. Airway foreign bodies: what's new? Semin Respir Crit Care Med. 2004;25:405–411.

[39] Heffner JE. Tracheotomy application and timing. Clin Chest Med. 2003;24:389–98.

[40] Cattano D, Abramson S, Buzzigoli S, et al. The use of the laryngeal mask airway during guidewire dilating forceps tracheostomy. Anesth Analg. 2006;103:453–457.

[41] Martin SE, Ochsner MG, Jarman RH, et al. Use of the laryngeal mask airway in air transport when intubation fails. J Trauma-Injury Infection Crit Care. 1999;47:352–7.

[42] The American Heart Association in Collaboration with the International Liaison Committee on Resuscitation. Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2000; 102(suppl 1):95–104.

[43] Wang HE, Simeone SJ, Weaver MD, Callaway CW. Interruptions in cardiopulmonary resuscitation from paramedic endotracheal intubation. Ann Emerg Med. 2009;54(5):645–52.

[44] Stone BJ, Chantler PJ, Baskett PJ. The incidence of regurgitation during cardiopulmonary resuscitation: a comparison between the bag valve mask and laryngeal mask airway. Resuscitation. 1998;38(1):3–6.

[45] Brimacombe J, Keller C. Insertion of The Lma-UniqueTM with and without digital intraoral manipulation by inexperienced personnel after manikin only training. J Emerg Med. 2004;26:1–5.

[46] Dingley J, Baynham P, Swart M, et al. Ease of insertion of the laryngeal mask airway by inexperienced personnel when using an introducer. Anaesthesia. 1997;52:756–60.

[47] Omi A, Fukuhara T, Isshiki A, et al. The effectiveness of the Fukuhara laryngeal mask airway holding forceps (F Forceps). Anesth Analg. 1997;85:697–700.

[48] Brimacombe J, Keller C, Puehringer F. Pharyngeal mucosal pressure and perfusion. A fiberoptic evaluation of the posterior pharynx in anesthetized adult patients with a modified cuffed oropharyngeal airway. Anesthesiology. 1999 Dec; 91(6): 661–5.

[49] Marjot R. Pressure exerted by the laryngeal mask airway cuff upon the pharyngeal mucosa. Br J Anaesth. 1993 Jan; 70(1):25–29.

[50] Brimacombe J, Berry A, Brain AIJ. Optimal intracuff pressures with the laryngeal mask. Br J Anaesth. 1996 Aug; 77(2):295–96.

[51] Asai T. Appropriate size of the laryngeal mask airway in adults. Br J Anaesth.1998;81:656–657.

[52] Asai T, Murao K, Yukawa H, et al. Re-evaluation of appropriate size of the laryngeal mask airway. Br J Anaesth.1999;83:478–479.

[53] Berry AM, Brimacombe J, McManus KF, et al. An evaluation of the factors influencing selection of the optimal size of laryngeal mask airway in normal adults. Anaesthesia.1998;53:565–570.

[54] Voyagis GS, Batzioulis PC, Secha-Doussaitou P. Selection of the proper size of laryngeal mask airway in adults. Anesth Analg. 1996;83:663–664.

[55] Voyagis GS. Appropriate size of the laryngeal mask airway in adults. Br J Anaesth.1998;81:656.

[56] Brimacombe, JR, Berry AM, Campbell RC, et al. In response. Anesth Analg.1996;83:664.

[57] Brimacombe J, Keller C. Laryngeal mask airway size selection in males and females: ease of insertion, oropharyngeal leak pressure, pharyngeal mucosal pressures and anatomical position. Br J Anaesth. 1999;82:703–707.

[58] Brimacombe J, Berry AM, Campbell RC, et al. Selection of the proper size of laryngeal mask airway in adults. Anesth Analg. 1996;83:664.

[59] Hirai S, Nakamura R, Mackawa N. Alternative formula for laryngeal mask airway size selection. Anesthesiology. 2004;100:460.

[60] Gallart LM, Mases A, Martinez-Perez JA, et al. An alternative method to determine the size of laryngeal mask airway in children. Br J Anaesth.1998;80: A486.

[61] Miller DM. A proposed classification and scoring system for supraglottic sealing airways: a brief review. Anesth Analg. 2004;99(5).

[62] Keller C, Brimacombe JR, Keller K, et al. Comparison of four methods for assessing airway sealing pressure with the laryngeal mask airway in adult patients. Br J Anaesth.1999; 82: 286–7.

[63] Joseph R. Brimacombe, Laryngeal Mask Airway: Principles and Practice, Second Edition (2005), pp. 23–26.

[64] van Zundert A, Brimacombe J. The LMA Supreme-a pilot study. Anaesthesia.2008;63:209–10.

[65] Hosten T, Gurkan Y, Ozdamar D, Tekin M, Toker K, Solak M. A new supraglottic airway device: LMA-Supreme™, comparison with LMA-Proseal™. Acta Anaesthesiol Scand.2009;53:852–7.

[66] Cook TM, Gatward JJ, Handel J, Hardy R, Thompson C, Srivastava R, et al. Evaluation of the LMA Supreme™ in 100 non-paralysed patients. Anaesthesia.2009;64:555–62.

[67] C. Verghese, B. Ramaswamy, LMA-SupremeTM—a new single-use LMATM with gastric access: a report on its clinical efficacy. BJA.2008; 101(3):405–410.

[68] Andrew JW Fletcher, Ramai Santhirapala, Peter J. Young, Introducing the LMA Supreme into clinical practice: use by experienced and inexperienced LMA users. BJA.2008; 101: eLetters Supplement.

[69] Länkimäki, Sami et al. "Feasibility of LMA Supreme for airway management in unconscious patients by ALS paramedics." Scandinavian journal of trauma, resuscitation and emergency medicine. 2015; 23 24. 26.

[70] Wong DT, Yang JJ, Jagannathan N. Brief review: The LMA Supreme™ supraglottic airway. Can J Anaesth. 2012;59(5):483–493.

[71] Changhong Miao, Meilin Weng, A novel way to choose the size of Laryngeal Mask Airway Supreme in adults, BJA.2015; 115, eLetters Supplement.

[72] Pajiyar AK, Wen Z, Wang H, Ma L, Miao L, Wang G. Comparisons of clinical performance of Guardian laryngeal mask with laryngeal mask airway ProSeal. BMC Anesthesiol. 2015 1;15:69.

[73] Tiefenthaler W, Eschertzhuber S, Brimacombe J, Fricke E, Keller C,

Kaufmann M. A randomised, non-crossover study of the GuardianCPV laryngeal Mask versus the LMA Supreme in paralysed, anaesthetised female patients. Anaesthesia. 2013;68 (6):600–4.

[74] LMA-Protector Instructions for use, Athlone, Ireland, Teleflex Medical, 2015.

[75] Chang, J., Kim, H., Lee, J. et al. A prospective, randomized comparison of the LMA-protector™ and i-gel™ in paralyzed, anesthetized patients. BMC Anesthesiol. 2019; 19: 118.

[76] Sng, B.L., Ithnin, F.B., Mathur, D. et al. A preliminary assessment of the LMA protector™ in non-paralysed patients. BMC Anesthesiol. 2017; 17: 26.

[77] AMBU (DK). AuraGain™ Disposable Laryngeal Mask [Internet]. Baltorpbakken (DK): ABMU A/S; Nov 2015[Cited 2016 Dec 19] Available from: http://www.ambu.com/corp/products/anaesthesia/product/auragain% E2% 84%A2_disposable_laryngeal_mask-prod18315.aspx

[78] Lopez AM, Agusti M, Gambus P, Pons M, Anglada T, Valero R. A randomized comparison of the Ambu AuraGain versus the LMA supreme in patients undergoing gynaecologic laparoscopic surgery. J Clin Monit Comput. 2017;31(6):1255–62.

[79] Shariffuddin II, Teoh WH, Tang E, Hashim N, Loh PS. Ambu® AuraGain™ versus LMA Supreme™ Second Seal™: a randomised controlled trial comparing oropharyngeal leak pressures and gastric drain functionality in spontaneously breathing patients. Anaesth Intensive Care. 2017;45(2):244–50.

[80] Singh K, Gurha P. Comparative evaluation of Ambu AuraGain™ with ProSeal™ laryngeal mask airway in patients undergoing laparoscopic cholecystectomy. Indian J Anaesth. 2017;61:469–74.

[81] Richez B, Saltel L, Banchereau F, Torrielli, Cros AM: A new single use supraglottic airway with a noninflatable cuff and an esophageal vent: An observational study of the i-gel: Anesth Analg. 2008 Apr;106(4):1137–9.

[82] I-gel user guide, Berkshire, uk, Intersurgical Ltd, 2020.

[83] Gabbott DA, Beringer R: The i-gel supraglottic airway: A potential role for resuscitation? Resuscitation. 2007 Apr; 73(1):161–2.

[84] Soar J: The i-gel supraglottic airway and resuscitation - some initial thoughts: Resuscitation. 2007 Jul;74(1):197.

[85] Das B, Mitra S, Jamil SN, Varshney RK. Comparison of three supraglottic devices in anesthetised paralyzed children undergoing elective surgery. Saudi J Anaesth 2012;6: 224–8.

[86] Mercer MH, Gabbott DA. Insertion of the Combitube airway with the cervical spine immobilised in a rigid cervical collar. Anaesthesia. 1998;53: 971–4.

[87] Calkins MD, Robinson TD. Combat trauma airway management: Endotracheal intubation versus laryngeal mask airway versus combitube use by Navy SEAL and Reconnaissance combat corpsmen. J Trauma. 1999;46:927–32.

[88] Frass M, Frenzer R, Rauscha F, Schuster E, Glogar D. Ventilation with the esophageal tracheal combitube in cardiopulmonary resuscitation. Promptness and effectiveness. Chest. 1988 Apr;93(4):781–4.

[89] Frass M, Frenzer R, Rauscha F, Weber H, Pacher R, Leithner C. Evaluation of esophageal tracheal combitube in cardiopulmonary resuscitation. Crit Care Med. 1987;15(6): 609–11.

[90] Wagner A, Roeggla M, Roeggla G, Weiss K, Marosi C, Locker GJ, Knapp S, Staudinger T, Metnitz PG, Frass M. Emergency intubation with the combitube in a case of severe facial burn. Am J Emerg Med. 1995;13(6):681–3.

[91] Staudinger T, Tesinsky P, Klappacher G, Brugger S, Rintelen C, Locker G, Weiss K, Frass M. Emergency intubation with the Combitube in two cases of difficult airway management. Eur J Anaesthesiol. 1995;12(2):189–93.

[92] Eichinger S, Schreiber W, Heinz T, Kier P, Dufek V, Goldin M, Leithner C, Frass M. Airway management in a case of neck impalement: use of the oesophageal tracheal combitube airway. Br J Anaesth. 1992;68(5):534–5.

[93] Jokela, Jorma & Nurmi, Jouni & Genzwürker, Harald & Castrén, Maaret. Laryngeal tube and intubating laryngeal mask insertion in a manikin by first-responder trainees after a short video-clip demonstration. Prehospital Disast Med. 2009; 24: 63–6.

[94] Mihai R, Knottenbelt G, Cook TM. Evaluation of the revised laryngeal tube suction: the laryngeal tube suction II in 100 patients. Br J Anaesth.2007;99:734–9.

[95] Genzwuerker HV, Altmayer S, Hinkelbein J, Gernoth C, Viergutz T, Ocker H. Prospective randomized comparison of the new Laryngeal Tube Suction LTS II and the LMA-ProSeal for elective surgical interventions. Acta Anaesthesiol Scand. 2007;51:1373–7.

[96] Gaitini LA, Vaida SJ, Somri M, Yanovski B, Ben-David B, Hagberg CA. A randomized controlled trial comparing the ProSeal Laryngeal Mask Airway with the Laryngeal Tube Suction in mechanically ventilated patients. Anesthesiology. 2004;101:316–20.

[97] Baska K, Baska M. Baska Mask. The new generation supraglottic airway with high volume suction clearance. Available on http://www.baskamask.com.au/main/page_about_the_mask.html [Accessed 30 July 2020].

[98] van Zundert T, Gatt S. The Baska Mask – A new concept in self-sealing membrane cuff extraglottic airway devices using a sump and two gastric drains: A critical evaluation. J Obstet Anaesth Crit Care.2012;2:23–30.

[99] Sachidananda R, Shaikh SI, Mitragotri MV, Joshi V, Ladhad DA, Mallappa M, Bhat VK. Comparison between the Baska Mask® and I-Gel for Minor Surgical Procedures Under General Anaesthesia. Turk J Anaesthesiol Reanim. 2019 Feb;47(1): 24–30.

[100] The Air- Q® Intubating Laryngeal Airway (ILA™, Cookgas® LLC, Mercury Medical, Clearwater, FL, USA): Information for Use [Package insert]

[101] Tran A, Thiruvenkatarajan V, Wahba M et al. LMA® Gastro™ Airway for endoscopic retrograde cholangiopancreatography: a retrospective observational analysis. BMC Anesthesiol. 2020;20: 113.