Supraglottic airway devices: current and future uses

ABSTRACT

Supraglottic airway devices have increasingly been used in anaesthesia since their invention in 1982. Now over half of general anaesthetic cases in the UK use them, and they have vital roles in difficult airway algorithms, pre-hospital use and emergency medicine. This article presents the current evidence regarding the complications of these devices, and compares these devices and endotracheal intubation. The technology of the newer generation devices has improved the safety profile, and they may be considered a better choice than endotracheal tubes in some cases. There may be a case for using these devices in a wider range of surgical and non-surgical cases.

The classic laryngeal mask airway was invented by Dr Archie Brain in the UK in 1982. Engineered to form a seal around and behind the glottis, it maintained a patent airway during anaesthesia and was an immediate success as it filled the void between securing the airway with an endotracheal tube and using face-mask ventilation. Since then, there has been strong investment in research and development of airway devices. In 2015, the global airway management device market was over US $1 billion, and the supraglottic airway proportion of this is anticipated to continue to flourish with exponential growth rates predicted up to 2025 (Grand View Research, 2017).

This dramatic increase is not only a result of the uptake of supraglottic airways in surgical lists, but also a result of their inclusion in algorithms used in the management of the difficult airway, as well as those for pre-hospital and emergency medicine. Their use is so widespread in anaesthesia that the 4th National Audit Project (NAP4) identified that out of 2.9 million general anaesthetics administered in the NHS each year, 56% were carried out using supraglottic airways to manage the airway, 38% with an endotracheal tube and 5% with a face mask (Cook et al, 2011).

The generations of supraglottic airway devices

The first generation supraglottic airways (e.g. the classic laryngeal mask airway) had several limitations, notably providing only a moderate pharyngeal seal (less than ~20 cmH_2O) that may be associated with regurgitation and pulmonary aspiration. The design of second generation supraglottic airways allows for greater pharyngeal seal pressures (around 28 cmH_2O) with an inflatable cuff or thermoplastic elastomer component, and they contain a separate oesophageal port which allows for the draining or aspiration of gastric contents (Cook et al, 2005; Beleña et al, 2015). Two commonly available second-generation supraglottic airways in the UK are the Laryngeal Mask Airway Supreme (Teleflex) and the i-gel by Intersurgical (*Figure 1*). The tip of the i-gel is narrower, and makes a seal lower down the oesophagus, a deliberate design feature which has been demonstrated to decrease the risk of dysphagia compared with laryngeal mask airways (de Montblanc et al, 2014; Beleña et al, 2015).

Complications of supraglottic airways

These airway devices are not without their complications. Of the 33 adverse events identified by the NAP4, contributing factors included obesity, comorbidities, traumatic insertion, inappropriate use of the devices, inadequate training or experience, non-standard patient positioning, and shallow depth of anaesthesia (Cook et al, 2011). This highlights that a fundamental level of training and skill are required for the insertion of supraglottic airway devices, and for maintenance of anaesthesia during their use.

Complications in the use of supraglottic airways include:

- Aspiration
- Trauma of the airway: from the lips to laryngeal apparatus
- Compression of the surrounding nerves, including:
  - Recurrent laryngeal nerve in the piriform fossa
  - Lingual nerve
  - Hypoglossal nerve
  - Mental nerve
  - Mucosal bruising from prolonged insertion or too high cuff pressures where pressure exerted by the cuff exceeds mucosal perfusion pressures
  - Loss of the airway on insertion, failed insertion or displaced device.

Some of these complications relate to the pressure exerted by the device on surrounding tissues, a factor that relates to the insertion technique, size of device inserted, pressure in the inflatable cuff, and also the length of time the device remains in situ. Certainly, there have been case reports of trauma and neuropraxia with the use of second generation devices (Oliveira et al, 2012; Jenkinson et al, 2014).

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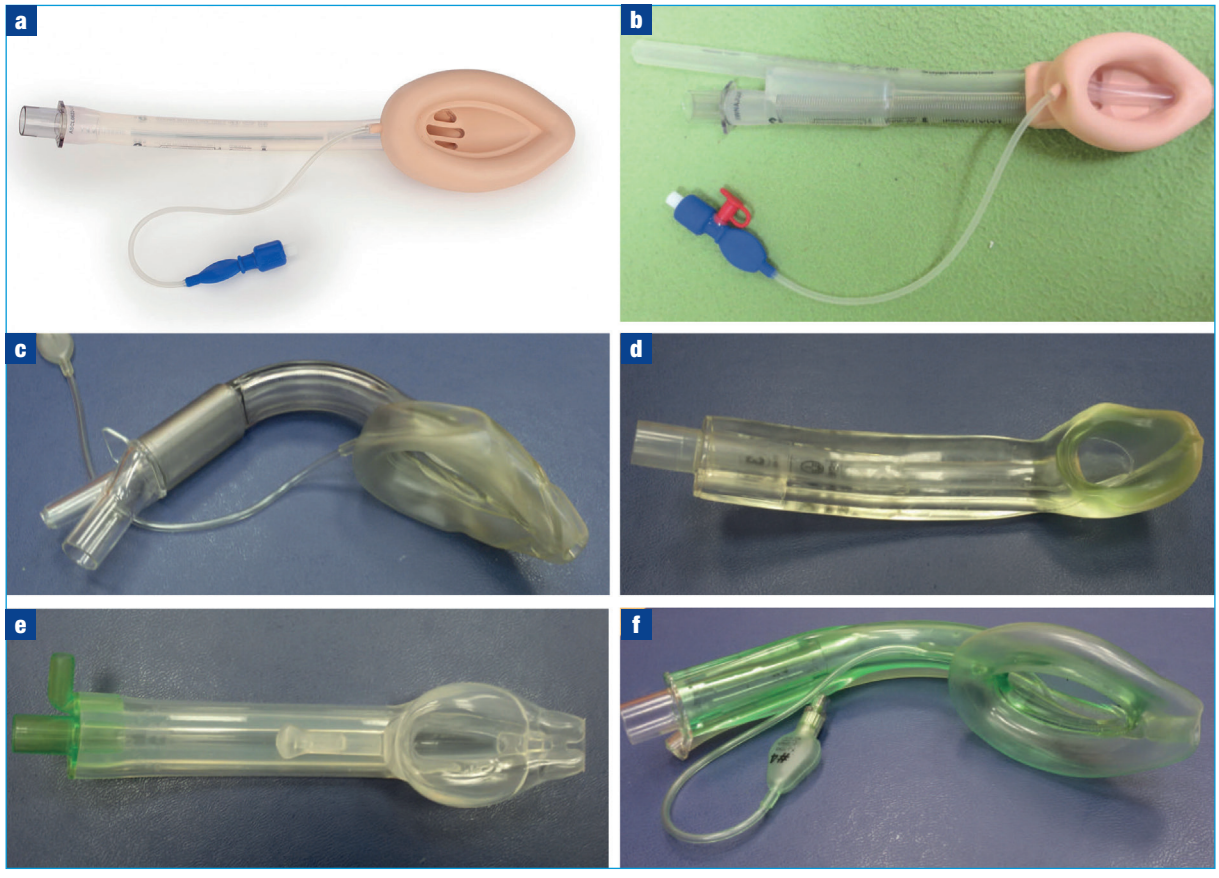

Figure 1. a. The classic laryngeal mask airway. Second generation devices **(b)** ProSeal laryngeal mask airway, **(c)** Supreme laryngeal mask airway, **(d)** i-gel, **(e)** Baska mask **(f)** AuraGain laryngeal mask. From Michalek et al (2015).

Before the development of second generation supraglottic airways, Brimacombe and Berry (1995) reported the overall incidence of aspiration as 0.02% based on a meta-analysis of 12 901 patients. A single centre retrospective analysis of 65 712 procedures corroborated this risk of aspiration, and they demonstrated no increased incidence in those managed with positive pressure ventilation with a classic laryngeal mask airway compared with an endotracheal tube. Identified risk factors for aspiration were unplanned surgery and being of male sex (Bernardini and Natalini, 2009). From the NAP4 data, the risk of aspiration increased with unfasted patients, malpositioning of the device or inadequate depth of anaesthesia (Cook et al, 2011). Of note, however, the incidence of perioperative regurgitation in surgical patients is likely to be underreported as a result of delayed or subclinical presentations.

A systemic review of twenty-nine randomized studies identified that endotracheal tubes have a statistically higher incidence in all the following: hoarse voice, laryngospasm during emergence, coughing and sore throat (Yu and Beirne, 2010). There were no differences identified in the risk of regurgitation, aspiration and success of insertion at first attempt. Dental injuries occur less frequently with supraglottic airway insertion than they do with laryngoscopy and insertion of an endotracheal tube (Yasny, 2009). Indeed, identifying significant statistical differences in such rare outcomes between devices is difficult because of the need for large cohorts.

In a randomized study in children undergoing minor surgery, vocal cord oedema and airflow resistance were increased in those whose airway was managed with an endotracheal tube compared with supraglottic airway (Tanaka et al, 2003). Vocal cord and airway oedema are important in all groups, but especially in paediatric patients, prolonged cases and in cases already at risk of increased airway oedema. A quantitative meta-analysis of respiratory complications in children (Luce et al, 2014) demonstrated significantly reduced rates of post-anaesthetic desaturation, laryngospasm, cough and breath-holding in the supraglottic airway group. There were no differences in desaturation, bronchospasm and laryngospasm during induction or aspiration, sore throat or bronchospasm in recovery. Joshi et al (1997) found that 24 hours postoperation, the patients managed with supraglottic airways had significantly less nausea and sore throat compared with those whose airways were managed with an endotracheal tube ($P<0.05$), while they also had shorter times in recovery and time to mobilization.

Looking specifically at the i-gel, a 2-year prospective observational study in Switzerland (Theiler et al, 2012) showed that the duration of use varied from 8 minutes to 6.5 hours ($n=2049$). There were no events of pulmonary aspiration of gastric contents reported over the course of

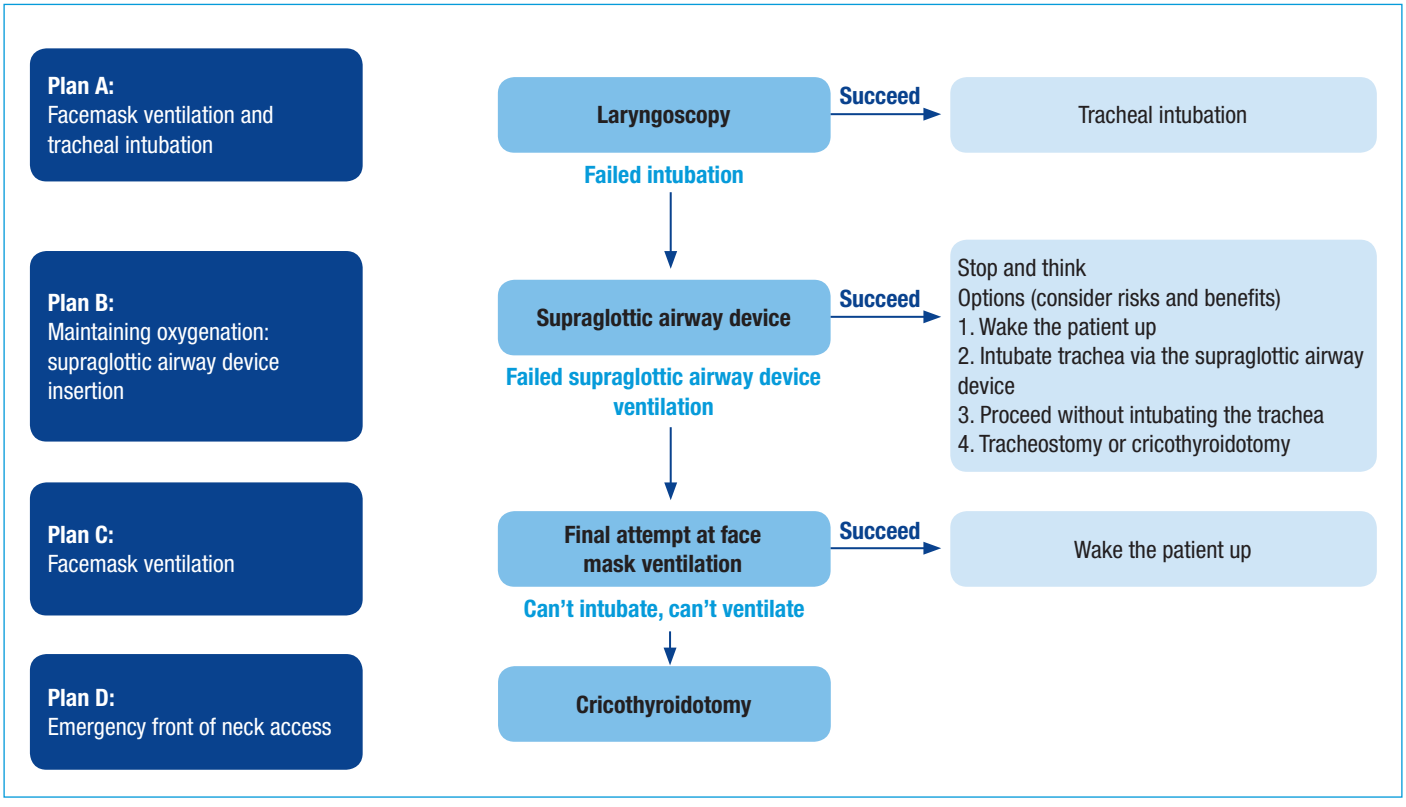

Figure 2. Overview of Difficult Airway Society guidelines for management of unanticipated difficult airway. This flowchart forms part of the Difficult Airway Society guidelines for unanticipated difficult intubation in adults 2015 and should be used in conjunction with the text. From Frerk et al (2015).

this study. Risk factors associated with i-gel failure included being male ($P<0.001$), older age ($P<0.01$), impaired mandibular subluxation ($P=0.01$), and poor dentition ($P=0.02$). Adverse events recorded included blood-stained airway devices (3.9%), laryngeal spasms (1.2%) and transient nerve damage (0.1%).

Duration of use and health economics

As the technology and sophistication of these devices has improved, this has allowed a longer duration of use in patients; first generation devices were initially recommended for 2 hours of continuous use, whereas the manufacturer of the i-gel states that use for up to 4 hours is safe. However, this figure is because of a paucity of data relating to safety beyond this time rather than any specific evidence of harm. Case reports of prolonged use of supraglottic airways have not demonstrated any adverse events; one in an unexpectedly complicated parotid tumour surgery for over 7 hours (Kammah and Añez, 2013), another for 9 hours in a multi-trauma patient (Braude et al, 2010), and a third from a medical patient in intensive care for over 24 hours (Arosio and Conci, 1995). It will be beneficial to further study the safety profile of these devices over longer periods of time, in cases where an endotracheal tube would previously have been used.

From a health economics point of view, it is speculated that there may be a cost benefit in using supraglottic airways rather than endotracheal tubes, by reducing the need for additional use of anaesthetic drugs, anti-emetics, patient complications and reducing time in theatre and recovery. However, the last cost-analyses in the literature were published over 20 years ago (Macario et al, 1995; Joshi et al, 1997) before the introduction of newer, disposable and second generation supraglottic airways. In regards to pre-hospital use, the upcoming AIRWAYS-2 trial will examine the cost effectiveness of the i-gel compared to tracheal intubation in out-of-hospital cardiac arrest.

Previously the risk of gastric regurgitation and pulmonary aspiration were seen as barriers to the use of supraglottic airways. Evidence has demonstrated the relative safety of supraglottic airways even in cases previously reserved for endotracheal intubation such as laparoscopic abdominopelvic surgeries (Badheka et al, 2015), airway (Schieren et al, 2017), thoracic and cardiac surgery (Elgebaly and Eldabaa, 2014; Gonzalez-Rivas et al, 2016), in positions other than supine (including prone) (Olsen et al, 2014), and in obese patients (Nicholson et al, 2013).

Management of the difficult airway

Supraglottic airways are now included in societal and national guidelines on the management of difficult airways. The NAP4 made the recommendation that all hospitals have supraglottic airways available for both routine use and rescue airway management, while highlighting the advantages of second-generation devices. The UK Difficult Airway Society guideline (*Figure 2*) recommends that after failed intubation attempts (plan A), the goal is to maintain

KEY POINTS

- Supraglottic airway devices are used to manage the airway in over half of the general anaesthetic cases in the UK.
- The second-generation devices have a better safety profile than earlier models without a gastric port. Common adverse events in the use of supraglottic devices include sore throat and minor trauma to the airway.
- Aspiration of gastric contents, a potentially lethal event, occurs rarely (incidence less than 0.025). This incidence is comparable to maintenance of anaesthesia with a face mask or endotracheal intubation, and second generation devices have a lower incidence of aspiration than first generation devices.
- Studies have demonstrated superiority in patient satisfaction and some outcomes of supraglottic devices compared with endotracheal intubation.
- There may be reluctance to use these devices for cases exceeding 4 hours. Further studies are needed to determine the safety profile beyond this, and if there is a cost benefit in using these devices in a greater breadth of cases.

oxygenation using a supraglottic airway (plan B) (Frerk et al, 2015). If effective oxygenation has not been established after three attempts with a supraglottic airway, a plan C should be implemented. The benefits of supraglottic airways in the management in difficult airways include ease of insertion with decreased trauma to the airway, availability in a variety of styles and sizes, high success rate on first attempt, and that they allow for the ability to oxygenate while also being used as a conduit for airway intubation (for example with a fibreoptic bronchoscope).

Use in the pre-hospital setting

The role of the supraglottic airway has extended beyond anaesthetists and from the operating theatre to use in the pre-hospital setting, for example in out-of-hospital cardiac arrest. In the field, endotracheal intubation by inexperienced providers is associated with high failure rate and higher mortality, and should only be attempted by trained personnel. The benefits of using supraglottic airway over endotracheal tube in out-of-hospital cardiac arrests include improved rate and speed of successful insertion with less training required for the technique, reduced trauma and potential failure, and importantly improved continuity of cardiopulmonary resuscitation chest compression (Gatward et al, 2008; Mohr et al, 2013; Duckett et al, 2014).

Indeed, the UK Resuscitation Council guidelines have downgraded the emphasis on early tracheal intubation unless performed by highly skilled providers with minimal disruption to chest compressions (Deakin et al, 2015). Furthermore, in the absence of waveform capnography, it may be preferable to use a supraglottic airway when advanced airway management is indicated, and second-generation devices are recommended because of their 'favourable characteristics' (Cook and Kelly, 2015). These recommendations are also highlighted in American, European, and Australian and New Zealand guidelines.

However, the results from a meta-analysis demonstrated reduced return of spontaneous circulation, hospital discharge and neurologically-intact survival in those managed with a supraglottic airway compared with an endotracheal tube (Benoit et al, 2015). Several multi-centre randomized controlled trials comparing airway strategy pre-hospital are ongoing.

Conclusions

The last 35 years has witnessed a phenomenal change in the practice of anaesthesia, critical care medicine and pre-hospital management because of the development of supraglottic airways. The technological sophistication of the newer generation devices has dramatically improved the safety profile, and it is foreseeable that improvements will continue to be seen with the next generation of supraglottic airways in development.

The newer generation of supraglottic airways arguably has a greater safety profile than endotracheal tubes. Yet despite this, there is still reluctance to use these devices in select patient groups. Should these devices be used in a wider range of surgical cases, and should clinicians be more comfortable using them in longer cases? Further studies are needed, but as the technology continues to improve we may see less need for endotracheal intubation in the future, although they retain a primary role for rapid securing of airway in the unfasted patient, use in prolonged surgical cases and need for more prolonged ventilation in intensive care. **BJHM**

Figure 1 *is reprinted, in part, with permission from Michalek et al (2015). Conflict of interest: none.*

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