An Evaluation of the Insertion and Function of a New Supraglottic Airway Device, the King LT™, During Spontaneous Ventilation

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Trials of the King LT™ (LT, King Systems, Noblesville, IN) in controlled ventilation of the lungs have shown that it is an effective supraglottic airway device. We designed this study to evaluate the King LT™ regarding ease of insertion, position within the airway, and anatomic sealing properties during spontaneous ventilation in 50 ASA physical status I–III, Mallampati I–III, adult patients undergoing routine general anesthesia. Anesthesia was induced with up to 2 μg/kg fentanyl and 1.5–2 mg/kg propofol and maintained with 70% N2O/30%O2 and isoflurane. Insertion time, oropharyngeal leak pressures, fiberoptic position, and spirometry and hemodynamic data were recorded. Any complications were noted. Insertion was determined to be easy and a patent airway was achieved in all patients. First, second, and third attempt insertion rates were 86%, 12%, and 2%, respectively. Time to place the King LT™ was <5 s in 90% of cases. Baseline leak pressures were 31 ± 8.8 cm H2O (17–50 cm H2O). Complications included laryngospasm (1) and coughing (3) on extubation. The incidence of sore throat at 1 h and 24 h postoperatively was 22% and 15%, respectively. The King LT™ is a simple and reliable supraglottic airway device for airway management during spontaneous ventilation.

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The King Laryngeal Tube (King LT™; King Systems, Noblesville, IN) is a relatively new supraglottic airway (SGA) for airway management patterned after the Combitube. Similar to the Combitube, it can be inserted blindly or with the aid of a laryngoscope, yet it requires a smaller mouth opening (23 mm) (1) and its S-shape design decreases the likelihood of tracheal intubation (Fig. 1). Since its introduction into clinical practice, several models of the King LT™ have been developed. The model used in this study is an S-shaped transparent silicon tube consisting of a proximal pharyngeal cuff and a distal esophageal cuff which are both high-volume, low-pressure cuffs. Between these cuffs are two oval-shaped ventilation apertures and two secondary lateral ventilatory openings that allow ventilation to pass from the oropharynx into the trachea (Fig. 2). The proximal cuff blocks the oropharynx and nasopharynx, while the distal esophageal cuff blocks the opening of the esophagus. The King LT™ is available for neonates to adults in sizes 0–5.

A number of studies have proven the King LT™ to be effective in mechanical ventilation (1–4). However, few studies have been conducted to examine the effectiveness of the King LT™ during spontaneous ventilation. This study evaluates the nondisposable King LT™ regarding ease of insertion, position within the airway, and anatomic sealing properties during spontaneous ventilation in anesthetized patients scheduled for elective surgery.

Methods

After approval by the IRB and written informed patient consent, 50 ASA I–III, Mallampati I–III, patients scheduled for elective surgery in which tracheal intubation was not deemed necessary were enrolled in this study. Patients were excluded if they presented as Mallampati III–IV, ASA physical status IV–V, or emergency status. Furthermore, patients were excluded if...
they met one of the contraindication criteria in using an laryngeal mask airway (LMA), including: 1) obesity, 2) pregnancy, 3) history of gastric regurgitation, heart burn, ileus or “full stomach,” 4) history of low pulmonary compliance or high pulmonary resistance, 5) known history of difficult intubation or signs suggesting the possibility of difficult intubation, 6) pharyngeal pathology, or 7) upper airway obstruction resulting from laryngeal pathology.

An IV was placed in each patient before transfer to the operating room. Standard routine ASA monitors were placed, and baseline measurements of arterial blood pressure, heart rate, oxygen saturation, and CO₂ were recorded. Vital signs were then recorded every minute from the time of induction of anesthesia until 5 min after induction and then at 5-min intervals thereafter for 15 min. After administration of oxygen (4 L O₂ for 3 min), anesthesia was induced with up to 2 μg/kg fentanyl and 1.5–2 mg/kg propofol and maintained with 70% N₂O/30% O₂. An appropriately sized King LT™ (a size 4 was used for patients 5–6 ft and a size 5 was used for patients >6 ft in height) was inserted by resident anesthesiologists with no prior King LT™ experience 1 min after completion of anesthetic induction and loss of eyelash reflex. With the patient’s head in the neutral position, each device was placed into the oropharynx and passed into the hypopharynx until distinct resistance was felt or the tube could advance no further.

The number of attempts required to insert the King LT™ was recorded. Insertion time (time from picking up the King LT™ until placement in the oropharynx was completed) and ease of insertion were also recorded. Both King LT™ cuffs were simultaneously inflated and cuff pressures were measured by using the manometer connected to the pilot tube of the pharyngeal cuff and were measured at 10-min intervals (Cuff Pressure Gauge; King Systems, Noblesville, IN), beginning after the introduction of the King LT™, for the first 30 min of anesthesia and then every 30 min thereafter. Pressures were maintained at 60 cm H₂O until just before device removal. Each device was taped securely in similar fashion to that of a LMA, with indirect position maintained. The depth of insertion was recorded and auscultation was made over the epigastrium to determine if there was any evidence of gastric insufflation.

An LF II Olympus fiberoptic bronchoscope (Olympus, Orangeburg, NJ) was then passed through a
bronchoscopic adapter (Bodai Suction Safe™ Swively, Phase II Medical Manufacturing, Inc., Rollinsford, NH) attached to the King LT™ to visualize all 4 ventilatory orifices and their relation to the laryngeal inlet. The airway view was recorded as visualized from the distal orifice as 1 = full vocal cords, 2 = posterior arytenoids, 3 = epiglottis, and 4 = no glottis/epiglottis.

Airway leak pressures were then determined by listening for the first sign of a leak over the mouth while closing the pop-off valve and ventilating the patient’s lungs against an outlet valve pressure of 15 mm Hg (5) while adjusting the fresh gas to 6 L/min. Assisted ventilation was performed until patients began spontaneous ventilation. If ventilation occurred easily with auscultation of bilateral breath sounds, the position of the device was considered good and its use satisfactory. If placement of the device was considered unsatisfactory (poor ventilation, inadequate chest excursion, leak pressure <15 cm H₂O), the King LT™ was removed and the patient’s lungs were ventilated by facemask. The King LT™ could be reinserted up to 3 times maximum. Measurements of ventilation, oxygen saturation, end-expiratory carbon dioxide, expiratory tidal volume, and peak airway pressure were recorded at both 2 and 10 min.

At the conclusion of surgery, anesthetics were discontinued and the King LT™ was removed when the patient was awake and protective airway reflexes returned. After its removal, the King LT™ was examined carefully for any evidence of blood or signs of regurgitation. All patients were interviewed at 2 h and 24 h postoperatively for the presence or absence of sore throat, dysphonia, and dysphagia.

Results

Patient demographics and types of surgery are displayed in Table 1 and Table 2, respectively. A size 4 or 5 King LT™ was used in 66% and 34% of patients, respectively. Both spontaneous ventilation and a patent airway were successfully achieved in all patients. Insertion was determined to be easy, with a physical placement time of <5 s in 98% of the cases and a placement time of 5–15 s in the remaining 2% of cases. Repositioning of the King LT™ was required in 9 (18%) patients. Placement attempts were as follows: 1 = 86%, 2 = 12%, and 3 = 2%.

The mean volume of air placed in the cuffs to attain an intracuff pressure of 60 cm H₂O was 73.5 ± 5.23 mL for the size 4 and 81.5 ± 4.24 mL for the size 5 King LT™. The minimum mean airway pressure at which gas leaked around the cuff of the device was 31 ± 8.8 cm H₂O (9–50 cm H₂O). Mean expiratory tidal volumes were 253 ± 85.2 mL (100–480 mL). Adequacy of ventilation through the King LT™ was either excellent or good in most (94%) cases (Table 3). Gastric insufflation was not detected by epigastric auscultation in any patient. The median fiberoptic view was 2 (posterior arytenoids) in the distal ventilation aperture and 3 (epiglottis) in the proximal ventilation aperture. Hemodynamic stability was maintained in all subjects.

The average duration of surgery was 82.5 ± 52.11 min (10–260 min). Intraoperatively, there were only single episodes (2%) of bucking, obstruction, and laryngospasm. Extubation events included visualization of blood on the device in 1 patient (2%), 1 episode of laryngospasm (2%), and 3 subjects (6%) experienced coughing. No signs of regurgitation were detected. The incidence of sore throat at 1 h and 24 h postoperatively was 22% and 15%, respectively. Furthermore, one patient experienced mild dysphagia and another mild dysphonia at the aforementioned postoperative periods.

Discussion

The results of this study demonstrate that the King LT™ is a reliable device for airway management during elective surgery with spontaneous ventilation. As previously mentioned, numerous studies have been performed that demonstrate its adequacy for controlled ventilation. There is sparse data regarding the adequacy of the King LT™ for spontaneous ventilation but some studies, most notably Miller et al. (6), determined that the King LT™ was unsatisfactory for this type of ventilation. Miller et al.’s findings were based on a frequent failure rate (7 of 17 patients) secondary to loss of airway control during surgery. It was inferred that “loss of airway control” was synonymous with obstruction.

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**Table 1. Demographic Data**

<table>
<thead>
<tr>
<th>Category</th>
<th>Range</th>
<th>Mean ± sd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>16–80 yrs.</td>
<td>43 ± 15.0 yrs.</td>
</tr>
<tr>
<td>Sex</td>
<td>29 Male : 21 Female</td>
<td></td>
</tr>
<tr>
<td>ASA physical status</td>
<td>I–III</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>45–113 kg</td>
<td>76 ± 15.6 kg</td>
</tr>
<tr>
<td>Height</td>
<td>125–193 cm</td>
<td>169 ± 12.4 cm</td>
</tr>
<tr>
<td>Body mass index</td>
<td>16–52 kg/m²</td>
<td>27 ± 6.5 kg/m²</td>
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**Table 2. Types of Surgery**

<table>
<thead>
<tr>
<th>Category</th>
<th>(n = 50)</th>
</tr>
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<tbody>
<tr>
<td>General</td>
<td>8</td>
</tr>
<tr>
<td>Orthopedic</td>
<td>28</td>
</tr>
<tr>
<td>Gynecological</td>
<td>4</td>
</tr>
<tr>
<td>Vascular</td>
<td>1</td>
</tr>
<tr>
<td>Neurological</td>
<td>2</td>
</tr>
<tr>
<td>Plastic</td>
<td>5</td>
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</table>

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Miller et al. speculated that there were three possible reasons for the frequent failure rate in their study. One reason was operator error; the other two reasons focused on tube design and its possible role in the causation of obstructive events. They reasoned that increases in the distal cuffs’ pressures may cause the King LT™ to be pulled inward, thus causing obstruction of the laryngeal opening. They noted that deflating the cuff seemed to clear the airway, whereas inflating it thereafter increased or reproduced the obstruction. Miller et al. also theorized that it was possible that the epiglottis was responsible for physically obstructing the sole ventilation aperture, thereby contributing to the observed obstructive incidents. This form of obstruction could be more easily overcome by the ventilator during positive pressure ventilation than by spontaneous ventilation.

Miller et al.’s findings were based on a first generation model of the LT manufactured by VBM (Sulz, Germany), which did not feature a second large ventilatory aperture and two lateral ventilatory openings that are now present in the first generation King LT™. Also, this newer model features a newly designed pharyngeal cuff that may be mechanically advantageous. The mean depth of insertion was higher than expected for each size of the King LT™; thus the company now manufacturers this device 1 cm longer and the depth markings have been moved more proximally. This extra length allows the device to be positioned more deeply so that the proximal aperture is in alignment with the glottis, thus facilitating either spontaneous or positive pressure ventilation. The disposable version (LT-D) is currently manufactured 2 cm longer than the original King LT™.

The infrequent incidence of obstruction/loss of airway control (1/50) demonstrated in our study is in stark contrast to Miller et al.’s study. It is inferred that the current features of this version of the King LT™ allow for fewer airway complications during its use. Consistent with our findings is a study of 100 patients mechanically ventilated with the new version of the King LT™, in which Asai et al. (7) noted the absence of obstruction on the return of spontaneous ventilation.

With the concerns of obstruction resolved, the clinical usage of the King LT™ for elective surgical procedures is intriguing for several reasons: 1) easy insertion, 2) frequent first time placement rate, 3) increased protection of the airway from the aspiration of gastric contents, 4) blockage of the esophageal opening, thereby decreasing the risk of gastric insufflation, if positive pressure is desired, and 5) fewer complications related to sore throat, dysphonia, or dysphagia.

Regarding its ease of insertion, our study found the first-time placement rate to be 86% (98% after 2 attempts). This is consistent with the first-time placement success rates of 85%–95% found in previous studies (2,7,8). Yet there are reports of 100% first attempt success rate even with inexperienced users (14). Interestingly, 8%–33% of LMA placements require more than one attempt for proper placement (9). Moreover, other SGAs may require hyperextension of the neck for placement of the device. However, the King LT™’s design allows for placement without such manipulation, further adding to its attractiveness.

The mean airway pressure at which gas leaks around the LMA has been reported to range from 18–20 cm H2O (± 5 cm H2O) (10). The King LT™ provided a good airtight seal in most patients (Table 2), and often there was no gas leak around the cuff at an airway pressure of 25 cm H2O. Our results are comparable to those reported by Asai et al. and others (11–13).

A known disadvantage of the LMA is its inability to protect the airway from the aspiration of gastric contents. Assuming an adequate seal, the distal esophageal cuff provides an invaluable means of airway protection. By blocking the opening of the esophagus, the King LT™ should minimize the risk of aspiration. Our study supports this concept, albeit in a small number of patients, as there were no incidences of regurgitation or aspiration.

Also, while this study focused on use of the King LT™ for spontaneous ventilation, it is foreseeable that clinical application may require transition to assisted ventilation. In these instances, the distal esophageal cuff prevents exposure of the esophagus to positive pressure ventilation, thereby decreasing gastric insufflation and minimizing aspiration risks. Only the LMA-ProSeal can offer such protection. Also, several studies have demonstrated equivalent or higher attainable ventilatory seal pressures during positive pressure ventilation with the King LT™ compared with the LMA (2,6,14), along with fewer incidences of gastric insufflation (15). Therefore, although our study demonstrates that the King LT™ is effective for spontaneous ventilation, positive pressure ventilation may also be used, if desired or necessary.

Finally, we determined the incidence of adverse perioperative events to be comparative, if not favorable, to rates involving the usage of other SGAs. In

### Table 3. Adequacy of Ventilation Through the King LT™

<table>
<thead>
<tr>
<th>Category</th>
<th>Airway pressure at which gas leak occurred</th>
<th>n (%)</th>
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</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>No gas leak at ≥30 cm H2O</td>
<td>31 (63%)</td>
</tr>
<tr>
<td>Good</td>
<td>19–30 cm H2O</td>
<td>15 (31%)</td>
</tr>
<tr>
<td>Fair</td>
<td>11–18 cm H2O</td>
<td>2 (4%)</td>
</tr>
<tr>
<td>Poor</td>
<td>≤10 cm H2O</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>Failure</td>
<td>Failed insertion or failed ventilation</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>
previous studies, concern of obstructive events and loss of airway control precluded the use of King LT™s in spontaneous ventilation (6). However, as addressed earlier, these results were not duplicated in our study, possibly because of the new design. Although there was 1 case in which airway trauma (2%) occurred, the incidence of sore throat at 2 hours and 24 hours (22% and 15%, respectively) were more frequent than that reported in other LT studies, which were as infrequent as 6% (16). On the other hand, the incidence of sore throat for the LMA and Combitube are 5.8%–18% (17,18) and 25–45% (19,20), respectively.

There are several limitations of this study. First, this is not a comparative trial to other SGAs, such as the LMA-Unique. This study was simply designed to determine the efficacy of the King LT™ for spontaneous ventilation. Second, resident anesthesiologists with limited experience with either the LMA or the King LT™ were involved in the insertion of the devices. Thus, the results reflect the use of the King LT™ in novice, rather than experienced, hands.

In conclusion, the King LT™ is an effective SGA device for the spontaneous ventilation of patients undergoing elective surgery. Its unique design allows for ease of placement and advancement, minimizes the risk of aspiration, and has acceptable rates of both intraoperative and postoperative complications. Further study is warranted in a large number of patients at higher risk for regurgitation and aspiration.

References