The UpsherScope™ in Routine and Difficult Airway Management: A Randomized, Controlled Clinical Trial

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The UpsherScope™, a rigid fiberoptic laryngoscope, may facilitate tracheal intubation. We performed a randomized, controlled trial of tracheal intubation using the UpsherScope™ and compared the success rate with that of direct laryngoscopy. Three hundred patients were randomly assigned to either fiberoptic oral intubation using the UpsherScope™ (Group US, n = 148) or to direct laryngoscopy (Group DL, n = 152). No significant differences in airway variables were observed between the groups. US intubation was successful in 129 of 148 patients (87%). A second or third attempt was required in 15% and 3%, respectively, of the patients successfully intubated with US. The remaining patients were intubated using DL (n = 17) or the flexible fiberoptic bronchoscope (n = 2). The success rate of DL was significantly higher (97%; P < 0.05), with a second or third attempt required in only seven patients. Time needed to perform successful intubation was 50 ± 41 s for the US group compared with 23 ± 13 s for the DL group (P < 0.05). We found no advantage of the UpsherScope™ over direct laryngoscopy during routine and difficult airway management. Time needed, number of attempts required to perform intubation, and incidence of failure were significantly longer and higher in group US. Implications: We studied tracheal intubation using the fiberoptic UpsherScope™ and compared the success rate with that of a control group of patients intubated using conventional laryngoscopy. No advantages of the new device were found. On the contrary, time needed, number of attempts required, and incidence of failure were even longer and higher.

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The UpsherScope™ (The Upsher Laryngoscope Corporation, Foster City, CA) (1), a C-shaped steel laryngoscope blade with integrated fiberoptics and tube channel, was recently introduced to enable fiberoptic oral intubation in adult patients. This device requires a short time to prepare, does not need an external light source, and enables the endoscopist to "look around the corner." We hypothesized that the UpsherScope™ might be advantageous for the airway management in routine patients, as well as in patients presenting with difficult airways because of small mouth opening, protruding incisors, large tongue, immobile or traumatized cervical spine, or anterior larynx. We considered that this device might be a useful adjunct to the alternative intubation techniques proposed for the management of the "can’t intubate, can ventilate" situation (2).

The objective of this randomized, controlled study trial was to determine the effectiveness, safety, and duration of fiberoptic oral intubation using the UpsherScope™ compared with conventional direct laryngoscopy in routine and difficult airway management.

Methods

After approval by our ethics committee and obtaining informed consent, 300 consecutive patients (ASA I or II) were recruited to the study. Only fasting patients scheduled for elective surgery at the Departments of Maxillofacial Surgery and Neurosurgery were included. Mallampati class and thyromental distance were not exclusion criteria. Patients younger than 18 yr or older than 70 yr, patients with a history of
coronary heart disease, patients with intracranial vascular malformations or bleeding, patients with signs of raised intracranial pressure, and patients who denied consent were excluded.

During the preoperative visit, patients were classified according to the modified Mallampati test (3,4) by asking each patient to maximally protrude the tongue from a fully open mouth while sitting upright. The maneuver was repeated by the same operator to decrease the chance of error. Furthermore, the thyromental distance was measured as described by Tse et al. (5). This distance is described as a straight line from the thyroid notch to the most anterior part of the chin with the head fully extended.

After intravenous (IV) administration of midazolam 0.05 mg/kg, anesthesia was introduced with 2 μg/kg fentanyl and 2 mg/kg propofol. After the assurance of adequate mask ventilation, vecuronium bromide 0.1 mg/kg was given. The onset and duration of relaxation were confirmed using a nerve stimulator (MiniStim MS II; Professional Instruments, Houston, TX). Usual monitoring was used during anesthesia. No antisynergogues were administered to any study patient.

Before induction of anesthesia, patients were randomly assigned to either fiberoptic intubation using the UpsherScope™ (Group US, n = 148) or direct laryngoscopy (Group DL, n = 152) as determined by a coin toss performed by an independent person. In all study patients, fiberoptic oral US intubation, as well as direct laryngoscopy (using a standard Macintosh 3 blade) was performed by laryngoscopists (PF and PK) experienced in both techniques. Each operator had performed approximately 30 US intubations before the study.

In Group US, tracheal intubation was performed using the new UpsherScope™ (Figs. 1 and 2). The UpsherScope™ consists of a C-shaped metal blade of fixed curve, with a light channel and viewing fiber bundle running along the length of the blade. During insertion, the laryngoscope follows the oropharyngeal curve and slides down the back of the tongue until the epiglottis is visualized. Pulling the tongue out of the patient’s mouth often facilitates this procedure. In the next step, the epiglottis is loaded onto the tip of the scope with a scooping motion, as is done during intubation using a Miller blade. As an alternative, insertion of the blade into the vallecula may be tried. When properly placed, elevation of the laryngoscope in an anterior direction elevates the epiglottis and exposes the opening between the vocal cords. The UpsherScope™ is a tube-guiding blade equipped with a tube channel, which is loaded with a 6.5- to 8.5-mm inner diameter endotracheal tube (ETT). After visualizing the vocal cords, the ETT is advanced and guided directly through the glottic opening (Fig. 3). The fiberoptic scope (equipped with a focusing ring on the eyepiece) allows visualization of the entire intubation process; one should never lose sight of the ETT, even as it passes through the vocal cords. The ETT is then disengaged from the channel, and the scope is withdrawn. During the entire procedure, the patient’s
head and neck may be maintained in the neutral position because a sniffing position might be unnecessary for a successful intubation. In our study patients, US intubation was first attempted with the patient’s head and neck in the neutral position. If the first attempt failed, manipulation of patient’s positioning was permitted. Illumination was provided by a standard laryngoscope battery handle (Upsher MkII, Universal™ Handle), which snaps on the scope. Furthermore, the UpsherScope™ allows visualization of the entire intubation procedure on a television screen by using the same snap-on camera often used for surgical procedures; however, this system was not used in our study patients. Because the UpsherScope™ combines the fiberoptic cable and tube-guiding blade in one rugged piece, fiberoptic tracheal intubation can be performed by one person. In all study patients, tracheal intubation was performed by just one laryngoscopist, without helping hands.

To compare patient airways between the groups, the laryngeal structures were inspected and graded according to the scale of Cormack and Lehane (6): Grade I = visualization of the entire laryngeal aperture, Grade II = visualization of just the posterior portion of the laryngeal structures, Grade III = visualization of only the epiglottis, Grade IV = visualization of just the soft palate. In Group US, laryngoscopic evaluation using a standard Macintosh 3 blade was performed by the same anesthesiologist after the performance of US intubation. Although the ETT already in place might have influenced the laryngoscopic grading, this approach was chosen to avoid the formation of excessive secretions and to avoid potential bias by the knowledge of patient’s airway anatomy before US intubation.

In Group DL, tracheal intubation was performed by the same personnel using a standard Macintosh 3 blade with the patient’s head and neck placed in the sniffing position according to Horton et al. (7). During direct laryngoscopy, the patient’s laryngeal structures were inspected and graded according to the Cormack and Lehane scale (6). ETTs with an internal diameter of 7.0 mm were used for female patients, and ETTs with an internal diameter of 8.0 mm were used for male patients in both groups.

After tracheal intubation in either group, correct tracheal placement of the tube was verified by capnography and bilateral chest auscultation. Intubation times for either method were recorded using a stopwatch, beginning at the moment the device was inserted into the oropharynx. As soon as intubation was performed, the breathing circuit was connected to the ETT. Intubation was considered to be successful after the detection of carbon dioxide in the exhaled gas by capnography. The interval between the time of device insertion into the oropharynx and the detection of end-tidal carbon dioxide is referred to as time to intubation. One attempt of intubation was defined as the entire process of US insertion and removal in and out of patients’ pharynx. In the case of three failed attempts with fiberoptic US intubation, the patients were switched to DL, and vice versa. If the alternative study method failed, an esophagotracheal Combitube (8), a laryngeal mask airway (9), and a fiberoptic bronchoscope (10) were always prepared for emergency rescue.

Data were recorded on a data collection sheet and included preoperatively assessed airway parameters, amount of anesthetic drugs used, number of attempts necessary, time to intubation (only successful procedures were used for time analysis), difficulties encountered during intubation, and any damage noticed on lips, denture, pharyngeal, or laryngeal structures. Data were tested for normal distribution and homogeneity of variances by using the Kolmogorov-Smirnov and F-tests. Normally distributed data are presented as mean ± SD; otherwise, the median (upper and lower quartile) data are presented. Differences between the groups were tested for statistical significance by using $\chi^2$ statistics or unpaired t-tests (normal distribution) or by calculating Mann-Whitney U-tests.
Correlations between patients’ height, weight or thyromental-distance, and time needed for intubation were examined by using Spearman’s ranked correlation coefficient. Differences were considered statistically significant if \( P < 0.05 \).

**Results**

Three hundred patients were studied; 148 were in Group US and 152 were in Group DL. Patient characteristics, including age, height, weight, and airway variables, are shown in Table 1. No significant differences were observed between the groups. Intubation for all patients was performed without a decrease in arterial oxygen saturation to less than 92% or without inducing severe hemodynamic instability.

Fiberoptic intubation using the UpsherScope™ was successful in 129 of 148 patients (87%). In this group, a second attempt was required in 19 (15%) patients, and a third attempt was required in 4 patients (3%). The trachea of the remaining 19 patients was intubated by DL \( (n = 17) \) or using the flexible fiberoptic bronchoscope \( (n = 2) \). Reasons for failed intubations were: difficulties in visualizing the epiglottis \( (n = 2) \), inability to pick up or elevate the epiglottis \( (n = 7) \), visualization of the posterior commissure only (resulting in esophageal misplacement of the ETT, \( n = 4 \)), inability to pass the ETT through the glottis \( (n = 2) \), mucous secretions on the fiberoptic scope \( (n = 2) \), minor bleeding interfering with fiberoptic vision \( (n = 1) \), or poor illumination \( (n = 1) \). Maldirectioning of the ETT tip toward the esophagus was fiberoptically observed and corrected in 39 patients (26%). Intubation with the US tip placed within the vallecula was attempted in 56 patients (38%).

The UpsherScope™ could be easily inserted into the pharynx of all patients. To facilitate or improve sliding along the back of the tongue, elevation of the epiglottis, and visualization of the glottic opening, the tongue was extended during the insertion of the device in 18 patients (12%). Bloody secretions because of minor pharyngeal or laryngeal tissue abrasions were observed on the removed US in six patients (4%). No patient suffered from dental damage, major abrasions, or sustained hoarseness.

The mean time necessary to perform a successful US intubation was 50 ± 41 s \( (n = 129) \). Time to successful intubation was 52 ± 43 s for Patients 1–50, 52 ± 43 s for Patients 51–100, and 48 ± 38 s for Patients 101–148 \( (P = \text{not significant [NS]}) \). No significant correlations were observed between the duration of the intubation procedure and patient height, weight, or thyromental distance \( (r^2 = 0.04-0.12, P = \text{NS}) \). Time to successful intubation or until termination of US intubation attempts was significantly longer in Mallampati class III or IV patients compared with class I or II patients \( (68 s [44,199] \text{ vs } 49 s [25,82], P < 0.05) \). Time to intubation or until termination of US attempts was significantly longer for patients presenting with laryngoscopic views III or IV compared with those with views I and II \( (80 s [49,162] \text{ vs } 58 s [25,75], P < 0.05) \).

Direct laryngoscopy was successful in 147 of 152 patients (97%), with a second and third attempt required in 5 (3%) and 2 (1%) patients, respectively. One patient with failed DL could be intubated using the new device. The airways of the remaining 4 patients were secured by using the flexible fiberoptic bronchoscope. Reasons for failed DL were the inability to visualize the glottic opening due to an anterior larynx \( (n = 3) \), a large tongue \( (n = 1) \), and an immobile cervical spine \( (n = 1) \). Minor bloody secretions on the removed blade were observed in 6 patients (4%). No patient suffered from dental damage, major abrasions, or sustained hoarseness.

Mean time needed to perform successful DL tracheal intubation was 23 ± 13 s. Time to successful intubation or until termination of DL attempts was significantly longer for patients presenting with Mallampati classes III and IV \( (45 s [25,86] \text{ vs } 17 s [13,23], P < 0.05) \), laryngoscopic views III and IV \( (63 s [46,180] \text{ vs } 15 s [10,18], P < 0.05) \) compared with classes or views I and II.

The overall success rate of fiberoptic US intubation was significantly lower compared with that of DL \( (87% \text{ vs } 97%, P < 0.05) \). The average time needed to perform intubation was significantly longer for Group US compared with Group DL \( (50 ± 41 s \text{ vs } 23 ± 13 s, P < 0.05) \).

**Discussion**

The main finding of our study was that UpsherScope™ intubation was of no advantage over conventional laryngoscopy. The time to intubation and the

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**Table 1. Patients Characteristics and Airway Variables**

<table>
<thead>
<tr>
<th></th>
<th>Group US</th>
<th>Group DL</th>
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<tbody>
<tr>
<td>No. of patients</td>
<td>148</td>
<td>152</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>49 ± 15</td>
<td>45 ± 13</td>
</tr>
<tr>
<td>Sex (f/m)</td>
<td>63/85</td>
<td>71/81</td>
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<tr>
<td>Height (cm)</td>
<td>172 ± 10</td>
<td>170 ± 9</td>
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<tr>
<td>Weight (kg)</td>
<td>78 ± 16</td>
<td>75 ± 13</td>
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<tr>
<td>Mallampati class</td>
<td>90/47/19/2</td>
<td>85/53/13/1</td>
</tr>
<tr>
<td>(I/II/III/IV)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thyromental distance (mm)</td>
<td>78 ± 11</td>
<td>79 ± 14</td>
</tr>
<tr>
<td>Cormack and Lehane (I/II/III/IV)*</td>
<td>82/52/11/3</td>
<td>88/50/11/3</td>
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</tbody>
</table>

* There were no statistically significant differences between the groups. Group US = fiberoptic oral intubation; Group DL = direct laryngoscopy.

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* Actual patient number per class/grade shown. Mallampati class, thyromental distance, and Cormack and Lehane were graded according to methods in References 3–6.
success rate were significantly longer or lower. Although all patients with failed US intubation could be intubated using DL, only one patient could be intubated using US after conventional laryngoscopy failed.

DL requires the alignment of oral, pharyngeal, and laryngeal axes, which might be difficult in patients with conditions such as anterior larynx or cervical spine pathologies. The UpsherScope™ was designed to circumvent these problems. However, in our hands, the typical problems of DL could not be eliminated by using the UpsherScope™. Our observation of a clear-cut relationship between airway variables and the ease of the US intubation further emphasizes this finding. With other alternatives, such as the Augustine Scope™ (Augustine Medical Inc., Eden Prairie, MN) (11) or light wands (Laerdal Medical, Armork, NY) (12), the ease of tracheal intubation does not seem to be influenced by anatomical variations of the upper airways.

Two reasons might account for the limited usefulness of the USs. First, the blade shape does not match airway anatomy in all patients. The angle of the blade curvature, and especially that of tube channel, is small (approximately 60°), often resulting in a restricted view of the larynx. We recommend an angle of the curvature closer to 90°, like that used in the Bullard™ (Circon, ACMI, Stanford, CT) laryngoscope (13) or Augustine Scope™ (11). Second, the pick-up process of the epiglottis proved difficult. The blade tip is not entirely seen during the intubation procedure and, thus, picking up the epiglottis is a blind maneuver. The shape of the viewing tip of the fiberoptic bundle has to be improved to allow visualization of the blade tip during intubation.

Our results are somewhat different from those reported by Pearce et al. (1), who evaluated the UpsherScope™ in an uncontrolled study of 200 patients. Intubation was successful in 96% of patients but was straightforward and without difficulties in only 44% of patients. The reason for these differing results is not entirely clear. Pearce et al. stressed the importance of administering antisialagogues to all patients. Although we did not use antisialagogues, we do not believe that our lower success rate was directly related to this fact. Heavy secretions interfering with a clear view were only observed in a minority of our patients. Unfortunately, Pearce et al. did not report any data concerning the ease of direct laryngoscopy in their patients. The authors studied only two patients with known difficult airways and excluded those from the analysis. On the contrary, we evaluated patients with routine and difficult airways, which might explain the poorer performance of the UpsherScope™ observed in our trial.

A limitation of our study might be the relatively small sample size. The incidence of patients who are difficult to intubate is within the range of 1%–4% (14). In our study, we observed an incidence of grade III or IV laryngoscopic views of 9%, which is well in accordance with the 10% incidence reported by Lewis et al. (15). We did not observe a clear-cut learning curve, and performance of the new device did not improve over time and with increasing training. We therefore do not feel that the results would be different by studying a larger patient series.

In summary, fiberoptic UpsherScope™ intubation was not advantageous over DL for performing tracheal intubation in patients presenting with routine and difficult airways. The success rate and the time to intubation were lower and longer compared with conventional laryngoscopy. The reasons for this finding seem to be a suboptimally shaped blade and a poor view of the blade tip during the intubation procedure.

References