Airway Scope for Tracheal Intubation in the Lateral Position

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BACKGROUND: Tracheal intubation in the lateral position is difficult because the laryngeal view is compromised during direct laryngoscopy. The Airway Scope facilitates intubation even when laryngeal views are poor with direct laryngoscopy, as they often are in the lateral position. We thus compared the efficacy of the Airway Scope in supine patients with those in the left- and right-lateral positions.

METHODS: Anesthetized adults were randomly assigned to supine, left-lateral, or right-lateral position (n = 43 for each group). Laryngeal views were obtained in the designated position with a Macintosh laryngoscope, and patients’ tracheas were subsequently intubated with the Airway Scope. Specifically, we tested the hypothesis that the time required for intubation in the left- and right-lateral positions is not increased by >10 seconds compared with tracheal intubation in the supine position.

RESULTS: Overall intubation success was 100% in the 2 lateral positions, and 98% in the supine position. Intubation times were similar in the left-lateral (24 [5] seconds, mean [SD]), right-lateral (24 [6] seconds), and supine (22 [7] seconds) positions. The numbers of required intubation attempts were similar in the 2 lateral positions and in the supine and left-lateral positions. However, more intubation attempts were required in the supine position than in the right-lateral position (P = 0.004). The incidences of airway complications were similar in each position; no hypoxia, dental injury, or esophageal intubation was observed. Modified Cormack-Lehane and the percentage of glottic opening scores obtained with the Airway Scope did not differ between the 2 lateral positions, but the modified Cormack-Lehane and percentage of glottic opening scores were superior in the supine position (all P < 0.001) compared with either of the lateral positions.

CONCLUSIONS: Despite worse laryngoscopic views in either lateral position than when patients were supine, intubation with the Airway Scope offered high success rates. Furthermore, intubation time using the Airway Scope in either lateral position was not longer by >10 seconds than in the supine position. The Airway Scope thus seems to be a useful tool when tracheal intubation is required in a laterally positioned patient. (Anesth Analg 2011;112:868–74)

Sudden airway loss during surgery when the patient is in the lateral position is potentially hazardous because tracheal intubation in that position can be difficult.1–3 There are several reports of successful ventilation with the laryngeal mask airway,1,3,4 ventilation and intubation in the lateral position with the intubating laryngeal mask airway (ILMA) with and without the aid of a lightwand,5,6 and intubation with a lightwand.7 However, recently developed videolaryngoscopes have not been formally evaluated for tracheal intubation in laterally positioned patients.

The Airway Scope (Figs. 1 and 2) (Pentax, Tokyo, Japan) is a new videolaryngoscope designed for tracheal intubation. It has a built-in 2.4-in. liquid crystal display that shows an image from a charge-coupled camera attached to its tip and is powered by standard AA-sized batteries. A single-use blade (Intlock) protects the camera unit from oral contamination and accepts tracheal tubes with outside diameters ranging between 8.5 and 11.0 mm and inside diameters between 6.5 and 8.0 mm. The Intlock is designed to be positioned dorsal to the epiglottis and moved slightly anteriorly. Once the glottic opening has been visualized on the display screen, a target signal, which is shown on the display, is aligned with the glottic opening, and the tracheal tube can be passed through the vocal cords.

A major advantage of the Airway Scope is that it allows intubation without alignment of the oral, pharyngeal, and tracheal axes, as is required with direct laryngoscopy. For example, visualization of the larynx is improved by the Airway Scope in patients having Cormack-Lehane grade 3 or 4 views with conventional direct laryngoscopy.8,9 The ability to intubate the trachea without alignment of the entire oral-tracheal axis may facilitate intubation in the lateral position where head and neck positioning can be compromised. Consistent with this theory, Asai10 found a 100% intubation success rate with the Airway Scope in 3 unconventional
patient positions using manikins. We therefore compared the
efficacy of the Airway Scope as an intubation tool in 3 patient
positions: left lateral, right lateral, and supine. Specifically, we
tested the hypothesis that time required for intubation in the
left- and right-lateral positions is not significantly worse
(longer) than in the supine position using a 10-second nonin-
feriority criterion.

METHODS
With approval of the Human Research Committee at Kosei
Hospital, Tokyo, Japan, and written informed consent, we
enrolled 129 patients scheduled for various surgical proce-
dures requiring tracheal intubation. Patients were aged 18
years or older, and were designated as ASA physical status
I, II, or III. Exclusion criteria were an increased risk of
pulmonary aspiration, cervical spine pathology, or antici-
pated airway difficulties (i.e., Mallampati grade 4 or thyro-
mental distance <6 cm).

Protocol
Before induction of general anesthesia, patients’ heads
were elevated by a pillow 7 cm in the supine position.
Anesthesia was induced with patients in the supine posi-
tion with fentanyl 2 μg/kg and propofol 2 mg/kg. Rocu-
ronium 0.6 mg/kg was given for neuromuscular blockade
after confirmation of adequate facemask ventilation, and
anesthesia was maintained with sevoflurane 2% in oxygen.

After complete muscle relaxation was confirmed with a
nerve stimulator, patients were randomly assigned to 1 of 3
intubation positions: left-lateral decubitus, right-lateral
decubitus, or supine. Randomization was based on
computer-generated codes that were maintained in sequen-
tially numbered, sealed opaque envelopes until after induc-
tion of anesthesia.

For patients assigned to the supine position, laryngos-
copy with a #3 Macintosh laryngoscope was performed by
an investigator (KK) without changing the patient’s posi-
tion to evaluate the laryngoscopic view with the patient
positioned in a sniffing position. Subsequently, patients’
tracheas were intubated with the Airway Scope by another
investigator (RK) without changing the patient’s position.
The Airway Scope with a preloaded, curved tracheal tube
(7-mm internal diameter for women and 8 mm for men)
was inserted into the mouth and positioned at the glottic
opening, which was shown at the center of the cross mark
on the scope’s monitor. The tracheal tube was then ad-
vanced into the trachea, and the scope was detached from
the tube and removed from the mouth. Finally, the breath-
ing circuit was connected to the tracheal tube and capnog-
raphy confirmed tracheal intubation.

Patients assigned to one of the other groups were
positioned in the designated left- or right-lateral position.
The head was placed on supporting pillows so that the
sagittal axis of the head and neck was parallel to the
Tabletop and the neck was extended. An assistant stabilized
the patient’s body during Macintosh laryngoscopy and
subsequent intubation with the Airway Scope, but the
patient’s head and neck were not stabilized during these
maneuvers. An investigator (KK) performed laryngos-
copy with a #3 Macintosh laryngoscope to evaluate the
laryngoscopic view, and the patients’ tracheas were
subsequently intubated with the Airway Scope by an-
other investigator (RK).

In each group, tracheal intubation was considered a
failure if not accomplished within 3 attempts. Any single
insertion of the Airway Scope past the patient’s lips was

![Figure 1. Airway Scope with attached Intlock blade and tracheal tube.](image1)

![Figure 2. Intlock blade (disposable part).](image2)
Intubation in the Lateral Position

considered an intubation attempt. If intubation failed, the trachea was intubated with a #3 Macintosh blade after turning the patient supine with the patient’s head elevated 7 cm by a supporting pillow.

The investigator (RK) who performed the Airway Scope intubations had previously performed 100 intubations using the Airway Scope in an optimal intubation condition in the supine position, but none in either lateral position. The investigator (KK) performed 5 laryngoscopies and intubations with the Macintosh laryngoscope in both left- and right-lateral positions before the start of the study.

Measurements
Before randomization, we recorded morphometric characteristics including the Mallampati score, mouth opening (interincisor distance in centimeters), and thyromental distance (with the head extended in upright position, in centimeters).

The following outcomes were recorded by an unblinded observer: (1) overall intubation success rate; (2) number of intubation attempts; (3) intubation time (defined as the time from picking up the Airway Scope to confirmation of tracheal intubation by capnography); (4) frequency of esophageal intubation; (5) mucosal trauma (i.e., blood detected on the device); (6) lip or dental injury; and (7) desaturation (SpO2 <95%).

When >1 intubation attempt was required, time from picking up the Airway Scope for the first intubation attempt until confirmation of successful intubation by capnography was considered to be the total intubation time. Intubation time was defined this way because the clinically significant time is that from the start of the intubation attempt to the time when the airway is secured by a tracheal tube. Intubations were deemed failures after 3 intubation attempts, and were assigned an intubation time equal to 1 second longer than that observed for any patient.

Modified Cormack-Lehane laryngoscopy grade and the percentage of glottic opening (POGO) score were reported when using a #3 Macintosh laryngoscope at each patient’s assigned position. The investigator who performed the Airway Scope intubations (RK) was blinded to the laryngeal view obtained with the Macintosh laryngoscope by investigator KK. Finally, reasons for any failed intubation attempt or overall unsuccessful intubation were also recorded.

Data Analysis
The randomized groups (i.e., left-lateral, right-lateral, and supine positions) were descriptively compared for demographics and baseline airway assessments using summary statistics, such as mean and SD, median and quartiles, or frequency, respectively, for symmetric continuous variables, skewed continuous variables, and categorical variables. The skewness of each continuous variable was visually assessed by histogram. Analysis was intent to treat.

Primary Analyses
We assessed noninferiority of intubation using the Airway Scope in each of the lateral positions to intubation in the supine position (2 comparisons) on time required for intubation regardless of the number of attempts. We claimed noninferiority if the upper limit of the 95% (2-sided) confidence interval for the difference in medians (lateral – supine) was lower than the a priori noninferiority criterion of 10 seconds. The nonparametric analysis (i.e., median differences) allowed us to assign the largest rank to the 1 patient in the supine group who had failed intubation. The 10-second noninferiority δ was chosen to be 50% of the 20-second difference thought to be the minimally clinically significant time for superiority.

We used a significance level of 0.025 (i.e., 0.05/2) for each comparison (Bonferroni adjustment), which corresponds to a 97.5% 1-sided (corresponding to a 95% 2-sided) confidence interval.

Secondary Analyses
We assessed equivalent effectiveness between left- and right-lateral positions on time to intubation. Our alternative hypothesis was that the true difference in the intubation time lies within the equivalency region of −10 to +10 seconds. We therefore claimed equivalence if the 90% (5% on each side) confidence interval for the difference lay entirely within the a priori equivalency region.

We compared the 3 intubation positions on secondary outcomes as follows: non-normally distributed outcome (i.e., POGO scores) and ordinal secondary outcomes (including modified Cormack-Lehane scores and number of intubation attempts) were compared using the Kruskal-Wallis test. Finally, overall intubation success rate, incidence of lip injury, and incidence of mucosal trauma were assessed using the Fisher exact test. In the presence of a significant overall test result among the 3 intubation positions for any of the secondary outcomes, we further performed pairwise comparisons. Bonferroni correction was used to adjust for multiple comparison; the significance criterion was \( P < 0.017 \) (i.e., 0.05/3) for each comparison.

SAS software version 9.2.2 for Windows (SAS Institute, Cary, NC) was used for all statistical analyses. Values were expressed as mean (SD) unless otherwise specified.

Sample Size Considerations
The standard deviation of intubation time using the Airway Scope in the supine position was 15 seconds in a preliminary study (unpublished data). Assuming the standard deviations of intubation times for both right- and left-lateral positions would also be 15 seconds, 42 patients in each group would achieve 85% power to reject the null hypothesis that intubation using Airway Scope in the supine position is shorter than left- and right-lateral positions by at least 10 seconds, and thus claim noninferiority of left- and right-lateral positions to supine position, each using a significance criterion of 0.025 (Bonferroni correction, i.e., 0.05/2). We therefore recruited 43 patients in each of the 3 study groups. SAS power procedure, specifically, “twosampelemeans” statement for a 1-sided pooled t test on the mean difference and noninferiority difference of 10 seconds, was used for sample size calculation.

RESULTS
Demographics and baseline airway assessments among patients who were randomly assigned to left-lateral, right-lateral, or supine position with the Airway Scope were
The mean of the intubation time for the right-lateral position was estimated as 0.5 (90% confidence interval: −1.5, 2.5) seconds longer as compared with the left-lateral position; the interval was entirely within the equivalency region (−10 to +10 seconds).

Table 2 shows the overall assessments of the intubation measures among the 3 positions. Overall intubation success rates were 100% for both lateral groups, and 98% for the supine position group (P > 0.99; Fisher exact test). However, the number of first, second, and third attempts at intubation for the supine group was different as compared with the right-lateral group (P = 0.004; Wilcoxon test). The number of intubation attempts was not different between the 2 lateral positions, nor between the supine position and the left-lateral position (P = 0.35 and P = 0.04, respectively, using Wilcoxon tests, as both values exceeded the Bonferroni-corrected significance level of 0.017). All failed attempts at intubation were attributed to the inability to position the introducer blade tip posterior to the epiglottis and consequently advance the blade into the vallecula.

Laryngoscopic views by Macintosh laryngoscopy, graded according to the modified Cormack-Lehane and POGO scoring systems, were not different between the 2 groups in the lateral positions (P = 0.37 and P = 0.68, respectively; Wilcoxon test). However, the modified Cormack-Lehane score by Macintosh laryngoscopy was better in the supine-position group than in the 2 lateral positions (both P < 0.001; Wilcoxon test). Glottic structures were not visible by Macintosh laryngoscopy (i.e., modified Cormack-Lehane grade 3a or higher) in 2 patients in the supine position, compared with 7 and 12 patients in the left- and right-lateral positions, respectively. POGO score by Macintosh laryngoscopy was also worse in the 2 lateral-position groups (both median of 20%) compared with the supine group (median of 70%) (both P values < 0.0001; Wilcoxon test).

Intubation complications are listed in Table 3. No significant differences were observed in the occurrence of any of the listed complications. Lip injury occurred in 3, 2, and 4 patients in the left-lateral, right-lateral, and the supine positions, respectively (P = 0.46; Fisher exact test). Furthermore, mucosal trauma occurred in 3 patients in the right-lateral position and 2 patients in the supine position; no trauma was observed in the left-lateral group (P = 0.37; Fisher exact test). Desaturation (Spo2 <95%), dental injury, and esophageal intubation were not observed in any patients.

After 3 unsuccessful attempts, intubation was considered a failure. This occurred in a single patient who was assigned to supine intubation. This patient had a modified Cormack-Lehane grade 2a view and a POGO score of 70%, and was subsequently intubated with direct laryngoscopy using a size 3 Macintosh blade without difficulty.

**DISCUSSION**

We compared tracheal intubation with the Airway Scope in patients placed in left-lateral, right-lateral, and supine positions. Overall intubation success rates were similar in each

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**Table 1. Demographics and Airway Assessment Data**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Left lateral (n = 43)</th>
<th>Right lateral (n = 43)</th>
<th>Supine (n = 43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>54 (16)</td>
<td>58 (17)</td>
<td>62 (18)</td>
</tr>
<tr>
<td>Sex (female/male) (n)</td>
<td>35/8</td>
<td>24/19</td>
<td>28/15</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>157 (7)</td>
<td>159 (7)</td>
<td>157 (9)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>54 (8)</td>
<td>57 (11)</td>
<td>57 (11)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>21.7 (2.9)</td>
<td>22.3 (3.0)</td>
<td>23.0 (3.8)</td>
</tr>
<tr>
<td>Dentition (partial/full/edentulous) (n)</td>
<td>12/29/2</td>
<td>11/29/3</td>
<td>14/25/4</td>
</tr>
<tr>
<td>Mallampati score (1/2/3/4) (n)</td>
<td>21/14/8/0</td>
<td>23/14/6/0</td>
<td>20/13/10/0</td>
</tr>
<tr>
<td>Mouth opening (cm)</td>
<td>4.8 (0.6)</td>
<td>4.7 (0.6)</td>
<td>4.9 (0.6)</td>
</tr>
<tr>
<td>Thyromental distance (cm)</td>
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<td>8.1 (1.0)</td>
<td>7.7 (0.8)</td>
</tr>
<tr>
<td>Sternomental distance (cm)</td>
<td>17.1 (1.6)</td>
<td>17.0 (1.2)</td>
<td>16.4 (1.5)</td>
</tr>
</tbody>
</table>

Data presented as mean (SD) or numbers of patients.
position: 100% in the 2 lateral positions, and 98% in the supine position. Mean intubation times of <25 seconds were clinically acceptable and comparable in each of the 3 positions.

In the left-lateral position, the occurrence of modified Cormack-Lehane grade 3a was 16% with the Macintosh laryngoscope, which was similar to the occurrence of Cormack-Lehane grade 3 reported by McCaul et al.4 However, in the right-lateral position, modified Cormack-Lehane grade 3a was encountered in 28% of the patients. Although the difference between the 2 lateral positions was not statistically significant, relative difficulty in the right-lateral position was likely attributable to the positioning of the tongue, which (influenced by gravity) has a tendency to slip off the laryngoscope blade while the blade is inserted from the right side of the tongue.14 Besides the deteriorated laryngeal view, limited space between the laryngoscope handle and the tabletop in the right-lateral position would contribute to intubation difficulty if direct laryngoscopy were attempted conventionally, by inserting the tracheal tube from the right corner of the mouth.

The 5% occurrence of modified Cormack-Lehane grade 3a in the supine position was significantly lower than those in the 2 lateral positions. Despite the difference in the occurrence of a poor laryngeal view in the supine and the 2 lateral positions, the larynx was fully visualized with the Airway Scope in all patients. As shown previously,8 there is little if any correlation between poor Cormack-Lehane grades with direct laryngoscopy and intubation difficulty with the Airway Scope.

Thirteen patients in the left-lateral position, 9 patients in the right-lateral position, and 21 patients in the supine position required ≥2 intubation attempts before the airway was secured. All failed attempts resulted from the tip of the introducer blade advancing into the vallecula, thus failing to reach the glottic side of the epiglottis. This problem was corrected easily by partially withdrawing the device, and with a subsequent scooping movement of the introducer blade, lifting the epiglottis, which allowed insertion of the tracheal tube. This maneuver required only a few seconds and is likely the reason intubation time was not significantly different among the 3 positions despite the difference in the number of attempts.

In the supine position, the distance between the epiglottis and posterior pharyngeal wall presumably becomes shorter because the anterior pharyngeal structure moves posteriorly because of gravity, compared with the lateral position in which the structure moves laterally. The introducer blade is thus more likely to advance into the vallecula in the supine position. No differences were observed between the 2 lateral positions in the number of intubation attempts. The Airway Scope is not symmetrical because the tracheal tube is accommodated on the right side of the trachea and is likely the reason intubation time was not significantly different among the 3 positions despite the difference in the number of attempts.

We did not include a comparison of other intubation modalities with the Airway Scope in the lateral position. Intubation with direct laryngoscopy in the left-lateral position has been studied by McCaul et al.4 who report a success rate of 79% with a mean intubation time of 39 seconds. Their criteria for failed intubation were intubation times >60 seconds or >2 attempts. Only 5% of our patients required 3 intubation attempts, and no patients required >60 seconds before the airway was secured; furthermore, our mean intubation time was 15 seconds shorter than that observed by McCaul et al. These results suggest that the Airway Scope may be superior to the Macintosh laryngoscope in the left-lateral position; presumably, the relative performance of the Airway Scope is even better in the
right-lateral position because the flange on the Macintosh blade prevented movement of the tongue into the midline less effectively.

Intubation success in the lateral position with the ILMA with and without lightwand assistance has been reported. Insertion and ventilation via the ILMA was possible in 100% of the patients in the right- and left-lateral positions. Subsequent blind intubation was successful within 2 attempts in 98% and 100% of left- and right-laterally positioned patients, respectively. For patients who required only a single insertion attempt of the ILMA and 1 intubation attempt, the time taken for overall intubation was similar to the mean intubation time with the Airway Scope in our patients, but our time included multiple intubation attempts. With lightwand assistance, intubation was successful in 100% of both lateral positions within 3 attempts, but the time taken for intubation without including time required for ILMA insertion was approximately 30 seconds in both lateral positions, and the time for overall intubation including ILMA insertion time would have been even longer. Furthermore, esophageal intubation occurred in 5% of patients in both lateral positions. With the lightwand only, intubation was successful in 100% of patients in both lateral positions within 3 intubation attempts with a mean intubation time of approximately 15 seconds. However, 7.5% of the intubations were esophageal in each lateral position. Although the ILMA has a clear advantage of providing ventilation before intubation is completed, the intubation process includes 2 steps (i.e., insertion of the ILMA followed by intubation through the ILMA), which prolongs the total time needed for intubation. Using the lightwand alone provided faster intubations, but the fraction of esophageal intubation remains concerning, as is the case for the ILMA.

Patients with anticipated airway difficulties were excluded from our study; this explains why modified Cormack-Lehane grade 3b or higher scores were not encountered in any of the 3 intubation positions. However, the inclusion of difficult airway populations might not have significantly influenced the results of the current study, because a poor laryngoscopic view has no influence on intubation when the Airway Scope is used. Our study was conducted in a controlled environment under general anesthesia with muscle relaxation. In emergency situations, the patient’s blood or secretions in the airway often complicate intubation attempts, and pharmacological optimization of airway management with adequate sedation and muscle relaxation might not be available. In these situations, the Airway Scope may prove less effective than in the current study because the camera view could be compromised by fogging or pharyngeal blood.

All intubations were performed by a single investigator (RK) who had considerable experience with the Airway Scope. Intubation with the Airway Scope has been reported to be easy for the novice intubator, which suggests that little training is necessary to obtain expertise. Nonetheless, it is likely that less-experienced clinicians will take longer and have less success than we report. All direct laryngoscopies were conducted by a single investigator (KK) who is an experienced anesthesiologist. Furthermore, we included the POGO score, which has a high interphysician concordance, in addition to Cormack-Lehane grading. Reported laryngeal view grades are thus likely to be accurate.

In summary, direct laryngoscopy is more difficult in lateral positions than in supine positions. The Airway Scope offers high success rates in each position. Furthermore, intubation times were fast and comparable in the left-lateral, right-lateral, and supine positions. The Airway Scope thus seems to be an effective approach for emergently securing Cormack-Lehane grades 1, 2, and 3a airways in patients positioned on either side.

DISCLOSURES
Name: Ryu Komatsu, MD.
Contribution: This author helped design the study, conduct the study, and write the manuscript.
Attestation: Ryu Komatsu has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.
Name: Kotoe Kamata, MD.
Contribution: This author helped conduct the study.
Attestation: Kotoe Kamata has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.
Name: Jing You, MS.
Contribution: This author helped analyze the data and write the manuscript.
Attestation: Jing You has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.
Name: Daniel I. Sessler, MD.
Contribution: This author helped write the manuscript.
Attestation: Daniel I. Sessler has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.
Name: Yusuke Kasuya, MD.
Contribution: This author helped design the study.
Attestation: Yusuke Kasuya has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

REFERENCES