Approach Combining the Airway Scope and the Bougie for Minimizing Movement of the Cervical Spine during Endotracheal Intubation

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Background: The Airway Scope (AWS, AWS-S100; Hoya-Pentax, Tokyo, Japan), a recently introduced video laryngoscope, has been reported to reduce movement of the cervical spine during intubation attempts in comparison with conventional laryngoscopes. Use of the bougie as an aid for the AWS may cause further reduction. The authors compared cervical spine movement during intubation with the AWS with and without a bougie.

Methods: Thirty patients without cervical spine abnormality were randomized into two groups: intubation with AWS only and intubation with the AWS and the bougie. The cervical spine motion between the occiput (C0) and the fourth cervical vertebra (C4) was observed fluoroscopically, and change in movement between adjacent vertebrae created by each intubation method was compared. Time to intubation was also measured.

Results: Laryngoscopy with the AWS produced extension of the cervical spine segments assessed (C0–4). Median extension angle of the C0–4 during intubation using the AWS was reduced from 16.0 degrees without the bougie to 6.5 degrees with the bougie (P < 0.01). There was no significant difference in time to intubation between them.

Conclusions: Use of the bougie resulted in significantly reduced extension of the cervical spine during intubation attempt with the AWS in patients with a normal cervical spine.

SPECIAL attention should be paid to airway management in patients with unstable cervical spine because movement of the cervical spine produced by laryngoscopy may be associated with spinal cord damage. It seems prudent to minimize the cervical spine movement during intubation attempt in these patients.

The Airway Scope (AWS, AWS-S100; Hoya-Pentax, Tokyo, Japan), a recently introduced video laryngoscope with a small and highly efficient charge-coupled device camera, is coming into wide use not only in the operating room but also in the emergency room in Japan. As the device consists of a blade designed to match the anatomy of the upper airway, it does not require alignment of the oral, pharyngeal, and laryngeal axes to visualize the glottis. Aligning these axes causes movement of the cervical spine, particularly bringing the pharyngeal axis close to the oral axis depends entirely on the degree of extension between the occiput (C0) and the axis (C2). Thus, the AWS allows reduction of the cervical spine movement during intubation attempt compared with a conventional laryngoscope. Hirabayashi et al. and Maruyama et al. demonstrated that extension of the cervical spine between the C0 and the fourth cervical vertebra (C4) was reduced from 38.6 degrees and 32.3 degrees using the Macintosh laryngoscope to 23.4 degrees and 22.3 degrees using the AWS, respectively. However, these results also indicate that a considerable degree of the cervical spine extension is needed for tracheal intubation with the AWS.

During intubation attempt with the AWS, the direction of advancing an endotracheal tube (ETT) is determined only by curvature of the ETT and the ETT-guiding groove of the blade. Thus the ETT is advanced in the fixed direction, which is displayed on the monitor screen of the AWS as the target symbol. To insert the tube into the trachea, the target symbol is simply aligned with the laryngeal aperture. For that purpose, near full view of the glottis is necessary. In contrast, conventional laryngoscopic intubation is possible by handling the tip of the ETT under direct vision even when the entire view of the glottis is not obtained and if the posterior portion of the laryngeal aperture is visible. Sawin et al. have demonstrated that extension angle of the C0–4 required to obtain a minimal glottic view for successful intubation with a Macintosh laryngoscope is 14.3 degrees. Although direct comparison between results with the AWS and those by Sawin et al. is difficult, whether the AWS is safer than the Macintosh laryngoscope in patients with unstable cervical spine is questionable.

The bougie, which is smaller in diameter and has an angulated tip, is a well-described option for tracheal intubation as a useful ETT introducer. Nolan and Wilson clarified usefulness of the bougie as an aid for intubation with a conventional laryngoscope in patients with a simulated cervical spine injury. When the bougie is used as an aid for intubation with the AWS, it can arrive at the whole areas on the monitor screen of the AWS by rotating its angulated tip. Thus, the bougie may be advanced into the glottis and the trachea when obtaining only a minimal glottic view for passage of the bougie and the ETT. A minimal glottic view is likely to require less movement of the cervical spine in comparison with a full view; therefore, use of the bougie may permit further reduction of the cervical movement dur-
ing intubation attempt with the AWS. As a result, we examined the efficacy of the bougie on the cervical spine movement during intubation with the AWS in patients without cervical abnormality.

Materials and Methods

Patients
The study was approved by the Institutional Ethical Committee (Nippon Steel Yawata Memorial Hospital, Kitakyushu, Japan), and written informed consent to participate in the study was obtained from all patients. Thirty patients classified as American Society of Anesthesiologists physical status 1–2 who were scheduled for elective orthopedic surgery under fluoroscopy requiring general anesthesia with tracheal intubation were studied. Patients with body mass index of more than 30 kg · m⁻², cervical spine abnormality, pharyngolaryngeal pathology, anticipated difficult airway, and an increased risk of aspiration were excluded. The patients were randomly assigned into two groups with a sealed envelope technique: intubation with AWS only and intubation with AWS and the bougie.

Experimental Protocol
All patients were premedicated with 50 mg of ranitidine. On arrival in the operating room, standard monitors were applied, and each patient lay supine on the operating table and his or her head placed on the flat table without a pillow. General anesthesia was induced with 1–2 mg · kg⁻¹ propofol, and muscle relaxation was produced with 0.6 mg · kg⁻¹ rocuronium. The patient’s lungs were ventilated with 2-4% sevoflurane in oxygen via a facemask until the train-of-four response evoked by ulnar nerve stimulation was abolished. The AWS blade, to which the ETT (Portex; Smith Medical, Kent, United Kingdom; 7.5-mm ID for men, and 7.0-mm ID for women) was set, was inserted into the mouth in the midline, over the center of the tongue, and advanced along the posterior wall of the pharynx until its tip was positioned beneath the epiglottis. With only the AWS, the epiglottis was fully elevated with the blade tip, the glottis was exposed until the target symbol was aligned with it, and the ETT was passed through the vocal cords. With the AWS and the bougie, elevation of the epiglottis was stopped when obtaining the minimal glottic view necessary to allow passage of the bougie (Portex Venn reusable tracheal tube introducer; Smith Medical, Keene, NH) and the ETT (fig. 1). The bougie, passed into the ETT, was then inserted into the trachea, and then the ETT was advanced over it. All laryngoscopies and intubations were performed by one anesthetist (Dr. Takenaka) who had experienced more than 200 intubations with the AWS before the study. An assistant (Dr. Aoyama) measured time to intubation, which was defined as the time taken from insertion of the AWS blade between the teeth until the ETT cuff was passed through the vocal cords. If the intubation attempt took longer than 120 s, it was deemed a failure.

Fluoroscopy
After standard precaution for protection against radiation exposure, the cervical spine motion during intubation attempt was observed fluoroscopically using a mobile image intensifier unit (OEC 9800; GE Medical Systems, Salt Lake City, UT) and recorded on DVD throughout the laryngoscopy intubation sequence. The exposure to radiation involved in this procedure was determined previously under similar conditions in this study in a healthy man (Dr. Takenaka). Because the time required for intubation with the AWS was reported to be 20–30 s, presumed total amount of exposure was less than 4 mGy, which was approximately equal to radiation dose to obtain three or four static x-ray images. All patients were informed of this small radiation dose.

Radiologic Measurement
Two experienced radiologists determined maximal change of the cervical spine motion during intubation attempt by review of the DVD recording, which was printed out (fig. 2 and 3). They were blinded to the purpose of the study and did not know whether the bougie was used or not. After shuffling the radiographs printed out, movement of the cervical spine was evaluated as follows. As a reference for the position of the occiput relative to the cervical spine, the McGregor line (CO) was used. This line connected the most dorsal edge of and caudal portion of the occiput and the dorsal edge of the hard palate (fig. 2). The reference line for the C1 was drawn through the anterior and posterior arches of the atlas (fig. 2). The reference lines for the C2, C3, and C4 were drawn through the anterior, inferior margin of the respective vertebral bodies and the lower cortical margin of the respective spinous processes (fig. 1).
Because reference lines did not intersect on the radiograph in some patients, the \( \angle C_0, C_1, C_2, C_3, \) or \( C_4 \) angle was defined as a difference in angle between the respective reference line and the common line that was the ventral vertical edge on each radiograph (fig. 2). The angle between adjacent levels was calculated as the following difference: \( \Delta C_{0-1} = \angle C_0 \) angle (C0 reference line to common line angle) - \( \angle C_1 \) angle (C1 reference line to common line angle), \( \Delta C_{0-2} = \angle C_0 \) angle (C0 reference line to common line angle) - \( \angle C_2 \) angle (C2 reference line to common line angle). Change \( \Delta \) in the angle between adjacent levels created by laryngoscopy and intubation was defined as the difference between the angle between adjacent levels that was maximum value during laryngoscopy and intubation and that before laryngoscopy. Positive and negative angles denoted extension and flexion, respectively. When differences in radiographic measurement between the two radiologists were more than 2 degrees, the radiographs were reviewed together to obtain consensus.

Statistical Analysis

Statistical analysis was carried out using StatView 5.0 (SAS Institute Inc., Cary, NC). Normally distributed data, demographic data, and time to intubation were represented as mean \( \pm SD \) and compared using a Student \( t \) test. Data regarding the cervical spine motion were represented as median (interquartile range) and was compared using the Mann-Whitney U test. A \( P \) value of less than 0.05 was considered significantly different.

Results

A total of the 30 patients (age, 21–85 yr) were entered into the study (table 1). All patient tracheas were successfully intubated at the first attempt. The AWS provided a clear view of the glottis (Cormack and Lehane’s classification Grade 1) in all patients in whom intubation was performed using only the AWS. Laryngoscopy with the AWS produced extension of the cervical spine segments assessed (C0-4). Median extension angle of the C0-4 (\( \Delta C_{0-4} \) angle) was 16.0 degrees with only the AWS and 6.5 degrees with combination of the AWS and the bougie (table 2). Among these segments, most of extension occurred between the C0 and the C2, and the subaxial segments were only minimally displaced. Median extension angle of the C0-2 (\( \Delta C_{0-2} \) angle) was 15.1 degrees with only the AWS and 7.0 degrees with combination of the AWS and the bougie (table 2). Use of the bougie significantly reduced the amount of extension at the C0-1, C1-2, C0-2, and C0-4 during intubation with the AWS (table 2). Mean times to intubation with only the AWS and with the AWS and the bougie were 18.2 \( \pm 6.3 \) s and 19.4 \( \pm 7.1 \) s, respectively (table 1). There was no significant difference between them. Measurement dis-

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**Table 1. Patient Characteristics and Time to Intubation**

<table>
<thead>
<tr>
<th></th>
<th>Airway Scope Only</th>
<th>Airway Scope + Bougie</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Age, yr</td>
<td>61.6 (19.3)</td>
<td>58.1 (20.0)</td>
</tr>
<tr>
<td>Height, cm</td>
<td>158 (11.3)</td>
<td>160 (8.8)</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>57.3 (13.6)</td>
<td>59.4 (12.5)</td>
</tr>
<tr>
<td>Sex, M/F</td>
<td>8/7</td>
<td>6/9</td>
</tr>
<tr>
<td>Time to intubation, s</td>
<td>18.2 (6.3)</td>
<td>19.4 (7.1)</td>
</tr>
</tbody>
</table>

Age, height, weight, and time to intubation values are mean (SD).

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**Fig. 2.** Sample lateral neck radiograph displaying reference lines for the occiput and each vertebral level. As reference for the occiput (C0), the McGregor line, which connects the most dorsal edge of and caudal portion of the occiput and the dorsal edge of the hard palate, is used. The reference line for the C1 is drawn through the anterior and posterior arches of the atlas. The reference lines for the C2, C3, and C4 are drawn through the anterior, inferior margin of the respective vertebral bodies and the lower cortical margin of the respective spinous processes. The \( \angle C_0, C_1, C_2, C_3, \) or \( C_4 \) angle is defined as a difference in angle between the respective reference line and the common line that is the ventral vertical edge on each radiograph.

**Fig. 3.** Representative radiographs during laryngoscopy and intubation with (A) only the Airway Scope (Hoya-Pentax, Tokyo, Japan) and with (B) the Airway Scope and the bougie. Note a difference in the position of the blade tip (arrow) between them. A = arytenoid cartilage; H = hyoid bone.
crepancies in radiographic measurement between the two radiologists averaged 1.3 degrees.

Discussion

Laryngoscopes with an anatomical curve-shaped blade can provide an excellent view of the glottis, even in patients with difficult airway.11,16–18 However, with these laryngoscopes, difficulty in introducing the ETT into the glottis that is visible often occurs because the ETT tip cannot be always aligned with the glottis.18,19 This problem also prolongs time required for successful intubation. The AWS solves this difficulty by an excellent function providing a guidance of the ETT. With the AWS, the direction of advancing the ETT is fixed as mentioned above, and the approximate location when the tube is advanced is indicated as the target symbol on the monitor screen.2,6 Thus the ETT is easily inserted into the trachea when the target symbol is aligned with the glottic opening by fully exposing the glottis.11,17 In this study, laryngoscopy with the AWS for obtaining a full glottic view produced the C0-4 extension of 16.0 degrees, which was slightly larger than that of 14.3 degrees at minimal glottic exposure for the ETT passage with the Macintosh laryngoscope reported by Sawin et al.7

Our study showed that, when the bougie was used as an aid for intubation with the AWS, intubation was possible at minimal glottic exposure, and the amount of the C0-4 extension was only 6.5 degrees. When using only the AWS, the ETT cannot be advanced into the laryngeal aperture at this view because the direction of advancing the tube (target symbol) is not aligned with the laryngeal aperture. In contrast, the bougie is advanced in a desired direction on the monitor screen of the AWS by rotating its angulated tip, as shown in figure 4. Thus the bougie was easily passed into the laryngeal aperture, even at the incomplete glottic exposure, which enabled subsequent tracheal intubation. That is, use of the bougie as an aid for the AWS did not require full glottic exposure for successful intubation, which allowed reduction of the cervical spine movement.

Intubation took 18.2 s with the AWS only and 19.4 s with the AWS and the bougie, and there was no significant difference between them despite necessity of manipulating the bougie. In case of intubation attempt with only the AWS, effort for alignment of the target symbol and the laryngeal aperture was needed in some patients. Thus use of the bougie along with the AWS might not prolong intubation time. The time required for conventional laryngoscopic intubation has been reported to be 12–30 s (table 3).5,8,13,15,18,20 In this regard, the AWS even with the bougie could stand comparison with conventional laryngoscopy.

It is difficult to determine maximum permissible movement of the cervical spine during airway management in patients with unstable cervical spine because it depends on many factors, such as region, severity, and direction of injuries.1 Thus, minimizing movement of the cervical spine during airway maneuver may be only the method for protection of the spine cord.1 Watts et al.13 found extension angle of 5.6 degrees at the C0-5 when using the Bullard laryngoscope with manual in-line stabilization. To our knowledge, this value is the smallest amount of extension of the cervical spine among intubation methods, including several rigid laryngoscopes, illuminating stylet, intubating laryngeal mask airway, and rigid fiberscopes.4,5,7,12–15,21 The amount of the C0-4 exten-

![](https://example.com/fig4.png)

Table 2. Change in Movement of the Cervical Spine during Intubation with the Airway Scope (AWS)

<table>
<thead>
<tr>
<th></th>
<th>ΔC0-1</th>
<th>ΔC1-2</th>
<th>ΔC2-3</th>
<th>ΔC3-4</th>
<th>ΔC0-2</th>
<th>ΔC0-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS only</td>
<td>10.3 (9.6/13.3)</td>
<td>3.9 (3.4/6.1)</td>
<td>1.0 (-0.4/1.3)</td>
<td>0.4 (-1.6/2.0)</td>
<td>15.1 (13.2/18.5)</td>
<td>16.0 (15.1/18.3)</td>
</tr>
<tr>
<td>AWS + bougie</td>
<td>3.9 (2.4/5.4)</td>
<td>1.8 (0.9/4.2)</td>
<td>0.0 (-0.5/0.9)</td>
<td>0.0 (-1.2/0.8)</td>
<td>7.0 (4.7/8.3)</td>
<td>6.5 (5.1/8.4)</td>
</tr>
</tbody>
</table>

Values (degrees) are median (25th/75th percentiles). Positive and negative angles denote extension and flexion, respectively. *P < 0.01 vs. AWS only; †P < 0.05 vs. AWS only.
sion with the AWS and the bougie was similar to that found by Watts et al.\textsuperscript{13} They clarified that application of manual in-line stabilization reduced extension of the cervical spine during intubation with the Bullard laryngoscope but significantly prolonged intubation time.\textsuperscript{13}

With combination of the AWS and the bougie, cervical spine motion was minimal, and intubation time was reasonable. In addition, although difficulty in passing the ETT over the bougie that is placed in the trachea is a well-recognized problem,\textsuperscript{22} we did not encounter this difficulty. We think that even when the difficulty occurs, solution becomes easy because the ETT passage is visible on the monitor screen of the AWS (e.g., rotating the tube under visual control).

There are some disadvantages of the AWS, and the most crucial one is that the AWS has only one fixed-size AWS blade. Thus, when the blade is too short to reach beneath the epiglottis and to lift it, intubation with the AWS becomes difficult.\textsuperscript{23} Also, even when the length of the blade is sufficient, its tip may not be always advanced beneath the epiglottis as a result of the difference between patients’ anatomy of the upper airway and the shape of the rigid blade, which causes difficulty. Moreover, even when the blade tip is correctly placed, it may be unable to provide an appropriate view of the glottis for passing the ETT through the vocal cords.\textsuperscript{24} In these cases, combination of the AWS and the bougie may be useful because the bougie is advanced through the vocal cords even when the AWS does not provide a sufficient glottic view and the target symbol is not aligned with the glottis (fig. 4). Although further study is needed, we expect that this combination can solve not only problems in patients with unstable cervical spine but also those in patients with difficult airway.

There are some potential limitations of our experimental design. First, one anesthetist who had experienced more than 200 intubations with the AWS performed all laryngoscopies and intubations to avoid interobserver variability. Minimal glottic exposure necessary to allow passage of the bougie and the ETT through the vocal cords depended on subjective decision of the laryngoscopist. To our impression, if only the arytenoid portion of the larynx is exposed on the monitor screen of the AWS and even if the vocal cords are invisible, the bougie is easily inserted into the trachea (fig. 1). Second, maximal change of the cervical spine movement during intubation with the AWS was also determined subjectively, which might cause a source of error in the measurement. Sawin et al.\textsuperscript{7} demonstrated that maximal cervical motion during direct laryngoscopic intubation at minimal glottic exposure occurred when the ETT was positioned in the posterior oropharynx after laryngoscopy. In their study, the cervical motion remained unchanged during advancement of the tube from the posterior oropharynx to the glottis and the trachea. Therefore, we believe that the error was of little importance. Third, the radiologists might have known of bougie use in some patients, although the bougie did not have a radiopaque marker and was difficult to distinguish on the radiographs. However, we do not consider that the bias of this nature was important because the radiologists were unfamiliar with the bougie and evaluated the cervical movement after sufficiently shuffling the radiographs. Also, regarding radiographic biases, the variation in the radiographic angle measurement was less than 1.3 degrees, demonstrating a low interobserver variability. Fourth, we did not apply manual in-line stabilization, which was recommended for minimizing the cervical motion during airway maneuver in patients with unstable cervical spine\textsuperscript{1} because the aim of our study was to examine the efficacy of the bougie on the cervical movement during intubation with the AWS. Thus the situation simulation in our study is not always similar to the trauma setting when the cervical spine injury is suspected. However, we believe that our results can provide useful information for managing the airway on this situation because combination of the AWS and the bougie enabled both minimal cervical spine movement and reasonable intubation time. In addition, previous investigators have demonstrated that application of manual in-line stabilization reduces the cervical motion during several airway maneuvers.\textsuperscript{13,25} Although more investigation is needed, we expect that applying this maneuver permits further reduction of the cervical movement with combination of the AWS and the bougie. Finally, although use of the bougie might reduce the cervical spine motion during conventional laryngoscopy and intubation, we did not examine it. We consider that the cervi-

### Table 3. Time Required for Intubation with Conventional Laryngoscopy

<table>
<thead>
<tr>
<th>References</th>
<th>ILS</th>
<th>CP</th>
<th>n</th>
<th>Head and Neck Position</th>
<th>Measured Endpoint of Intubation Attempt</th>
<th>Intubation Time, s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maruyama et al.\textsuperscript{5}</td>
<td>X</td>
<td>X</td>
<td>12</td>
<td>Neutral</td>
<td>Withdrawal of laryngoscope from the mouth</td>
<td>16.8 (10.7)</td>
</tr>
<tr>
<td>Watts et al.\textsuperscript{13}</td>
<td>X</td>
<td>X</td>
<td>29</td>
<td>Neutral</td>
<td>ETT tip position: vocal cord</td>
<td>12.3 (3.7)</td>
</tr>
<tr>
<td>Sun et al.\textsuperscript{14}</td>
<td>X</td>
<td>X</td>
<td>99</td>
<td>Neutral</td>
<td>Confirmation of successful intubation</td>
<td>30 (13)</td>
</tr>
<tr>
<td>Turkstra et al.\textsuperscript{15}</td>
<td>O</td>
<td>X</td>
<td>18</td>
<td>Neutral</td>
<td>ETT tip position: vocal cord</td>
<td>17 (8)</td>
</tr>
<tr>
<td>Maharaj et al.\textsuperscript{20}</td>
<td>O</td>
<td>X</td>
<td>19</td>
<td>Neutral</td>
<td>ETT tip position: trachea</td>
<td>20.3 (12.2)</td>
</tr>
<tr>
<td>Watts et al.\textsuperscript{13}</td>
<td>O</td>
<td>O</td>
<td>29</td>
<td>Neutral</td>
<td>ETT tip position: vocal cord</td>
<td>20.3 (12.8)</td>
</tr>
<tr>
<td>Nolan and Wilson\textsuperscript{8}</td>
<td>O</td>
<td>O</td>
<td>74</td>
<td>Neutral</td>
<td>Confirmation of successful intubation</td>
<td>20 (13–95)</td>
</tr>
</tbody>
</table>

Values are mean (SD). * – median (range).

CP = cricoid pressure; ETT = endotracheal tube; ILS = in-line stabilization; O = performed; X = not performed.
cervical movement when using a combination of a Macintosh laryngoscope and the bougie is similar to that reported by Sawin et al. During conventional laryngoscopy, obtaining the best glottic view increases the cervical motion and a poor (i.e., minimal) view requires less motion. Use of the bougie facilitates intubation at a poor (i.e., minimal) view, but it does not directly reduce the cervical movement. An important determinant of the cervical movement during conventional laryngoscopy is the degree of the glottic exposure and not use of the bougie. Thus, we think that the cervical movement does not change greatly when the bougie is used during conventional laryngoscopic intubation at minimal glottic exposure. When manual in-line stabilization is not applied, the C0-4 extension of 14.3 degrees described by Sawin et al. is the smallest. Therefore, we believe that the cervical movement using combination of the AWS and the bougie is less than that using combination of the Macintosh laryngoscope and the bougie.

In summary, use of the bougie as an aid for intubation with the AWS resulted in reduced extension of the cervical spine for successful intubation. The amount of extension with combination of the AWS and the bougie was a minimal level among intubation methods. This method is quicker to use because it does not require special preparation. Therefore, we believe that this approach is a reasonable technique of choice for intubation when minimal cervical movement is indispensable.

References


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