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ORIGINAL ARTICLE

Comparison of Pentax-AWS Airwayscope video laryngoscope, Airtraq optic laryngoscope, and Macintosh laryngoscope during cardiopulmonary resuscitation under cervical stabilization: a manikin study

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Abstract
Purpose The 2010 American Heart Association or European Resuscitation Council guidelines for cardiopulmonary resuscitation emphasize that rescuers should minimize interruption of chest compressions, even for endotracheal intubation. Cervical stabilization should also be maintained during traumatic cardiac arrest. The utility of the Pentax-AWS Airwayscope (AWS) video laryngoscope and Airtraq (ATQ) optic laryngoscope for airway management has been reported under cervical stabilization. We first evaluated ATQ utility during chest compression with or without cervical stabilization and then compared the AWS, ATQ, and Macintosh laryngoscope (McL) during chest compressions under cervical stabilization in a manikin.
Methods In the first trial, 19 novice doctors performed tracheal intubation with ATQ during chest compression with or without cervical stabilization. In the second trial, 21 novice doctors performed tracheal intubation on a manikin with cervical stabilization using AWS, ATQ, and McL with or without chest compression in a manikin. The rate of successful intubation, time to intubation, and subjective difficulty of use (visual analog scale) were recorded.
Results In the first trial, intubation time during chest compression was significantly shortened under cervical stabilization compared to without cervical stabilization ($P < 0.05$). In the second trial, using McL, 3 participants failed to perform tracheal intubation without chest compression and 11 failed during chest compression ($P < 0.05$). Using ATQ, all intubations were successful without chest compression, but 5 failed during chest compression ($P < 0.05$). Intubation time was significantly prolonged by chest compression using McL or ATQ ($P < 0.05$). All participants successfully secured the airway with AWS regardless of chest compression, and chest compression did not prolong intubation time. Chest compression worsened the score on the visual analog scale of laryngoscopy in the McL trial ($P < 0.05$), but not in ATQ or AWS trials. Difficulty of tube passage through the glottis increased with chest compression with the McL and ATQ ($P < 0.05$) but not with AWS.
Conclusion The AWS was superior to McL and ATQ for endotracheal intubation during simulated cervical stabilization and chest compression.

Keywords Pentax-AWS Airwayscope · Airtraq · Macintosh laryngoscope · Chest compression · Manikin · Cervical stabilization

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Introduction

Recent advanced cardiac life support (ACLS) guidelines from the American Heart Association (AHA) or European Resuscitation Council (ERC) indicate that chest compression should be minimized during cardiopulmonary resuscitation (CPR) because interruptions in chest compression can reduce the patient's chance of survival [1, 2]. Tracheal intubation is specifically indicated in several trauma-related conditions, including cardiac arrest [3]. All unconscious blunt trauma victims should be assumed to have an unstable neck until this condition is ruled out [4]. As a result, physicians may be required to intubate the trachea of a trauma patient during the difficult situation of continuous chest compression and simultaneous cervical spine stabilization [5].

The Pentax-AWS Airwayscope (AWS; Hoya, Tokyo, Japan) video laryngoscope and Airtraq (ATQ; Prodol Meditec, Vizcaya, Spain) optic laryngoscope have been reported to be useful for cervical protection during tracheal intubation [6, 7]. Both devices provide a non-sightline view of the airway. Because there is no need to extend the patient's neck, the AWS and ATQ appear to be better for tracheal intubation under neck stabilization [6, 7].

Concerning tracheal intubation during chest compression, clinical reports of AWS or ATQ without chest compression have been reported [8, 9]. In simulation studies utilizing a manikin, we and others have previously reported that AWS more effectively secures the airway during chest compression simulation in a manikin than the Macintosh laryngoscope (McL) [10, 11]. One group reported that AWS was superior to ATQ and McL [12]. One reported weakness of ATQ was that participants had to keep their eyes very close to the monitor, which moved continuously during chest compression [12].

Under cervical stabilization, the head is fixed by hands or a neck collar. Thus, the previously reported weakness of ATQ may be minimized as the head and monitor do not move with chest compression. For this reason, we decided to evaluate ATQ utility with or without cervical stabilization and then to validate the utility of AWS and ATQ for tracheal intubation during chest compression under cervical stabilization.

To this end, we first compared the performance of ATQ during chest compression with or without chest compression. Second, we directly compared the performance of the AWS, ATQ, and McL laryngoscopes during chest compression in a manikin under cervical stabilization.

Methods

Approval for this study was obtained from the college's Research Ethics Committee.

In the first trial, we recruited 19 novice doctors with less than 1 year of experience in our anesthesia department for the comparison of ATQ utility with or without chest compression. In the second trial, 21 novice doctors with less than 1 year experience were recruited for the comparison of AWS, ATQ, and McL under cervical stabilization with or without chest compression. The participants of the two trials were completely different. The participants were asked about their prior experience with general anesthesia, and each provided written consent before participating in the study.

In the first trial, we compared the utility of ATQ during chest compression with or without chest compression. In the second trial, we compared the utility of AWS, ATQ, and McL under cervical stabilization with or without chest compression.

The AirMan manikin (Laerdal, Sentrum, Stavanger, Norway) was used for intubation and chest compression. We used the McL size 3 blade, regular ATQ blade size, and the standard Intlock blade of the AWS, as described in previous studies [10, 13]. A tracheal tube (Portex, St. Paul, MN, USA) with an internal diameter of 7.5 mm was used. The cervical collar Stiffneck (Laerdal, Sentrum, Stavanger, Norway) was used for cervical spine stabilization. Participants were given 5 min to perform tracheal intubation with each device. The manikin was placed on a hard table; all trials were performed at the same height. Continuous chest compressions were performed by the same ACLS instructor at a rate of 100 per minute [10].

To minimize learning effects, the study was designed as a randomized crossover trial. The order of the two (i.e., ATQ during chest compression with or without cervical stabilization) or six interventions (i.e., the three devices with and without chest compression) was randomized using a random number table. Participants were instructed to place the tracheal tube, inflate its cuff, connect a self-inflating bag, and then attempt to ventilate the lungs of the manikin. There was no requirement to tie the tracheal tube. The necessary equipment for each intervention was placed in a box next to the manikin's head. Participants were given time to practice tracheal intubation using the three laryngoscopes. Intubation times from the starting point (the moment the participant picked up the laryngoscope) to the endpoint (manual ventilation after insertion) were recorded for both tracheal and esophageal intubations. At the end of the examination, participants rated each device for laryngoscopy and passage of the tracheal tube through the glottis on a visual analog scale (VAS) from 0 mm (extremely easy) to 100 mm (extremely difficult).

Results obtained from each trial were compared using two-way repeated measures analysis of variance for intubation time and VAS scores, the Mann–Whitney *U* test for number of experiences with each laryngoscope, and Fisher's exact test for success rate. Data are expressed as mean ± standard deviation. $P < 0.05$ was considered significant.

We calculated sample size from a preliminary study including 10 novice anesthesiologists who performed tracheal intubation with McL under cervical spine stabilization. The mean (±SD) time required to ventilate the lungs after tracheal intubation in a manikin was 17.9 ± 6.2 s. We considered that a difference of 6 s (roughly one-third of 17.9 s) between the groups would be clinically important. To detect this difference with a power of 80% and significance of $P = 0.05$, approximately 22 subjects would be needed for two independent groups. However, because this study had a crossover design, fewer than 22 subjects would be required. Accordingly, we decided on 21 subjects and determined the time to intubation with the three devices.

Results

In the first trial for ATQ utility during chest compression with or without cervical stabilization, mean clinical experience with anesthesia was 3.3 ± 2.8 months for the 19 participants. The 19 participants had no clinical experience of ATQ usage. In the second trial for AWS, ATQ, and McL comparison, mean clinical experience with anesthesia was 3.2 ± 1.6 months for the 21 participants. The number of times the McL had previously been used (66.2 ± 78.5 times) was significantly higher than that of the AWS (0.9 ± 1.0 times) and ATQ (0.5 ± 0.6 times) ($P < 0.05$). There was no difference between previous usage of AWS and ATQ.

Comparison of ATQ utility during chest compression with or without cervical stabilization

In the first trial for the evaluation of ATQ during chest compression with or without cervical stabilization, 6 of 19 participants failed without cervical stabilization and 3 of 19 participants failed under cervical stabilization (NS). As shown in Fig. 1, intubation time was significantly increased without cervical stabilization (31.1 ± 6.8 s) compared with under cervical stabilization (24.7 ± 6.2 s; $P < 0.05$).

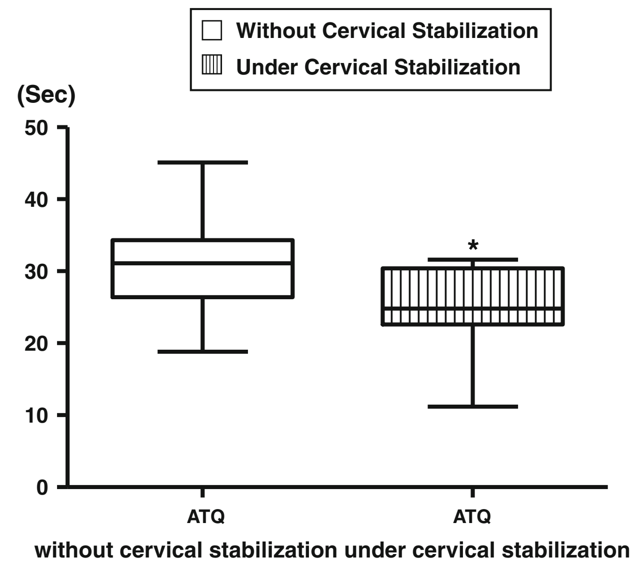

Fig. 1 Box-and-whisker plot (median, IQR, and range) of time needed for tracheal intubation with ATQ during chest compression under or without cervical stabilization. *ATQ*, Airtraq optic laryngoscope. *Significantly different ($P < 0.05$) compared without cervical stabilization

Success of endotracheal intubation among the three laryngoscopes under cervical stabilization

Table 1 shows the number of successful intubations for each device in the second trial. With the McL, 3 participants failed to achieve intubation without chest compression, and 11 of 21 participants failed to achieve intubation during chest compression ($P < 0.05$). With the ATQ, intubation was successful at each attempt without chest compression, but 5 of 21 participants failed to achieve intubation during chest compression ($P < 0.05$). With the AWS, all tracheal intubations were successful regardless of whether chest compression was performed.

Table 1 Success rates of tracheal intubation for the three laryngoscopes

	McL	ATQ	AWS
No chest compression	18/21	21/21	21/21
Chest compression	10/21	16/21	21/21
	$P < 0.05$	$P < 0.05$	NS

Results are expressed as successful intubations/total number of intubations

McL conventional Macintosh laryngoscope, *ATQ* optic laryngoscope Airtraq, *AWS* video laryngoscope, Pentax-AWS Airwayscope, *NS* no significant difference

* $P < 0.05$ (Fisher's exact test)

Intubation time among the three laryngoscopes under cervical stabilization

With the McL, intubation time was significantly longer during chest compression (27.8 ± 4.9 s) than without chest compression (21.3 ± 4.9 s; $P < 0.05$) (Fig. 2). With the ATQ, chest compression significantly increased intubation time (28.9 ± 6.7 s) compared with no chest compression (17.4 ± 5.7 s; $P < 0.05$). In contrast, chest compression did not significantly increase intubation time with the AWS (during chest compression, 18.8 ± 6.1; without chest compression, 16.9 ± 2.8 s).

Without chest compression, the time required for intubation with the ATQ did not differ significantly from that required with the AWS, but both times were significantly shorter than the time required with the McL. Intubation

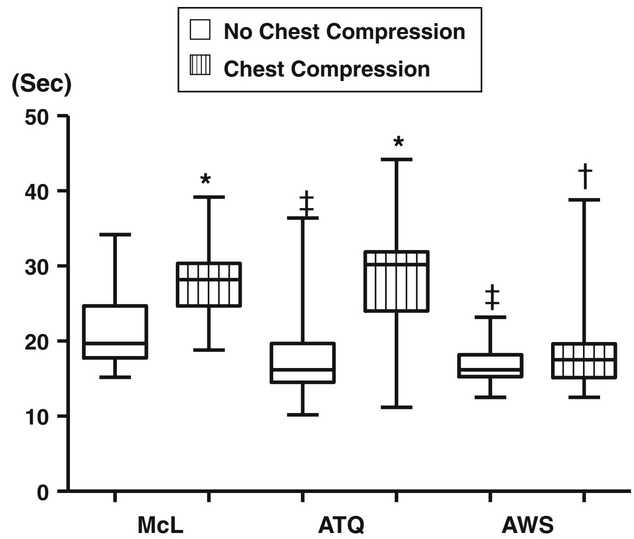

Fig. 2 Box-and-whisker plot (median, IQR, and range) of time needed for tracheal intubation with or without chest compression. *McL*, conventional Macintosh laryngoscope; *AWS*, Pentax-AWS video laryngoscope; *ATQ*, Airtraq optic laryngoscope. *Significantly different ($P < 0.05$) compared with no chest compression. †Significantly ($P < 0.05$) different compared to both the ATQ and McL groups during chest compression. ‡Significantly ($P < 0.05$) different compared to McL groups without chest compression

time with chest compression was significantly shorter using the AWS than when using the McL or ATQ.

VAS scores for laryngoscopy and tube passage through the glottis among the three laryngoscopes under cervical stabilization

As shown in Fig. 3, VAS scores for laryngoscopy and tube passage through the glottis were significantly higher during chest compression than without chest compression using the McL ($P < 0.05$). Although the VAS score for laryngoscopy was not significantly higher with chest compression using the ATQ, the VAS score for tube passage through the glottis was higher during chest compression than without chest compression. With the AWS, neither VAS score was significantly affected by chest compression ($P < 0.05$).

Overall, VAS scores for the AWS and ATQ without chest compression were significantly lower than those for the McL. VAS scores for the AWS during chest compression were significantly lower than those for the McL and ATQ for both laryngoscopy and tube passage ($P < 0.05$).

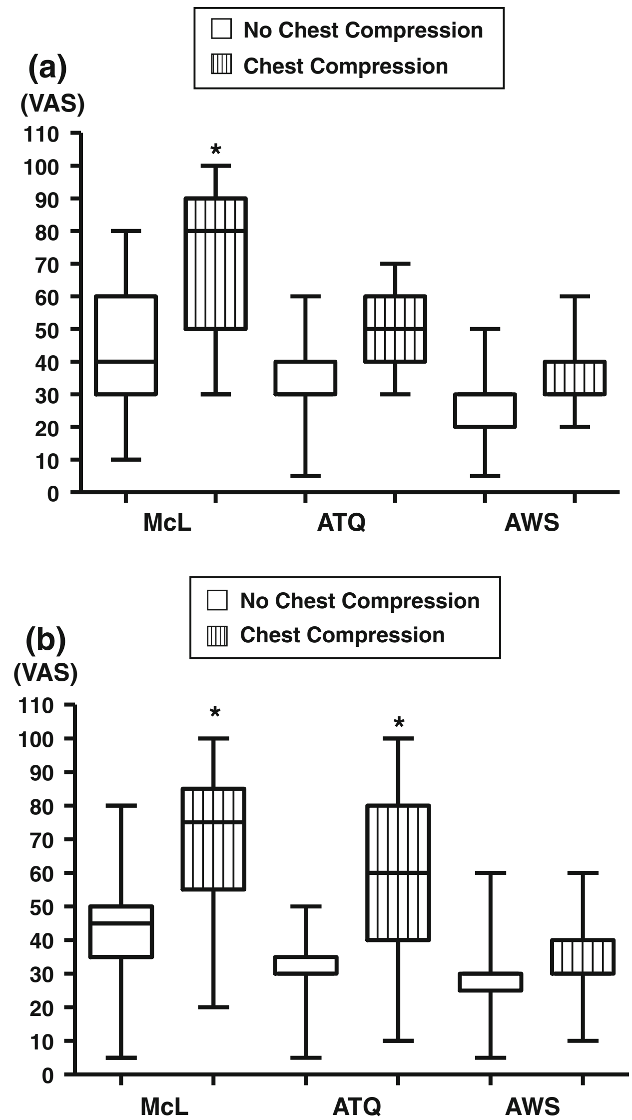

Fig. 3 Box-and-whisker plot (median, IQR, and range) of scores from the visual analog scale (*VAS*) for laryngoscopy (**a**) and tube passage through the glottis (**b**). *McL*, conventional Macintosh laryngoscope; *AWS*, Pentax-AWS video laryngoscope; *ATQ*, Airtraq optic laryngoscope. *Significantly different ($P < 0.05$) compared with no chest compression

Discussion

The 2010 AHA or ERC ACLS guidelines emphasized the further importance of high-quality CPR with a high regard for chest compression [1, 2]. Actually, the guidelines strongly recommend a depth of chest compression more than 5 cm and a rate of more than 100/min. In addition, they recommend initiation of compression before ventilation for basic life support [1]. Rescuers should perform tracheal intubation or defibrillation either without interrupting chest compression or with a brief pause.

For trauma patients, airway management is essential because these patients are at risk of airway obstruction and inadequate respiration, including cardiac and respiratory arrest [1]. Simultaneously, rescuers should consider spinal support for traumatic CPR [14]. In summary, the airway should be secured without chest compression even in traumatic cardiopulmonary arrest under cervical stabilization.

Although the McL is the most widely used laryngoscope for tracheal intubation, its use is considered difficult to master, especially in patients requiring cervical stabilization or chest compressions [15]. Therefore, the incidence of inaccurate intubation can be unacceptably high for infrequent operators [16]. The ACLS guidelines do not recommend tracheal intubation for all operators, but rather suggest the use of supraglottic devices, such as the laryngeal mask airway or the laryngeal tube [8]. However, use of these alternatives risks insufficient ventilation or expansion of the stomach, which could lead to gastric fluid regurgitation and aspiration pneumonia [17].

Glottic views obtained during direct laryngoscopy in patients with cervical spine immobilization have been shown to be consistently worse than those in nonimmobilized patients [18]. Further, direct laryngoscopy can be harmful in patients with cervical spine injury. There are published reports on the successful use of the ATQ or AWS in patients with normal airways, in difficult airway scenarios simulated with manikins, and under cervical immobilization [19, 20].

Tracheal intubation with the McL requires axial alignment of the oral cavity, pharynx, and larynx, and handling of tracheal tubes. Such axial alignment is often difficult under cervical stabilization [19, 20]. In the present study, the VAS score for laryngoscopy was significantly lower with the McL, even without chest compression. In contrast, AWS and ATQ provide a non-sightline view of the airway and do not require axial alignment. These devices improve the laryngeal view, and the tube guide facilitates rapid and reliable tracheal intubation under vision, even for difficult cases such as patients with cervical neck immobility or those who are morbidly obese [21, 22]. Once the glottis is targeted in the AWS or ATQ monitor, the tracheal tube is pushed to achieve passage through the vocal cords [23].

In the present study, we demonstrated that the rate of successful intubation with the McL decreased with chest compression, and intubation time significantly increased under cervical stabilization. However, use of the AWS decreased intubation time as well as the frequency of failed tracheal intubations under cervical stabilization. Further, all participants were successful intubating with the AWS during chest compression. Although participants had significantly less clinical experience with the AWS than with the McL before the study, the rate of successful intubations was higher with the AWS; in addition, intubation times were shorter with the AWS, and subjective evaluation as assessed by VAS score was lower. During an emergency situation, airway management is often performed by less-experienced physicians [24]. A short training on the use of the video laryngoscope will be beneficial for novice doctors in emergency airway management [25, 26].

A previously reported possible reason for ATQ weakness during chest compression is that rescuers need to bring the eye close to the ATQ during use; thus, any movement of the head would increase the difficulty of observing the larynx and passing the tube through the glottis [11, 12]. However, with cervical stabilization, head and neck movements resulting from chest compression are minimized. Actually, in our first trial, the intubation time was significantly shortened under cervical stabilization compared to that without it. The mean time difference, 6.4 s, is not negligible in the situation of resuscitation. Therefore, we decided to compare the utility of AWS and ATQ during chest compression under cervical stabilization. However, in the second trial, the ATQ showed lower performance compared to AWS during chest compression under cervical stabilization. One considerable advantage of the AWS may be that the attached tube is designed to advance toward the target mark on the screen, which facilitates intubation by adjusting the glottis position within the target mark [21, 22]. Another considerable reason is that the AWS provides rescuers with a wider monitor than that of ATQ, resulting in easy manipulation of the tube passage through the glottis.

The VAS score for laryngoscopy did not significantly differ with chest compression for the ATQ or AWS. However, chest compression lowered the VAS score for passage through the glottis for the ATQ, but not the AWS. Thus, the superiority of the AWS to ATQ results, in part, from easier tube passage through the glottis. Features of AWS such as easy tube manipulation by the target mark and the wide screen may contribute to the rapid and definite tube passage through the glottis. Although the ATQ is an effective intubation tool, the AWS appears to be a more suitable device for airway management under cervical stabilization with chest compression.

The present study has a number of limitations worth noting. First, the simulations did not take into account factors such as the oropharynx filling with blood, vomitus, or sputum. Use of the AWS may be impaired in patients with restricted mouth opening as a consequence of rigid cervical collars. In addition, there is a theoretical risk of fogging with the AWS, resulting in blurred images. Furthermore, the present study was performed with a manikin rather than real patients. Although we used a manikin that was designed for training in simulated chest compression and airway management, a drawback of using the manikin is that the time needed to perform airway intervention is generally shorter than the time required in patients [27]. Randomized trials are needed to compare the use of AWS, ATQ, and McL in patients receiving CPR under cervical stabilization in clinical situations.

In conclusion, the AWS was superior to the McL and ATQ in this manikin study of endotracheal intubation during simulated cervical stabilization and ongoing chest compression.

Conflict of interest The authors have no affiliation with any manufacturer of any device described in the manuscript and declare no financial interest in relation to the material described in the manuscript. Financial support for the study was provided by our institution and department.

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