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ORIGINAL ARTICLE

Validation of the Pentax-AWS Airwayscope utility as an intubation device during cardiopulmonary resuscitation on the ground

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Abstract

Purpose The 2005 American Heart Association guidelines for cardiopulmonary resuscitation emphasize that all rescuers should minimize interruption of chest compressions even for endotracheal intubation. We previously reported that the utility of the Pentax-AWS Airwayscope (AWS) was superior to that of the Macintosh laryngoscope (McL) for securing airways during chest compression in "on the bed" simulated circumstances. However, because most cardiopulmonary arrest happens "on the ground" in the real world, we compared the utility of the McL and the AWS during chest compression on the ground and on the bed.

Methods Fourteen doctors training in the anesthesia department performed tracheal intubation on a manikin with the McL and the AWS in simulations "on the bed" and "on the ground".

Results In the McL trial, 6 participants failed on the bed, and 10 of them also failed on the ground during chest compression. In the AWS trial, all participants successfully secured the airway regardless of chest compression both on the bed and on the ground. With the AWS, intubation time was not lengthened because of chest compression either on the bed or on the ground. The AWS scored better than the McL on the visual analog scale in laryngoscopy and tube passage of the glottis both on the bed and on the ground.

Conclusion We conclude that the AWS is an effective device for endotracheal intubation during chest compression not only on the bed but also on the ground.

Keywords Pentax-AWS Airwayscope · Macintosh laryngoscope · Chest compression · Manikin · On the ground

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Introduction

Airway management during cardiopulmonary resuscitation (CPR) is often performed under sub-optimum conditions because of several influencing factors, for example patient anatomy, severity of trauma, presence of hemorrhage, obstruction of the airway with a foreign object, position of the patient, and CPR skills of the rescuer, and circumstantial factors, for example location where CPR is performed. According to the American Heart Association (AHA) 2005 guidelines for CPR, rescuers are strongly encouraged to minimize interruption of chest compressions [1, 2]. Therefore, rescuers often encounter difficulties securing the airway.

The Pentax-AWS Airwayscope (AWS; Hoya, Tokyo, Japan) is a new, rigid, videolaryngoscope for tracheal intubation that provides a non-sightline view of the airway [3]. Increasing evidence indicates that the AWS may be suitable for tracheal intubation in various clinical settings involving difficult airway or emergency status [4–6].

Previously, we reported that the AWS may be a more effective device to secure the airway than the Macintosh laryngoscope (McL) during chest compression simulation on a manikin on the bed [7]. To use the McL for tracheal intubation, the patient should be placed supine on a stable table of appropriate height, with the head extended and the lower neck flexed. Cardiopulmonary arrest occurs not only on the hospital bed but also on the ground [8, 9]. The position of the patient lying on the ground may not always be ideal to provide the rescuer with an optimum position for tracheal intubation [10, 11].

We hypothesized that the AWS may be favorable for tracheal intubation during chest compression while performing CPR on the ground. Therefore, we compared the performance of the AWS and the McL on the bed and ground, during chest compression, with a manikin.

Materials and methods

Approval for this study was obtained from the college's Research Ethics Committee. Between September and November 2009, 16 non-anesthesia residents and initial trainee doctors who temporarily worked in the department of anesthesia were invited to participate in the study. Fourteen doctors agreed to participate, and none had previous experience partaking in manikin studies. Each doctor was asked about their prior experience with general anesthesia and provided written consent before participating in the study.

The AirMan® (Laerdal, Sentrum, Stavanger, Norway) manikin was used for performing intubation and chest compression [7]. A size 3 blade of the McL or a standard Intlock blade of the AWS was used as described in previous studies [12–14]. A tracheal tube (Portex, St. Paul, MN, USA) with an internal diameter of 7.5 mm was used.

The manikin was placed on a solid table or on the floor for "on the bed" or "on the ground" simulations, respectively. Chest compressions were performed by the same Advanced Cardiac Life Support (ACLS) instructor at a rate of 100 per minute according to guidelines.

The study was designed as a randomized cross-over trial in order to minimize learning effects. First, the order of on the bed or on the ground simulations was randomized, where half the participants were asked to start with on the bed simulation and the rest to start with on the ground simulation. Second, the order of interventions with or without chest compression was randomized for each participant by drawing tickets from an envelope. All on the bed simulation trials were performed at the same height. This randomization process resulted in a total of eight interventions per participant, with four trials on the bed and four trials on the ground.

Each participant was instructed to place the tracheal tube, inflate its cuff, connect a self-inflating bag, and attempt to ventilate the lungs of the manikin. There was no requirement to tie the tracheal tube in place. The starting-point of the intubation attempt was when the participant picked up the AWS or McL and the end-point was the point of manual ventilation after insertion. The necessary equipment for each intervention was placed on a pillow next to the manikin's head. Participants were given time to practice tracheal intubation using the McL or AWS. Intubation times from the starting-point to the end-point were recorded for both tracheal and esophageal intubations.

Participants were told to secure the airway as soon as possible, but if they found tracheal intubation extremely difficult they were allowed to choose between continuous chest compression or discontinuation for up to 10 s. The time for which chest compression was discontinued (i.e., "hands-off" time) was recorded.

At the end of the examination, participants rated the difficulty of use of each device on a visual analog scale (VAS) from 0 mm (extremely easy) to 100 mm (extremely difficult) for laryngoscopy and passage of the tracheal tube through the glottis.

Results obtained from each trial were compared using two-way repeated measures analysis of variance for intubation time and VAS, the unpaired Student's t test for comparison of intubation experience between the McL and AWS, and the chi-squared test for success rate. Data were presented as mean $\pm$ SD. A P value <0.05 was considered statistically significant.

Result

The average clinical experience with anesthesia of the 14 participants was 3.0 ± 1.3 months. Number of uses of the McL was significantly greater than that of the AWS (50.7 ± 27.7 vs. 3.7 ± 2.7 times, $P < 0.01$).

Success of endotracheal intubation

Table 1 shows the number of successful intubations for each trial. In the McL trial on the bed, all intubations without chest compression were successful, and six of 14 participants performed esophageal intubation during chest compression ($P < 0.01$). In contrast, in the McL trial on the

Table 1 Number of successful tracheal intubations/all intubations in each trial

	No CPR	CPR	*P* value
McL-Bed	14/14	8/14	<0.01
McL-Ground	11/14	4/14	<0.01
AWS-Bed	14/14	14/14	NS
AWS-Ground	14/14	14/14	NS

McL Macintosh laryngoscope, *AWS* airway scope, *CPR* cardiopulmonary resuscitation, *Bed* on the bed, *Ground* on the ground

ground, three of 14 participants performed esophageal intubation even without chest compression, and ten of 14 participants performed esophageal intubation during chest compression ($P < 0.01$).

With AWS, all tracheal intubations performed both on the bed and on the ground were successful regardless of chest compression.

Intubation time

Results for intubation time are shown in Fig. 1. In the McL trial, intubation time was significantly longer on the ground than on the bed, even without chest compression ($P < 0.05$). Performing chest compression significantly increased intubation time not only on the bed but also on the ground (on the bed: 11.7 ± 1.7 s without chest compression vs. 20.1 ± 4.9 s during chest compression, $P < 0.01$; on the ground: 17.3 ± 3.2 s without chest compression vs. 30.5 ± 12.1 s during chest compression, $P < 0.01$).

In contrast, intubation times on the bed and on the ground were almost equivalent with the AWS. The times were not significantly lengthened by chest compression on the bed (11.8 ± 1.7 s without chest compression vs. 12.9 ± 2.0 s during chest compression) or on the ground (12.1 ± 1.7 s without chest compression vs. 14.2 ± 3.3 s during chest compression).

Furthermore, intubation times during chest compression were significantly shorter with the AWS than with the McL for both on the bed and on the ground simulations.

Discontinuation of chest compression

In the McL trial, two participants requested discontinuation of chest compression on the bed (discontinuation times were 4.9 and 3.2 s), and five participants requested discontinuation of chest compression on the ground (mean discontinuation time was 6.6 ± 0.7 s). In the McL trial, participants who requested discontinuation performed tracheal intubation uneventfully on the bed, but one of five participants failed tracheal intubation with the McL on the ground. In the AWS trial, only one participant requested the discontinuation of chest compression (discontinuation time of 3.3 s).

VAS of intubation difficulty

The VAS scores for laryngoscopy and passage of the tube through the glottis are shown in Fig. 2. The VAS score of the McL was significantly higher for on the ground than on the bed simulations, regardless of chest compression. In contrast, the difficulty of AWS application did not significantly change between on the bed and on the ground simulations. The VAS score for the AWS was significantly

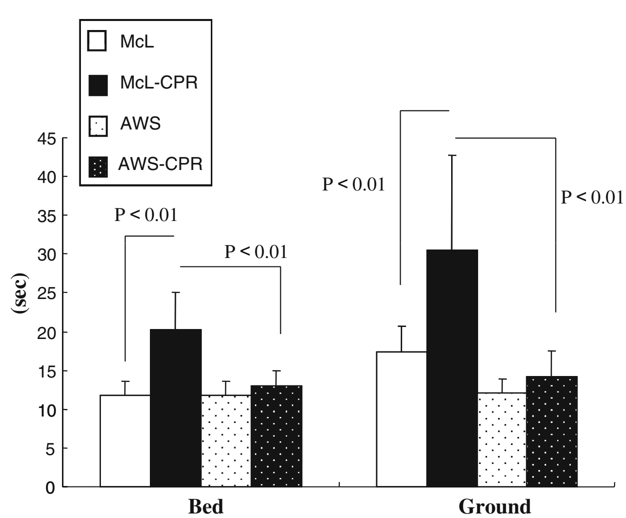

Fig. 1 Comparison of intubation time for each simulation. *McL* Macintosh laryngoscope, *AWS* airway scope, *CPR* cardiopulmonary resuscitation, *Bed* on the bed, *Ground* on the ground

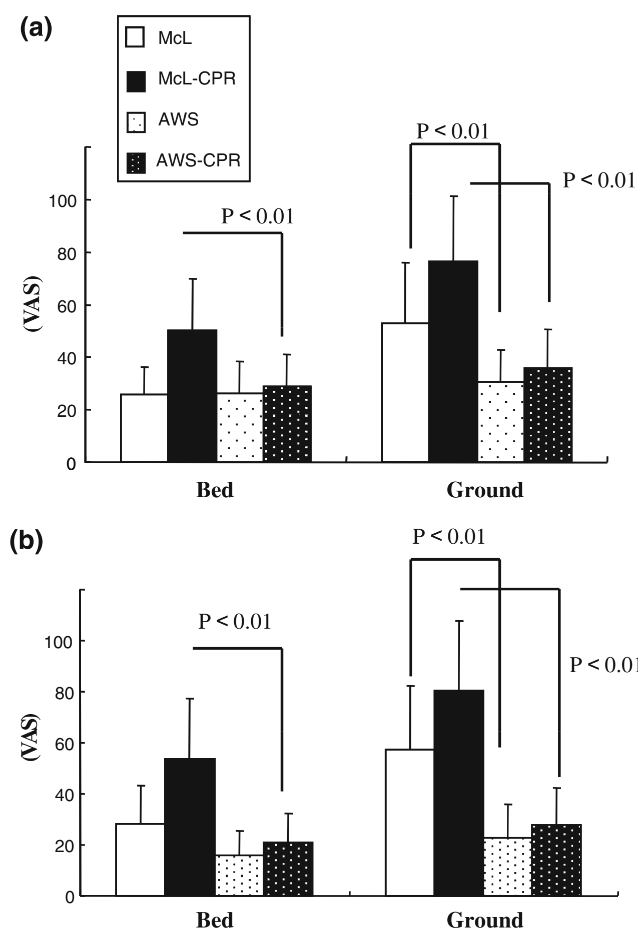

Fig. 2 VAS score for laryngoscopy and passage of the tube through the glottis for each simulation. **a** Laryngoscopy, **b** passage of the tube through the glottis. *McL* Macintosh laryngoscope, *AWS* airway scope, *CPR* cardiopulmonary resuscitation, *VAS* visual analog scale, *Bed* on the bed, *Ground* on the ground

lower than that for the McL for both laryngoscopy and passage of the tube for both on the bed and on the ground simulations during chest compression.

Discussion

Current AHA-ACLS guidelines emphasize the delivery of continuous chest compression with as few interruptions as possible, including pauses for airway management efforts [15]. Several studies have shown that prolonged interruption of chest compression is associated with both decreased coronary and cerebral perfusion and reduced venous return to the heart, resulting in low survival and impaired post-resuscitation myocardial function [16–18].

Airway management is considered to be one of the essential elements of both in-hospital and out-of-hospital CPR. Although the conventional McL is the most widely used laryngoscope for tracheal intubation, its use is considered a difficult skill to be performed. Incidence of inaccurate intubation can be unacceptably high for occasional operators. The AHA-ACLS guidelines do not always recommend tracheal intubation for all operators, suggesting the alternative use of supraglottic devices, for example the laryngeal mask airway (LMA) or Combitube [1]. However, the use of these devices risks insufficient ventilation or expansion of the stomach, leading to gastric fluid regurgitation and aspiration pneumonia [19].

The AWS is a new videolaryngoscope for tracheal intubation designed to provide a clear view of the glottis and its surrounding structures [4, 5]. The AWS improves the laryngeal view and its tube guide facilitates rapid and reliable tracheal intubation under vision even for difficult cases such as cervical neck immobility or morbid obesity [6]. Increasing evidence indicates that the AWS is suitable for tracheal intubation during various difficult airway management (DAM) and emergency situations, and is easy to use for trainees and beginners [20, 21]. Reports indicate that the AWS requires less operator skill and is highly suitable for operators who perform infrequent tracheal intubations outside the operating room during emergencies. Moreover, a tracheal tube can be easily inserted through its built-in conduit [3]. When the target mark of the AWS is aligned on the glottis, as shown in the monitor, the tracheal tube is pushed, allowing passage through the vocal cords.

The concept of DAM includes physical difficulties associated with the patient, for example a small jaw and restricted opening of the mouth [22, 23]. It also includes several situations that make intubation more difficult, for example administration of CPR and location during intubation. Previously, we reported the superior use of the AWS compared with the McL during chest compression on the bed [7].

From the viewpoint of location of the victims, a patient lying on the ground does not provide the rescuer with an ideal position for tracheal intubation with the McL [10, 11]. Tracheal intubation with the McL requires axial alignment of the oral cavity, pharynx, and larynx and handling of tracheal tubes. It has been reported that such axial alignment is often hard when the patient is on the ground [17, 18]. In contrast, the AWS provides a non-sightline view of the airway and does not need such axial alignment [5, 6]. In this study the VAS score for laryngoscopy with the McL was significantly higher on the ground than on the bed, even without chest compression. In the AWS trial there was no significant difference.

In this study we demonstrated that the success rate for intubation with the McL decreased during chest compression on the bed and on the ground, with a significant increase in intubation time. The AWS reduced intubation time and the frequency of failed tracheal intubations in both on the bed and on the ground simulations. All participants were successful in intubating with the AWS during chest compression. Although clinical experience of AWS use was significantly less than with the McL, participants had a high success rate, short intubation times, and their subjective evaluation by VAS score was low. During an emergency, airway management is often performed by less experienced physicians. A short training period on the use of the videolaryngoscope for doctors in training and residents will be beneficial for future emergency airway management [24, 25].

This study has a number of limitations worth noting. First, the simulations do not take into account other factors, such as when the oropharynx is filled with blood, vomitus, or sputum. Use of the AWS may be impaired in patients with restricted mouth opening. There is also a theoretical risk of blurred images in the AWS caused by fogging. Second, this study was performed on a manikin rather than real patients. The manikin used in our study was intended for training in simulated chest compression and airway management. A drawback of using a manikin is that the time needed to perform airway intervention is generally shorter than the time required for patients [12, 13].

There is one case report of successful intubation with the AWS performed without the interruption of chest compression [26]. Randomized trials of AWS or McL use in patients receiving CPR in clinical situations are needed in the future. We conclude that the AWS is an effective tool for endotracheal intubation during chest compression on the bed and on the ground.

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