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ORIGINAL ARTICLE

Utility of the Pentax-AWS Airwayscope and Macintosh laryngoscope for airway management during chest compressions in 27° left-lateral tilt: a manikin simulation study of maternal cardiopulmonary resuscitation

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Abstract
Purpose American Heart Association (AHA) 2010 cardiopulmonary resuscitation guidelines recommend high-quality chest compressions (minimum interruption, a pace >100 compressions/min, and a depth more than 5 cm). They propose minor changes for pregnant women: manual left deviation of the uterus or a left-lateral incline of 27°–30° to alleviate pressure on the inferior vena cava. We examined the performance of the Pentax-AWS Airwayscope (AWS) and Macintosh laryngoscope (McL) for airway management during chest compressions on a 27° left-lateral tilt (27 LLT) operating table.
Methods The study included 18 novice doctors in our anesthesia department. They performed tracheal intubation on a manikin positioned on a 27 LLT operating table using the AWS or McL with or without chest compressions. We measured the intubation time and success rate for tracheal intubation.
Results Intubation success rate with the McL decreased with chest compressions compared to without chest compressions (12/18 vs. 18/18, $P < 0.05$). Intubation time with the McL was lengthened with chest compressions compared to without chest compressions (18.9 ± 4.0 s vs. 11.1 ± 1.0 s, $P < 0.05$). Intubation success rate was the same for the AWS with and without chest compressions (18/18 in both cases), and intubation time did not increase significantly without compressions compared to with compressions (11.6 ± 1.4 s vs. 12.6 ± 1.2 s, NS).
Conclusions The AWS is an effective tool for airway management during chest compressions in 27 LLT in a manikin, suggesting that the AWS may be a useful device for airway management during maternal resuscitation.

Keywords Chest · Compression · Maternal cardiopulmonary resuscitation · 27° left-lateral tilt

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Introduction

Pregnancy-related mortality is rare in developed countries, estimated to occur in approximately 1:30,000 deliveries [1]. Although pregnant women are younger than most patients who experience cardiopulmonary arrest, their survival rate is poorer. One report from the United Kingdom shows that only 6.9 % of pregnant women survive cardiac arrest [2].

The American Heart Association (AHA) 2010 Advanced Cardiac Life Support (ACLS) guidelines emphasize high-quality chest compressions characterized by minimum interruption, a pace of more than 100 compressions/min, and a depth >5 cm [3]. Cardiopulmonary resuscitation (CPR) of pregnant woman is rare, but must be addressed promptly [4]. The guidelines recommend the following two minor changes for effective chest compressions on pregnant women: perform chest compressions closer to the head than usual, and manually deviate the uterus to the left and left-laterally incline 27°–30° (27 LLT) to prevent pressure on the inferior vena cava. According to these recommendations, CPR in pregnant women should include rapid and definite airway management, such as tracheal intubation during chest compressions modified as just described [4, 5].

The Pentax-AWS Airwayscope (AWS) is an intubation device that allows indirect observation of the glottis. The utility of the AWS for emergent tracheal intubation during chest compressions has been reported by several groups [6, 7]. Furthermore, there are reports that the AWS is useful in lateral and supine positions [8]. Based on these findings, we hypothesized that pregnant women might be more accurately intubated with the AWS than with the Macintosh laryngoscope (McL) during chest compressions in 27 LLT. However, such a clinical study does not appear to be a feasible, because cardiac arrest during pregnancy is fortunately a rare event. For this reason, we conducted such a simulation-based manikin study.

To this end, we examined the utility of the AWS and McL during chest compressions in 27 LLT using a manikin.

Materials and methods

This study was approved by the Research Ethics Committee of the Hyogo College of Medicine. Eighteen novice doctors with less than 1 year of experience with anesthesia were invited to participate, and all agreed. Doctors were asked about their prior experience with general anesthesia and provided their written consent to participate.

For intubations, we used the AirMan manikin (Laerdal, Stavanger, Norway) and the size 3 blade of the McL or the standard Intlock blade of the AWS. For each insertion, all airway devices and the manikin's airway were well lubricated in accordance with manufacturer's instructions. The internal diameter of the tracheal tube (Portex, St. Paul, MN, USA) was 7.5 mm. An Alphamaquet table (Maquet; MAQUET, Germany) was used as the 27 LLT operating table. Participants were given 5 min to practice intubation with the AWS and McL.

The manikin was placed on the operating table in 27 LLT. The same advanced cardiac life support (ACLS) instructor carried out 100 chest compressions/min, more than 5 cm deep, without interruption, and from the left side according to the guidelines.

A cross-over trial design was used with trial order randomized by lots to minimize learning effects. Each participant intubated with the AWS or McL, with or without chest compressions (Fig. 1). This randomization process resulted in a total of four interventions per participant. Each participant performed intubation with the AWS or McL, inflated a tube cuff with 5 ml air, connected it to a bag-valve-mask, and attempted ventilation of the manikin's lungs.

Intubation times were recorded from start-point to end-point: the start-point was when the participant picked up the AWS or McL, and the end-point was manual ventilation after intubation, regardless of success or failure in inflating the manikin's lungs. Successful ventilation was

Fig. 1 Trial scenes with the Macintosh laryngoscope and Pentax-AWS Airwayscope for tracheal intubation in 27° left-lateral tilt. **a** Trial with the Macintosh laryngoscope during chest compressions on a 27° left-lateral tilt operating table. **b** Trial with the Pentax-AWS Airwayscope during chest compressions on a 27° left-lateral tilt operating table

confirmed by visible chest rise of the manikin. Participants were instructed to secure the airway as quickly as possible.

Sample size was calculated based on our previous study regarding the time required for intubation in a normal state [7]. The mean (SD) time was 13.9 (4.4) s to ventilate the lungs after tracheal intubation. To detect a 33 % difference in intubation time with a power of 0.8, we estimated that 16 operators would be adequate for each device.

Intubation time was expressed as mean ± standard deviation. We analyzed data with two-way repeated-measures analysis of variance (ANOVA) for intubation time, the χ^2 test for rate of intubation success, and the unpaired Student's t test for clinical experience with the McL or AWS. $P < 0.05$ was considered significant.

Results

The mean training period in our anesthesia department was 3.0 ± 1.1 months. The mean number of times participants used the McL was 37.3 ± 10.5, which was significantly higher than the number of times they used the AWS (3.7 ± 2.0 times; $P < 0.05$).

Number of successful intubations

Table 1 shows the number of successful intubations. All participants successfully intubated with the McL and AWS without chest compressions. The rate of intubation success with chest compressions was only 12/18 with the McL, whereas it was 18/18 with the AWS ($P < 0.05$). The rate of intubation success with the AWS did not decrease by chest compression, whereas that of the McL significantly decreased ($P < 0.05$).

Table 1 Number of successful intubations for each intervention

	Without chest compression (success/total)	With chest compression (success/total)	*P* value
McL	18/18	12/18	<0.05
AWS	18/18	18/18	NS
P value	NS	<0.05	

NS not significant, *McL* Macintosh laryngoscope, *AWS* Pentax-AWS Airwayscope

Table 2 Intubation times for each intervention

	Without chest compression	With chest compression	*P* value
McL	11.1 ± 1.0 s	18.9 ± 4.0 s	<0.05
AWS	11.6 ± 1.4 s	12.6 ± 1.2 s	NS
P value	NS	<0.05	

NS not significant, *s* second, *AWS* Pentax-AWS Airwayscope, *McL* Macintosh laryngoscope

Intubation times

Intubation times are shown in Table 2. Intubation time with the McL during chest compressions lengthened significantly compared to without chest compressions (11.1 ± 1.0 s vs. 18.9 ± 4.0 s; $P < 0.05$). Intubation times with the AWS did not significantly differ with or without compressions (12.6 ± 1.2 s vs. 11.6 ± 1.4 s, respectively; NS). Intubation time with the AWS was significantly shorter than with the McL during chest compression ($P < 0.05$).

Discussion

The AHA-2010-ACLS guidelines make several points about the resuscitation of pregnant women [3, 9]. First, emergency cesarean section should always be considered to save the lives of mother and fetus, or the mother only. If cesarean section can be performed within 5 min from cardiac arrest, a newborn infant at 24–25 weeks of gestation has a good prognosis for survival [10]. Furthermore, the mother can be rescued because her vena cava is released from compression by the uterus. Second, chest compressions must be performed closer to the head than usual because the mother's diaphragm shifts upward during pregnancy. Third, chest compressions should be executed with a manual shift of the uterus to the left or with a 27°–30° left-lateral tilt to avoid compression of the inferior vena cava [11].

Changes in the mother's body during pregnancy include an increase in respiratory minute volume and oxygen consumption, and a decrease in reserve air and functional residual capacity because of the elevated diaphragm [3]. Hypoventilation can quickly progress to hypoxemia. Thus, quick and decisive airway management and ventilation are very important in maternal resuscitation [4].

Airway management with general anesthesia, even for elective cesarean section, is potentially difficult because patients have a low tolerance to hypoxia, high risk of aspiration from a rise in gastric pressure, and unique upper airway narrowing [12, 13]. The incidence of failed tracheal intubation is much higher in pregnant patients than in nonpregnant patients. In emergent situations such as CPR, the difficulty increases. The AHA 2010 ALS guidelines recommend early and careful establishment of the airway during CPR in pregnant women [3].

The McL is the most widely used laryngoscope for tracheal intubation in obstetrics airway management, but its use requires skill and the incidence of inaccurate intubation can be unacceptably high, especially for occasional operators. Failure of tracheal intubation during cardiopulmonary resuscitation can result in serious complications such as stomach expansion, vomiting, and hypoxia, leading to poor outcomes [12].

The AWS is a videolaryngoscope for tracheal intubation designed to provide a clear view of the glottis and its surrounding anatomy [14]. The AWS improves the laryngeal view, and its tube guide facilitates rapid and accurate tracheal intubation, even for difficult cases such as cervical neck immobility or morbid obesity [15, 16]. Increasing evidence indicates that the AWS is suitable for tracheal intubation during emergent situations, such as CPR or restricted access [17, 18].

Using the McL in 27 LLT, the axes between the tube and the glottis do not agree because of the inclination. Furthermore, the glottis moves up and down with chest compressions. These difficulties synergistically increase the difficulty of laryngoscope placement and smooth tube passage through the glottis. With the AWS, the axes between the tube and the glottis do not change in 27 LLT. The glottis and the tube move vertically during chest compressions, and the relative position between the tube and the glottis does not change on the video monitor. These characteristics allow rapid and accurate tracheal intubation using indicators on the AWS screen. Additionally, as the height of the resuscitation table is low to facilitate chest compressions, it may be difficult to perform direct laryngoscopy with McL because of increased bending of the back. As the AWS provides non-sightline view of the airway, participants could easily perform tracheal intubation even at the low-height table.

Our results suggest that there might be either less or no interruption of chest compressions with the use of the AWS by novice doctors. Furthermore, with the AWS, visualization of the tube passing through the vocal cords can be performed by another, more experienced doctor, which might lessen the chance of an esophageal intubation by a novice.

Our study has some limitations. First, there is the possibility that we could not completely simulate the anatomical changes of pregnancy. There may be additional airway difficulties to consider, such as edema of the tongue and trachea [12, 13]. Second, in the clinical situation, left uterine displacement could be created with material placed underneath the patient on the right side, which would have less effect on the position of the head. Third, as we conducted this survey with novice doctors, it is possible that more-experienced doctors may have had better success with the McL. Furthermore, our study is a manikin simulation, and there are differences between simulation and a real clinical situation [19].

We conclude from a simulation manikin study that the AWS may be an effective device for airway management of pregnant women during cardiopulmonary resuscitation in 27 LLT.

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

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