J Anesth (2015) 29:331–337
DOI 10.1007/s00540-014-1936-1

ORIGINAL ARTICLE

Comparison of tube-guided and guideless videolaryngoscope for tracheal intubation during chest compression in a manikin: a randomized crossover trial

Daisuke Okada · Nobuyasu Komasawa · Shunsuke Fujiwara · Toshiaki Minami

Received: 24 September 2014 / Accepted: 15 October 2014 / Published online: 28 October 2014

Abstract
Background Previous studies have shown the utility of indirect glottis viewing videolaryngoscopes for tracheal intubation during chest compression, but the efficacy of a videolaryngoscope with tube guide has not been sufficiently validated. We compared the utility of two videolaryngoscopes, the KingVISION® (KingV) with or without tube guide blade and Pentax-AWS Airwayscope® (AWS), which contain tube guide function, during chest compressions on an adult manikin.
Methods Twenty-five novice doctors and 22 experienced anesthesiologists performed tracheal intubation on an adult manikin using the AWS and KingV with or without chest compressions. The KingV trials were performed either with a tube guide 'channeled blade' (KingV-Guided) or without, using a 'standard blade' (KingV-Guideless).
Results In the KingV-Guideless trial, all novice doctors successfully secured the airway without chest compressions but seven failed with chest compressions ($p < 0.05$), while no experienced doctors failed without chest compression and two did during chest compression. In the AWS and KingV-Guided trials, all participants succeeded both with and without chest compressions performed by both novice doctors and experienced anesthesiologists. Intubation time was lengthened significantly by chest compressions in the KingV-Guideless trial ($p < 0.05$), but not in the AWS or KingV-Guided trials performed by both novice doctors and experienced anesthesiologists. The intubation time for KingV-Guided during chest compression was significantly smaller by experienced anesthesiologists compared to by novice doctors.
Conclusions These findings suggest that the AWS and KingV-Guided devices are more effective than the KingV-Guideless for airway management with chest compressions in adult simulations, especially performed by novice doctors. The tube guide function may contribute to successful airway management during chest compression by the added videolaryngoscopy function.

Keywords KingVISION® · Pentax-AWS Airwayscope® · Tube guide · Tracheal intubation · Chest compression

D. Okada · N. Komasawa (✉) · S. Fujiwara · T. Minami
Department of Anesthesiology, Osaka Medical College, Daigaku-machi 2-7, Takatsuki, Osaka 569-8686, Japan
e-mail: ane078@poh.osaka-med.ac.jp

Introduction

The European Resuscitation Council (ERC) cardiopulmonary resuscitation (CPR) guidelines emphasize the importance of minimizing chest compression interruptions to maximize coronary and cerebral perfusion pressure. The guidelines also suggest that rescuers should be able to secure the airway without interrupting chest compressions to visualize vocal cords and allow passage of the tracheal tube [1, 2].

The Pentax Airwayscope® (AWS; Hoya, Tokyo, Japan) is a videolaryngoscope reported to provide an indirect view of the airway and easy and definite tracheal intubation with tube guide [3]. Previous simulation studies have found that the AWS is useful not only for difficult airway management but also for emergent tracheal intubation with chest compressions [4–6]. The KingVISION® (KingV; King-Systems, Noblesville, USA) is a device that has been developed with a high-resolution video camera, providing indirect views of the glottis and tube guide or guideless

blade available. Utility of KingV are also reported in various situations involving difficult airways [7, 8]. While the AWS and KingV contain similar indirect glottis viewing function for difficult or emergent airway management, there have been no studies comparing the utility of these two devices during resuscitation situations. Furthermore, it has been suggested that not only the indirect glottis viewing but also the tube guide is effective for tracheal intubation with videolaryngoscope during chest compression [4–6]. We considered that comparison of KingV with or without tube guide and AWS, which contain tube guide function, may clarify the role of tracheal tube guide function of videolaryngoscope for tracheal intubation during chest compression.

The present study aimed to determine which of the two devices would improve intubation in simulations with chest compressions and whether tube guide function may contribute to the rapid and definite tracheal intubation during chest compression. To this end, we compared the performance of the AWS versus the KingV with or without tube guide for tracheal intubation by novice doctors or experienced anesthesiologists in a manikin simulation with chest compressions.

Materials and methods

This study was approved by the institutional review board of Osaka Medical College, and written informed consent was obtained from each participant. For the evaluation of clinical experience difference, novice doctors and experienced anesthesiologists were recruited. From May to August 2014, 25 novice doctors who attended an anesthesiology training module at Osaka Medical College were recruited. Novice doctors performed trials when they had completed 1.0 month of anesthesia training with 20–30 tracheal intubation experience with Macintosh laryngoscope. Twenty-two experienced anesthesiologists with more than 2 years of clinical experience were recruited from anesthesiology training simulation course that was held on July 5 and 6, and August 2 and 9, 2014. Their clinical experience of anesthesia was about 6.5 ± 4.5 years. Participants completed a questionnaire about their previous experience with airway management using the AWS and KingV.

The ALS simulator® (Laerdal, Sentrum, Stavenger, Norway) manikin was used to perform intubation and chest compressions. A size 3 blade and a standard Intlock blade were used for the KingV and the AWS, respectively. KingV trials were performed either with the tube guide 'channeled blade' (KingV-Guided) or with a 'standard blade' (KingV-Guideless) (Fig. 1). Tracheal tubes (Portex, St. Paul, MN, USA) with an internal diameter of 7.5 mm were used [9].

The manikin was placed on a hard, flat table for an "on the bed" simulation. Chest compressions were performed by the same Advanced Life Support instructor at a depth of about 5 cm and a rate of 100 compressions per minute in accordance with current guidelines.

Each participant was instructed to insert the tracheal tube, attach a bag valve mask, and attempt to ventilate the lungs of the manikin. Participants were given 5 min to practice intubation, with the instructor available to give advice. The necessary equipment for each trial was placed in a box next to the manikin's head. Intubation time started when the participant picked up the AWS, KingV-Guided, or KingV-Guideless and ended at the point of manual ventilation after tube insertion. Intubation times were recorded for both tracheal and esophageal intubations. At the end of the study, participants rated the difficulty of using each device for laryngoscope imaging 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) [10].

Results obtained from each trial were compared using two-way repeated-measures analysis of variance for intubation time and VAS, and Fisher's exact test for the success rate. Data are presented as mean ± SD. $p < 0.05$ was considered statistically significant.

The study was designed as a randomized crossover trial to minimize the learning curve effect. The order of intervention was randomized for each participant by a random table number, which yielded a total of six interventions per participant.

Results from eight doctors in the preliminary study showed that the time required for successful intubation with the AWS was approximately 14 ± 4 s. We considered 5 s as a clinically meaningful difference. We estimated that 22 participants would be adequate for two independent groups, and set $\alpha = 0.05$ and $\beta = 0.2$.

Results

None of the novice doctors had any clinical experience with the KingV, while three participants had used the AWS one time each. All experienced anesthesiologists had clinical experience with AWS for 84.3 ± 36.3 times, while they had used KingV for 2.3 ± 4.5 times.

Tracheal intubation success with the AWS or KingV

Numbers of successful tracheal intubations by novice doctors for each device are displayed in Table 1. With the KingV-Guideless, no participant failed to achieve intubation without chest compressions, and seven failed with chest compressions ($p < 0.05$). All intubation attempts using the

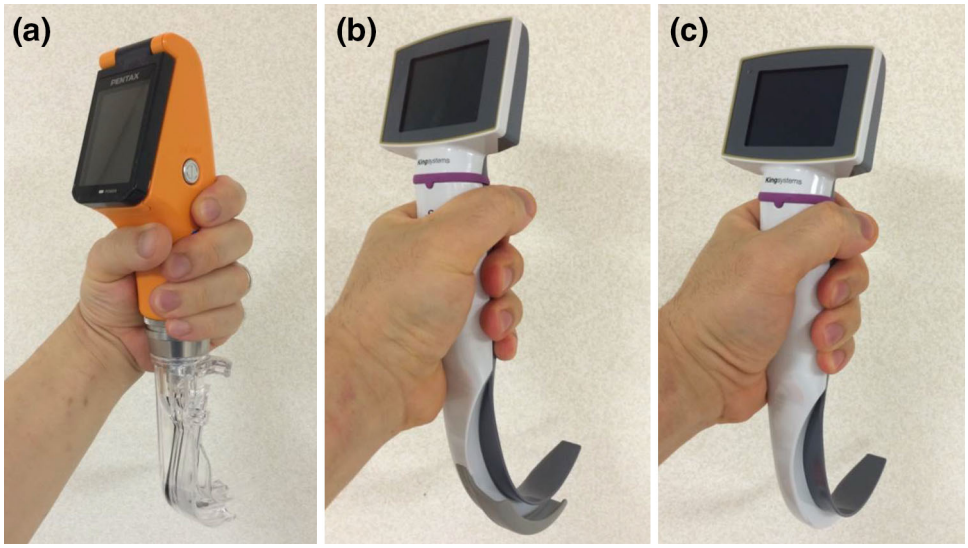


Fig. 1 Laryngoscopes used in the study. **a** Pentax AWS Airwayscope® with normal Intlock, **b** KingVISION® laryngoscope with channeled blade (guided), **c** KingVISION® laryngoscope with standard blade (guideless)

Table 1 Tracheal intubation success rates for KingV and AWS with and without chest compressions by novice doctors

	Without chest compression (successful/total)	With chest compression (successful/total)	*p* value (Fisher's exact test)
AWS	25/25	25/25	1.00
KingV-Guided	25/25	25/25	1.00
KingV-Guideless	25/25	18/25	0.004*

KingV KingVISION® laryngoscope, *AWS* Pentax AWS Airwayscope®

Values are presented as number of participants who achieved successful intubation/number of participants who attempted intubation. * $p < 0.05$

Table 2 Tracheal intubation success rates for KingV and AWS with and without chest compressions by experienced anesthesiologists

	Without chest compression (successful/total)	With chest compression (successful/total)	*p* value (Fisher's exact test)
AWS	22/22	22/22	1.00
KingV-Guided	22/22	22/22	1.00
KingV-Guideless	22/22	20/22	0.48

KingV KingVISION® laryngoscope, *AWS* Pentax AWS Airwayscope®

Values are presented as number of participants who achieved successful intubation/number of participants who attempted intubation

AWS and KingV-Guided devices were successful, regardless of whether or not chest compressions were performed.

Intubation success rate by experienced anesthesiologists for each device are displayed in Table 2. With the KingV-Guideless, no participant failed to achieve intubation without chest compressions, and one failed with chest compressions ($p = 0.48$). Intubation attempts using the AWS and KingV-Guided devices were all successful with or without chest compressions.

For the comparison of novice doctor and experienced anesthesiologists, the success rate was not significantly different during chest compression in KingV-Guideless trial ($p = 0.13$).

Intubation time with the AWS or KingV

Figure 2 shows the intubation time with AWS or KingV by novice doctors (Fig. 2a) and experienced doctors (Fig. 2b). Tracheal intubation with the KingV-Guideless required significantly more time with chest compressions than without compressions ($p < 0.05$). In contrast, chest compressions did not significantly increase the intubation time with the AWS or KingV-Guided.

In both novice doctors and experienced anesthesiologists, intubation time without chest compressions did not significantly differ among the three different trial conditions. The time required for intubation with chest compressions was also significantly shorter in the AWS or KingV-Guided trials than with the KingV-Guideless in both groups ($p < 0.05$).

For the comparison for of experiences of participants, the intubation time was significantly shorter in experienced anesthesiologists than in novice doctors during chest compression in KingV-Guideless trial ($p < 0.05$).

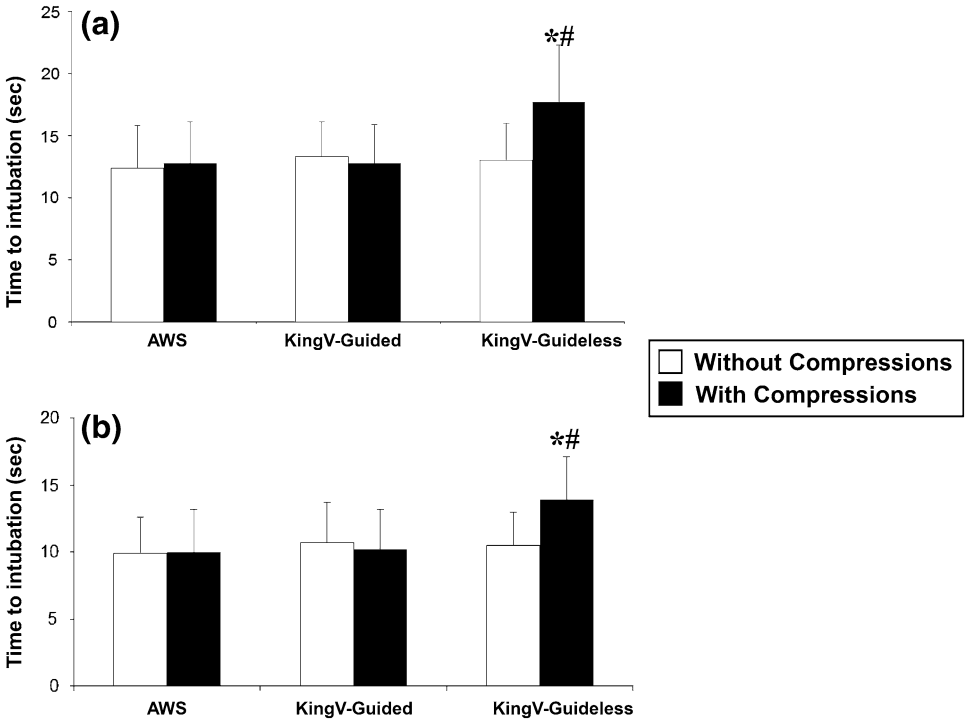


Fig. 2 Time elapsed for simulated tracheal intubation with and without chest compressions for the three trial conditions showing **a** time to intubation by novice doctors and **b** time to intubation by experienced doctors. *KingV* KingVISION® laryngoscope, *AWS* Pentax AWS Airwayscope®; *white box* without compressions; *black box* with compressions. Results are expressed as mean ± SD and were analyzed by two-way analysis of variance. *NS* no significant difference; * $p < 0.05$ compared to without chest compression. # $p < 0.05$ compared to the KingV-Guideless

VAS scores for laryngoscopy and tube passage through the glottis with the AWS or KingV devices

We show the VAS score by novice doctors in Fig. 3a, b. Difficulty of laryngoscopy operation according to the VAS showed no significant increases with chest compressions in all three trial situations, while the ratings for tube passage through the glottis increased with compressions only when using the KingV-Guideless ($p < 0.05$). VAS ratings for laryngoscopy by novice doctors with the AWS did not differ significantly from those with the KingV-Guided or KingV-Guideless, regardless of chest compression. In contrast, VAS ratings for tube passage through the glottis were significantly higher in the KingV-Guideless trial relative to the AWS or KingV-Guided trials, both with and without chest compressions ($p < 0.05$).

VAS for laryngoscopy and tube passage through the glottis by experienced anesthesiologists is shown in Fig. 3c, d. The VAS ratings for laryngoscopy did not change by chest compression or among the devices. The rating of VAS for tube passage glottis was significantly higher in KingV-Guideless than in KingV-guide or AWS during chest compression ($p < 0.05$), but not without chest compression.

For the comparison for of experiences of participants, both VAS for laryngoscopy or tube passage through the glottis was significantly smaller in experienced anesthesiologists than in novice doctors among the three devices regardless of chest compression ($p < 8$).

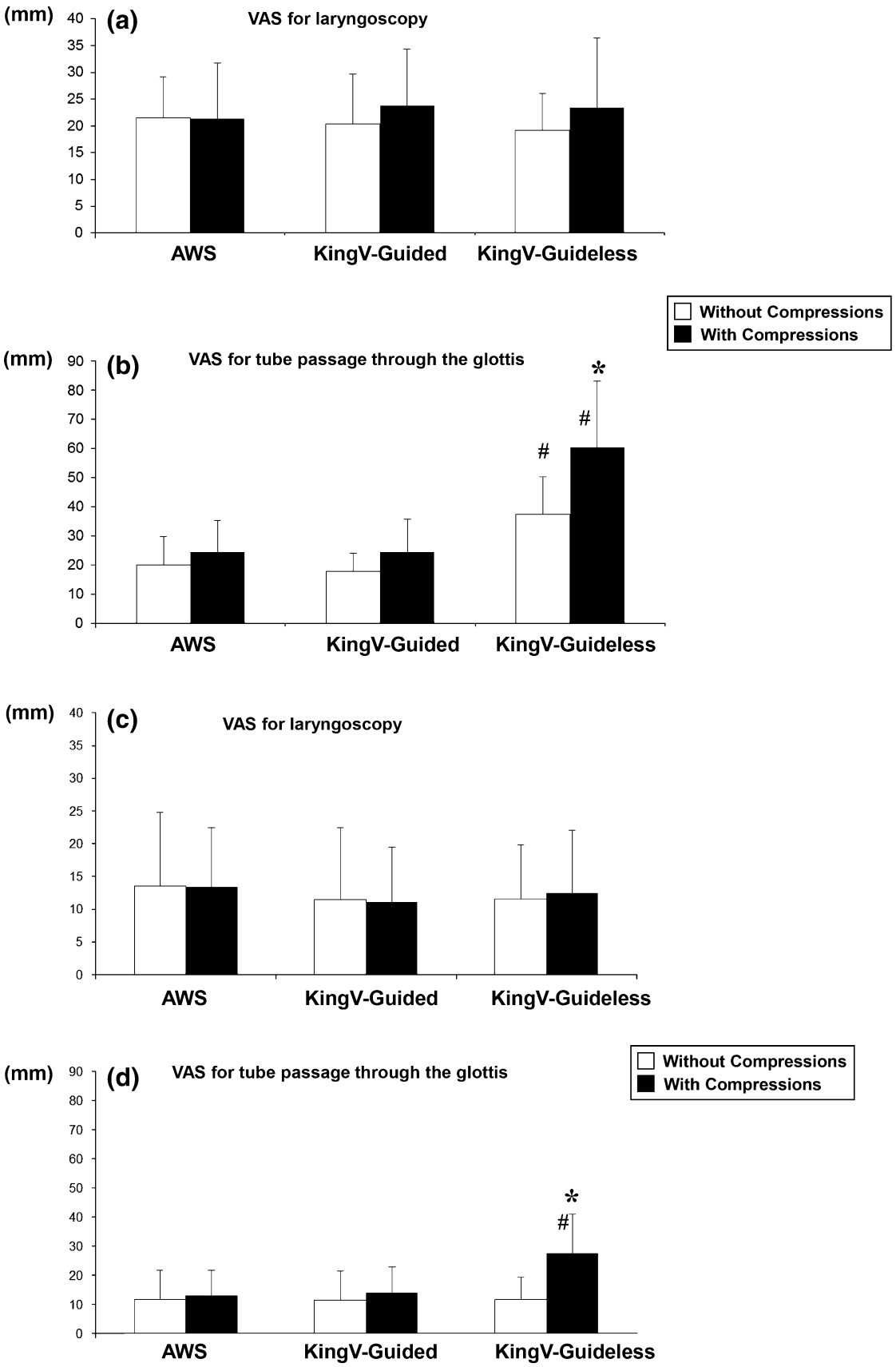
Discussion

Current ERC-CPR guidelines emphasize the importance of continuous chest compression with as few interruptions as possible, even for airway management efforts [1, 2]. Several studies have shown that prolonged interruption of chest compressions is associated with both decreased coronary and cerebral perfusion and reduced venous return to the heart, resulting in low survival rates and impaired post-resuscitation myocardial function [11].

Airway management is considered an essential element, particularly for in-hospital CPR. While the conventional direct view laryngoscope such as the Macintosh laryngoscope is used most widely for tracheal intubation, the skills required for use are difficult to master, and the incidence of inaccurate intubation can be unacceptably high for occasional operators [12, 13].

The AWS is a videolaryngoscope for tracheal intubation designed to provide a clear view of the glottis and its surrounding structures. The AWS improves the laryngeal view, and its tube guide facilitates rapid and reliable

Fig. 3 Visual analog scale for simulated tracheal intubation with and ▶ without chest compressions for the three trial conditions. **a** Laryngoscope image and **b** passage of the tube through the glottis by novice doctors. **c** Laryngoscope image and **d** passage of the tube through the glottis by experienced doctors. *KingV* KingVISION® laryngoscope, *AWS* Pentax AWS Airwayscope®; *white box* without compressions; *black box* with compressions. Results are expressed as mean ± SD and were analyzed by two-way analysis of variance. *NS* no significant difference; * $p < 0.05$ compared to without chest compression. # $p < 0.05$ compared to the KingV-Guideless


(mm)
(a)
VAS for laryngoscopy
40
35
30
25
20
15
10
5
0
AWS
KingV-Guided
KingV-Guideless
Without Compressions
With Compressions
(mm)
(b)
VAS for tube passage through the glottis
90
80
70
60
50
40
30
20
10
0
#
#
*
AWS
KingV-Guided
KingV-Guideless
(mm)
(c)
VAS for laryngoscopy
40
35
30
25
20
15
10
5
0
AWS
KingV-Guided
KingV-Guideless
(mm)
(d)
VAS for tube passage through the glottis
Without Compressions
With Compressions
90
80
70
60
50
40
30
20
10
0
#
*
AWS
KingV-Guided
KingV-Guideless

tracheal intubation under vision, even in difficult cases such as cervical neck immobility or morbid obesity [14, 15]. Increasing evidence indicates that the AWS is suitable for tracheal intubation during various difficult airway management and emergency situations [4–6].

The KingV is an affordable, durable, and portable video laryngoscope. KingV is an indirect laryngoscopy, not only for routine intubations but also for difficult tracheal intubations [7, 8]. The KingV accommodates minimum mouth openings of 13 mm for the standard blade (KingV-Guideless) and 18 mm for the channeled blade (KingV-Guided). The KingV offers clinicians an immediate and clear view of the vocal cords, allowing for more accurate intubation while minimizing soft tissue manipulation.

In the KingV-Guideless trial, all novice doctors succeeded in tracheal intubation with chest compression with the tube guide, but a significant number failed without it. Two experienced anesthesiologists also failed during chest compression in the KingV-Guideless trial. Intubation time was also lengthened by chest compression in the KingV-Guideless trial, but not in the KingV-Guided trial performed by novice doctors and experienced anesthesiologists. As for the comparison of clinical experience difference, intubation time was generally smaller by experienced anesthesiologists than by novice doctors. Both groups succeeded in tracheal intubation with AWS or KingV-Guided with or without chest compression. However, chest compression significantly lengthened intubation time in the KingV-Guideless trial in both groups, with significant decrease in success rate in novice doctor groups.

One probable reason for difficulties experienced with the KingV-Guideless is that the glottis, but not the tube, moved during chest compressions, and thus the relative positions of the glottis and tube were unstable. With both the AWS and the KingV-Guided, the tube and glottis move simultaneously and their relative positions remain the same, leading to easy and safe tracheal intubation. Furthermore, a tracheal tube can be easily inserted through its built-in conduit in the AWS or the KingV-Guided. Once the glottis is aligned in the monitor of the AWS or KingV-Guided, the tracheal tube is pushed, allowing passage through the vocal cords. The tube guide function of the AWS or KingV may facilitate easy and definite tracheal intubation during chest compression. In our previous study evaluating intubation devices during chest compression, we showed the superiority of AWS to McGRATH MAC®, which provides both direct and indirect glottis view but does not contain tube guide [16]. The difference of AWS and McGRATH MAC® performance may be partially associated with or without tube guide existence. Another study comparing the utility of AWS and Glidescope®, which does not contain tube guide for tracheal intubation during chest compression, showed prolonged intubation time of Glidescope® compared to AWS. The difference may be also attributed to the existence of tube guide [17].

This study has several limitations worth noting. First, the simulations do not account for factors such as blood, vomit, or sputum in the oropharynx; they also do not include the risk of blurred images due to fogging of the AWS or the KingV monitor [18]. In cases that involve bleeding or vomiting, the KingV may be more useful, as it provides a direct view. Second, use of either of these devices may be less than ideal in patients with severely restricted mouth openings [19]. Third, chest compressions and intubation were performed on a manikin, which leads to shorter airway intervention times than that required for actual patients [20]. Fourth, asking the reason of difficult laryngoscopy or tube passage through the glottis may also be informative. Finally, homogeneity of CPR techniques cannot always be assured in clinical situations.

Future studies should investigate the effect of clinical experience accumulation, as well as conducting randomized trials using the AWS and KingV in which actual patients receive CPR. The present study findings suggest that both the AWS and the KingV-Guided devices are more effective than the KingV-Guideless for airway management with chest compressions in adult simulations, especially by novice doctors. The tube guide may contribute to the successful airway management during chest compression due to the videolaryngoscope function.

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 here. Financial support for the study was provided by our institution and department.

References

1. Nolan JP, Soar J, Zideman DA, Biarent D, Bossaert LL, Deakin C, Koster RW, Wyllie J, Böttiger B. European resuscitation council guidelines for resuscitation, 2010 section 1. Exec summ Resusc. 2010;81:1219–76.
2. Deakin CD, Nolan JP, Soar J, Sunde K, Koster RW, Smith GB, Perkins GD. European resuscitation council guidelines for resuscitation 2010 section 4. Adult adv life support Resusc. 2010;81:1305–52.
3. Asai T, Liu EH, Matsumoto S, Hirabayashi Y, Seo N, Suzuki A, Toi T, Yasumoto K, Okuda Y. Use of the Pentax-AWS in 293 patients with difficult airways. Anesthesiology. 2009;110:898–904.
4. Komasawa N, Ueki R, Itani M, Nomura H, Nishi S, Kaminoh Y. Evaluation of tracheal intubation in several positions by the Pentax-Aws Airway Scope: a manikin study. J Anesth. 2010;24:908–12.
5. Komasawa N, Ueki R, Nomura H, Itani M, Kaminoh Y. Comparison of tracheal intubation by Macintosh laryngoscope and Pentax-AWS (Airway Scope) during chest compression: a manikin study. J Anesth. 2010;24:306–8.

6. Koyama J, Iwashita T, Okamoto K. Comparison of three types of laryngoscope for tracheal intubation during rhythmic chest compressions: a manikin study. Resuscitation. 2010;81:1172–4.
7. Gaszynska E, Samsel P, Stankiewicz-Rudnicki M, Wieczorek A, Gaszynski T. Intubation by paramedics using the ILMA or AirTraq, KingVISION, and Macintosh laryngoscopes in vehicle-entrapped patients: a manikin study. Eur J Emerg Med. 2014;21:61–4.
8. Gaszynska E, Gaszynski T. Endotracheal intubation using the Macintosh laryngoscope or KingVISION Video Laryngoscope during uninterrupted chest compression. Biomed Res Int. 2014;2014:250820.
9. Komasawa N, Ueki R, Itani M, Nishi S, Kaminoh Y. Validation of Pentax-AWS Airwayscope utility for intubation device during cardiopulmonary resuscitation on the ground. J Anesth. 2010;24:582–6.
10. Komasawa N, Ueki R, Kohama H, Nishi S, Kaminoh Y. Comparison of Pentax-AWS Airwayscope video laryngoscope, Airtraq optic laryngoscope, and Macintosh laryngoscope during cardiopulmonary resuscitation under cervical stabilization: a manikin study. J Anesth. 2011;25:898–903.
11. Kern KB, Hilwig RW, Berg RA, Sanders AB, Ewy GA. Importance of continuous chest compressions during cardiopulmonary resuscitation: improved outcome during a simulated single lay-rescuer scenario. Circulation. 2002;105:645–9.
12. Yu T, Weil MH, Tang W, Sun S, Klouche K, Povoas H, Bisera J. Adverse outcomes of interrupted precordial compression during automated defibrillation. Circulation. 2002;106:368–72.
13. Helm M, Hossfeld B, Schafer S, Hoitz J, Lampl L. Factors influencing emergency intubation in the pre-hospital setting—a multicentre study in the German Helicopter Emergency Medical Service. Br J Anaesth. 2006;96:67–71.
14. Ueshima H, Asai T. Tracheal intubation in daylight and in the dark: a randomised comparison of the Airway Scope, Airtraq, and Macintosh laryngoscope in a manikin. Anaesthesia. 2010;65:684–7.
15. Asai T. Tracheal intubation with restricted access: a randomised comparison of the Pentax-Airway Scope and Macintosh laryngoscope in a manikin. Anaesthesia. 2009;64:1114–7.
16. Komasawa N, Fujiwara S, Mihara R, Minami T. Comparison of McGrath® and Pentax-AWS Airwayscope® for tracheal intubation by anaesthesiologists during chest compression in a manikin: a randomized crossover trial. Eur J Anaesth. 2014 (in press).
17. Shin DH, Choi PC, Han SK. Tracheal intubation during chest compressions using Pentax-AWS®, GlideScope®, and Macintosh laryngoscope: a randomized crossover trial using a mannequin. Can J Anaesth. 2011;58:733–9.
18. Ng I, Hill AL, Williams DL, Lee K, Segal R. Randomized controlled trial comparing the McGrath videolaryngoscope with the C-MAC videolaryngoscope in intubating adult patients with potential difficult airways. Br J Anaesth. 2012;109:439–43.
19. Wetsch WA, Spelten O, Hellmich M, Schier R, Böttiger BW, Hinkelbein J. Comparison of different video laryngoscopes for emergency intubation in a standardized airway manikin with immobilized cervical spine by experienced anaesthetists. A randomized, controlled crossover trial. Resuscitation. 2012;83:740–5.
20. Gatward JJ, Thomas MJ, Nolan JP, Cook TM. Effect of chest compressions on the time taken to insert airway devices in a manikin. Br J Anaesth. 2008;100:351–6.