Comparison of VividTrac®, King Vision® and Macintosh laryngoscopy for normal and difficult airways during simulated cardiopulmonary resuscitation among novices

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Abstract

Background: Successful early endotracheal intubation improves neurological outcomes in cardiopulmonary resuscitation. However, endotracheal intubation should not compromise cardiopulmonary resuscitation effectiveness and thus requires experience. The use of videolaryngoscopes might decrease the number of attempts as well as the time needed for intubation, especially among novice users. We sought to compare videolaryngoscopes with direct laryngoscopy in simulated cardiopulmonary resuscitation scenarios in mannequins by novices.

Methods: Forty-four medical students were recruited to serve as novice users. Following brief, standardized training, students were asked to execute endotracheal intubation with each of the devices, including the King Vision®, the Macintosh laryngoscope and the VividTrac®, on acardiopulmonary resuscitation trainer (Ambu Man Advanced®) in normal and difficult airway scenarios. We evaluated the time to and the proportion of successful intubation, the best view of the glottis, esophageal intubation, dental trauma and user satisfaction.

Results: In the normal airway scenario, significantly shorter intubation times ($P < 0.05$) were measured by King Vision®than by Macintosh laryngoscope. However, VividTrac® was proven to be similar ($P > 0.05$) to Macintosh laryngoscope in this regard in the normal airway scenario. In the difficult airway scenarios, we found VividTrac® superior ($P < 0.05$) to King Vision® and Macintosh laryngoscope regarding laryngoscopy times, but there were no significant differences between devices in intubation times. In both normal and difficult airway cardiopulmonary resuscitation scenarios, we noted no difference ($P > 0.05$) in first attempt success rates, the best view of the glottis and dental trauma, but esophageal intubation and the use of bougie were more frequent ($P < 0.05$) withMacintosh laryngoscopethan with videolaryngoscopes. The shortest tube insertion times were related to King Vision® in both scenarios.

Conclusion: Based upon our results, King Vision®was superior to Macintosh laryngoscoperegarding intubation time in the normal airway cardiopulmonary resuscitation scenario for novice users. We noted significantly less esophageal intubationwhen using videolaryngoscopes compared to Macintosh laryngoscope in both scenarios; thus,videolaryngoscopes might be recommended for novice users for both cardiopulmonary resuscitation scenarios.

Background

An early successful intubation attempt during cardiopulmonary resuscitation (CPR) might significantly increase the neurological outcome of CPR. However, in most cases, continuous chest compression must be halted for the duration of the intubation attempt, which will result in deteriorated coronary blood flow and therefore decrease the effectiveness of CPR [1]. Currently, the accepted gold standard device for endotracheal intubation (aside from COVID-19 infection-related case management) is Macintosh-type bladed direct laryngoscopy (DL) [2]. A critical point of DL is the proper alignment of the vocal cords, oropharynx and oral cavity-mouth, which should be in a straight continuous line, allowing the insertion of

the cuffed endotracheal tube [3]. A common maneuver to achieve the mentioned position is head-tilt manipulation, which cannot be used in situations in case of a probable or suspected cervical spine injury. To circumvent this and other airway management-related problems, various models of video laryngoscopy (VL) have been developed in recent years. These devices do not necessitate the alignment of airway-related structures, utilizing a fiber-optic or optical lens system to provide airway visibility. In recent developments, one might observe an increase in VLs with tube-guiding equipment [2][3][4]. According to recent literature, the use of VLs compared to DLs might improve the first intubation attempt success in users with scarce experience with DL or VL [5][6][7][8][9]. In the hands of more experienced users, benefits have been observed, with a shorter duration of uninterrupted chest compression [10].

The early successes of VLs lead to a broad diversity of available devices with different shapes, forms and sizes, but the result of these differences in intubation success is not yet completely clear [4][8][11][12][13] [14][15].

Considering the abovementioned data, our research group aimed to assess the effectiveness of DLs and various VLs in the hands of nonprofessional airway providers during simulated resuscitation situations. Based on our previous study, (VT), a new VL device with minimal representation in the literature, was also included in our study [16].

Methods

The study was carried out with the prior permission of the Institutional Scientific and Human Research Ethics Committee of the University of Pécs (7176 – PTE 2018). The investigation was performed at the Medical Skills Lab of Medical School, University of Pécs, Hungary. Based on previous studies, we defined both the devices to examine and the required minimum sample size. All participants provided written consent prior to the study. The following laryngoscopes were selected for our study: direct laryngoscopy with a Macintosh blade, size 4, (KaWe®, Asperg, Germany); (b) VividTrac® with an adult channeled blade (Vivid Medical, Palo Alto, USA); and King Vision®(KV) with a size 3 channeled blade (Ambu, Copenhagen, Denmark). For the previously estimated sample size, using $\alpha=0.05$ and $\beta=0.1$, we calculated that the minimum of 44 participants is required for pairwise comparison of our results. For nonprofessionals without broad intubation experience, medical students were invited to participate in our study. Novice users took part in 15-minute trainings supervised by consultant anesthesiologist experienced investigators. During practice, participants acquired manual skills and theoretical knowledge to use each laryngoscope in the normal airway scenario and in the difficult airway scenario. The utilization of optimization maneuvers, the use of bougie, and the estimation of the Percentage of Glottic Opening (POGO) score were also explained and practiced. Their attention was drawn to the mechanism and the relevance of dental injuries. Airway trainings were carried out on the Laerdal® Airway Management Trainer (Laerdal®, Stavanger, Norway). The study was performed using an Advanced Life Support (ALS) simulator (Ambu® Man Advanced) during continuous chest compression by one of the study supervisors. Both the frequency and depth of chest compressions were in accordance with the protocol. This was verified by the provided Ambu ALS monitoring program. Two airway management scenarios

were assessed. In the normal airway scenario (Scenario A), during continuous chest compression, head tilt was allowed, and in the difficult airway scenario (Scenario B), the cervical spine was immobilized with manual in-line stabilization (MILS) according to the advanced trauma life support algorithm. Each endotracheal intubation attempt was performed with a standard, 7.0 mm internal diameter, cuffed, plastic, endotracheal tube (Mallinckrodt®, Covidien, Dublin, Ireland). Participants were asked to perform intubation with each device in both scenarios in random order. The primary endpoint was successful endotracheal intubation. Additional endpoints included the number of intubation attempts, laryngoscopy time (LT), tube insertion time (TIT), and intubation time (IT); furthermore, the best achieved POGO was determined. We recorded esophageal intubation, tooth injury, and bougie application. The laryngoscopy time was defined from when the laryngoscope blade passed through the interdental line until the achievement of the best POGO indicated by the beginning of tube manipulation. Intubation time ranged from the passage of the tube through the interdental line to successful intubation. The difference between exploration and intubation time is tube insertion time. An attempt was considered unsuccessful if the attempt took more than 120 seconds or if the tube was removed from the oral cavity. The intubation failed after 3 unsuccessful intubations, if the participant did not recognize esophageal intubation, or if the participant gave up the attempt. After each scenario, we asked the participants to rate the devices on the basis of ease of technical use (1 = easy, and 5 = difficult), ease of physical use (1 = easy, and 5 = difficult) and willingness to reuse (1 = would never use again and 5 = would like to use) to the relevant scenario without ranking.

Statistical analysis

Analyses were conducted by Statistical Package for the Social Sciences (SPSS) Statistics software, version 22.0 (IBM Corporation, Armonk, NY, USA). Continuous and ordinal data are presented as the median and interquartile range(IQR), while categorical data are presented as raw numbers and as frequencies. Nonparametric tests were used since the data were not normally distributed, including the Kolmogorov-Smirnov and Shapiro-Wilk tests. The Kruskal-Wallis test and one-way ANOVA with Dunn's post hoc test were used to assess pairwise differences between devices regarding the following variables: LT, TIT, IT, POGO score, ease of technical use, ease of physical use and willingness to reuse. Chi-square tests were used to evaluate differences between the categorical data results of devices regarding the rate of successful tracheal intubation, esophageal intubation, dental injury, and bougie usage. Values of $P < 0.05$ were considered significant.

Results

Data regarding the normal airway scenario are shown in detail in Table 1.

Table 1. Results of normal airway scenario

Normal airway scenario	DL (n=44)	KV (n=44)	VT (n=44)
Number of attempts (n, 1/2/3)	30/8/6	35/6/3	37/5/2
Laryngoscopy time (s)	10.09 [7.57-13.35]	9.36 [7.31-14.91]	9.3 [6.05-15.13]
Tube insertion time (s)	7.4[5.84-14]	3.35 [2.33-8.7]¶	11.69 [5.3-19.61]†
Intubation time (s)	19.19 [14.28-27.09]†	15.2 [11.1-23.9]*¶	23.08 [15.9-33.2]†
POGO (%)	75 [60, 90]	75 [70-80]	60 [50-90]
Ease of technical use (1-5)	2 [1-4]	3 [2-4]	2 [2-4]
Ease of physical use (1-5)	3 [2-4]	2 [2-3]	2 [1-3]
Willingness of reuse (1-5)	4 [3-5]	3 [2-4]	4 [2-5]
Use of bougie (n)	11¶†	0*	0*
Dental injury (n)	0	1	0
Esophageal intubation (n)	11¶†	1*	1*

Data are reported as median [IQR] or as numbers (n). *Significant difference (P < 0.05) compared to DL; †Significant difference (P < 0.05) compared to KV; ¶Significant difference (P < 0.05) compared to VT. DL: Direct laryngoscope (Macintosh); KV: King Vision®; POGO: Percent of Glottic Opening; VT: VividTrac®.

There were no significant differences in the number of intubation attempts or the achieved best POGO score. The KV was faster regarding TIT than VT (P < 0.05). Assessing IT, the KV was superior to VT and DL. There were no significant differences in LT and TIT between the VLs and DL. The esophageal intubation and use of bougie were higher with DL (P < 0.05). Overall, only one dental injury occurred in this scenario. Neither the ease of use score nor the grade of willingness to reuse were significantly different between all devices.

Data regarding difficult airway scenariosare shown in detail in Table 2.

Table 2. Results of difficult airway scenario

Difficult airway scenario	DL (n=44)	KV (n=44)	VT (n=44)
Number of attempts (n, 1/2/3)	35/4/5	40/3/1	35/2/7
Laryngoscopy time (s)	13.7 [8.37-18.89]¶	14.52 [10.72-26.05]¶	8.04 [6.33-14.33]*†
Tube insertion time (s)	8.15 [4.4-17.09]†	4.76 [2.05-11.42]*¶	8.09 [4.03-18.64]†
Intubation time (s)	23.39 [16.93-34.31]	21.91 [14.76-39.51]	20.83 [12.65-39.45]
POGO (%)	60 [40-80]	67.5 [50-80]	60 [40-76.3]
Ease of technical use (1-5)	3 [2-4]	3[2-4]	2 [1-4]
Ease of physical use (1-5)	4 [2-4]¶	3 [2-4]	2 [1-3]*
Willingness of reuse (1-5)	3 [2-5]	3 [2-4]	4 [2-5]
Use of bougie (n)	17¶†	0*	0*
Dental injury (n)	0	0	0
Esophageal intubation (n)	7¶†	0*	0*

Data are reported as median [IQR] or as numbers (n). *Significant difference (P < 0.05) compared to DL; †Significant difference (P < 0.05) compared to KV; ¶Significant difference (P < 0.05) compared to VT. DL: Direct laryngoscope (Macintosh); KV: King Vision®; POGO: Percent of Glottic Opening; VT: VividTrac®.

There were no significant differences in the number of intubation attempts or the achieved best POGO score. Faster LT was found with VT compared to KV and DL (P < 0.05), but in the TIT, the KV was superior compared to VT and DL. There was no significant difference in IT between the devices. VT received better ease of physical use scores than DL (P < 0.05) and KV, but the ease of technical use and rate of willingness to reuse were similar. Dental injury did not occur. The incidence of esophageal intubation and the use of bougie was higher with DL (P < 0.05).

Discussion

The success of CPR is highly dependent on the effectiveness of chest compressions and their necessary breaks. In case a longer chest compression pause would deteriorate the overall CPR outcome [1]. In the hand of unexperienced providers, DL would result in longer compression pauses and multiple intubation attempts[7]. The use of VLs improved Cormack-Lehane and decreased intubation attempts in these scenarios [11][17]. Our study assessed the effectiveness of KV and VT during intubation by unexperienced users in a simulated reanimation situation. Previous studies concluded that the type of laryngoscope used for intubation during CPR is not a significant correlator of success by experienced

users [9]. The current literature is inconclusive regarding this question, as some former data suggest that certain VLs are more suitable in this scenario, while other publications report no differences in the benefits of different equipment [6][8][18].

The selected VLs were not assessed earlier. According to data in the literature, with the use of DL, approximately 5.8% of cases are difficult airways, while during emergency situations (including CPR), 14.8% of cases are proven difficult [8]. The literature is scarce regarding difficult airway situations with unexperienced providers during CPR, and the two VLs assessed were not measured in these scenarios before.

We found no difference inintubation attempts between DL and each VL in the simulated CPR intubation environment. A study by Gaszynska *et al*. was unable to find a significant difference between KV and DL [18], while others found particular VLs that provided a better success rate [5][6][7][8]. In the case of DA, the difference is also notable by experienced users [15].

A significant difference was not found between laryngoscopes in normal airway situations, while difficult airway VT provided significantly shorter LT compared to the other tools. Regarding TIT, the KV provided significantly shorter results. Our data regarding shorter IT by KV compared to VT and DL in the normal airway scenario. During the DA scenario, no VL proved to be superior. Szarpak *et al* and Han *et al* formerly reported shorter LT and IT with VLs compared to DLs [6][15], while there is controversy regarding KV compared to DL[18].

The benefit of VLs in the hands of experienced users is still questionable. Earlier studies provided evidence that the use of certain VLs comes with the benefit of significantly shorter IT, while others did not show improvement even in the hands of unexperienced providers compared to DLs. In the case of experienced providers, it is more difficult to provide evidence for the use of VLs.The main difficulty of DLs is the proper alignment of the mouth-oropharynx-glottic opening [3][19]. This procedure is not required during VL; thus, former studies provided better visualization results with VLs during CPR, independent of user experience [6][9][15]. In contrast, our results during constant chest compressions in both scenarios cannot support this conclusion. Teeth injury was not registered during intubation attempts, while esophageal intubation was increased with DL, in accordance with former results [7][8][9]. This might result from the possibility of visual checks during tube insertion with VLs [6]. The use of elastic tube guidance was significantly higher with DL, although this might result from the fact that all VLs had tube-guiding sheaths.

Subjectively no device was preferred by our providers in the normal airway scenario. AlthoughVT felt physically easier to use in the DA scenario, no preference was significantly noted in these situations.In studies where the number of intubation attempts was lower and users found the use of VLs subjectively superior to DL, an increased POGO score and lower incidence of intubation-related complications were registered [6]. Currently, an increasing number of VL devices are available on the market, indicating that their real benefit during emergency intubation situations is not completely clear. The significant heterogeneity of the studied patient populations and study approaches could be a cause of the different

effectiveness results of VLs [20]. Additionally, the experience of the studied providers might play a key role in these discrepancies.

Conclusion

No certain assessed VL device was triumphed in our study design compared to other VLs or DL. The KV might be recommended against other VLs in normal-airway situations for shorter ITs and during MILS situations for shorter TITs. To increase patient safety and with the approach of ever newer devices, further continuous assessment is required of different VLs in emergency situations. To further clarify this question, novel studies assess recently developed VLs, and possible viable alternative custom 3D printing equipment is increasingly available, presenting real competition to manufacturers. Broad-available medical simulation centers provide a vital background for the comparison of novel airway devices in a safe environment before clinical practice and use.

Declarations

- **Ethics approval and consent to participate:** The study was carried out in accordance with the Declaration of Helsinki. Ethical Approval was obtained from the Institutional Scientific and Human Research Ethics Committee of the University of Pécs (7176 – PTE 2018) for this study. All participants provided written informed consent before participation.
- **Consent for publication:** Non applicable.
- **Availability of data and material:** The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.
- **Competing interests:**The authors declare that they have no competing interests.
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