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*Original Article*

# Comparison of endotracheal intubation and a new-generation supraglottic airway device in training of difficult airway: a manikin study

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**Abstract:** Objective: To compare the performance times and success rates of the classic Macintosh laryngoscope (CML) or video laryngoscope (VL) with endotracheal intubation (ETI) and second-generation supraglottic airway devices (SAD) in difficult airway management during cardiopulmonary resuscitation (CPR). Materials and methods: Classic Macintosh Laryngoscope (D1), C-Mac® videolaryngoscope (D2), Laryngeal Tube LTS-D® (D3), LMA Supreme® (D4), i-gel® (D5) and air-Q® (D6) were used to achieve a secure airway in the study. In the first week, 60 trainee paramedics made ten attempts with each device using a manikin that was immobilized with a collar. Eight weeks later, the trainees made ten more attempts with each device. Application times, success rates, and the device preferences of the trainees were compared. Results: When we analyzed total application times, the shortest times were identified in the D5 and D6 groups. The success rate was low in the D1 group in the first ten attempts. There was no statistically significant difference in the last ten attempts. When we evaluated application skills after eight weeks, application times were improved significantly in all groups. The trainees stated that they would prefer D2, D5, and D3 devices during CPR. Conclusions: Practitioners with sufficient experience had high success rates with both ETI and SAD even though application times were different during CPR. SADs without a cuff seem advantageous compared with the others regarding total application times. However, no success rate difference was observed with the other devices.

**Keywords:** Videolaryngoscope, laryngeal tube, LMA supreme, i-gel, air-Q, endotracheal intubation

## Introduction

The standard airway management method during cardiopulmonary resuscitation (CPR) is endotracheal intubation (ETI). However, its application requires experience and time [1]. Studies identified 0.5%-25% intubation misplacement rates among emergency health providers during resuscitation [2, 3]. Besides this, an increased number of chest compression interruptions was identified during ETI application in the studies [4]. In recent guidelines, it is emphasized that practitioners should complete ETI application without pausing chest compressions and should not insist on ETI [5, 6].

Paramedics may have to secure the airway of patients whose neck is immobilized with a cervical collar after trauma and give these patients CPR. High rates of ETI misplacement seen in the study of Katz et al. gave rise to the thought of alternative airway methods to ensure ventilation [3]. Thus, when a difficult airway is detected during CPR, video laryngoscope (VL) or supraglottic airway devices (SAD) might be indicated to secure the airway [7, 8]. C-Mac and many similar VLs were produced to ensure better vision in difficult airways, and these are used successfully for ETI in the pre-hospital environment [9, 10]. On the other hand, the classic laryngeal mask (LMA)® (cLMA) and similar SADs were also designed to secure the airway in patients with difficult airways. It is stated that these devices can be used in a faster and safer way compared with conventional airway methods [11, 12]. At present, due to research

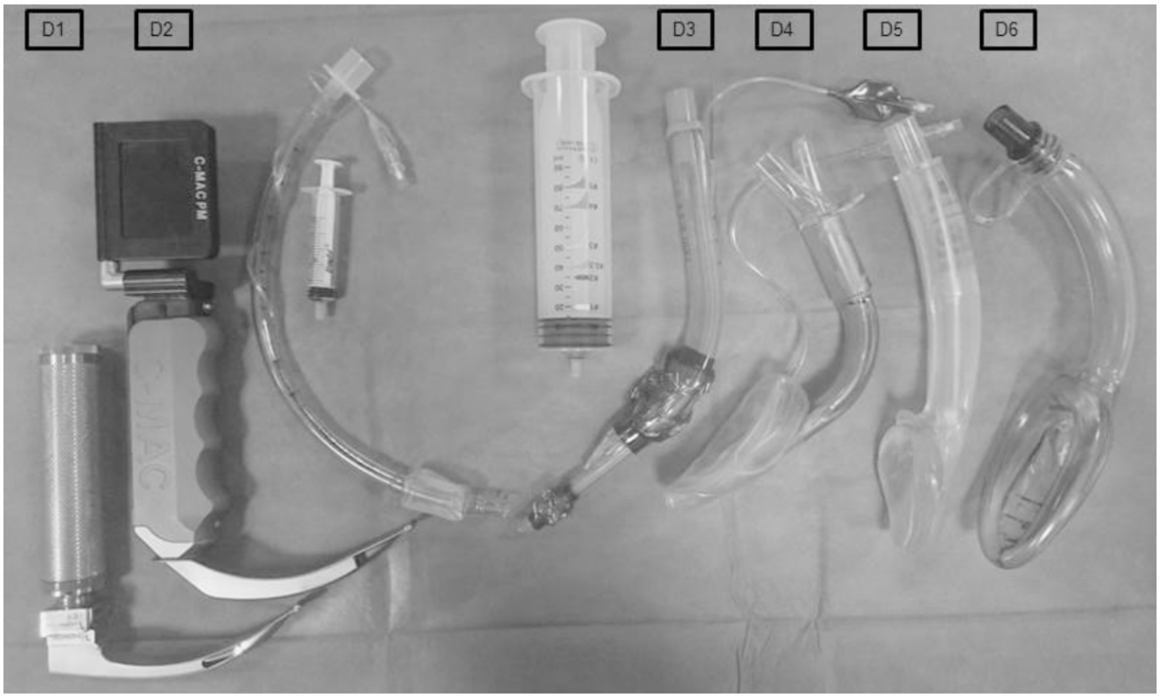


Figure 1. Devices were used in the study: (Classic Macintosh laryngoscope (D1), C-Mac® video laryngoscope (D2), Laryngeal tube LTS-D®(D3), LMA Supreme®(D4), i-gel®(D5), air-Q®(D6)).

on "safer" and "more effective" devices, new-generation SADs with different advantages became available. Some devices of second-generation SADs such as Supreme LMA®, Combitube®, and Laryngeal tube-II® include a cuff, while others such as i-gel® and air-Q® do not include a cuff [11].

In our study, our first aim was to compare the application time and success rates of second-generation SADs with the classic Macintosh laryngoscope (CML) and VL with ETI during CPR without pausing chest compressions. Our second aim was to identify how well paramedics could use their application skills with these devices eight weeks after their first applications. Our third aim was to determine the device preference of trainees in difficult airway management during CPR.

## Materials and methods

The Ethics Committee of Ahi Evran University approved the study (Number: 2016-04/08). Sixty trainee paramedics from Ahi Evran University Vocational School of Health Care who previously had ETI training were included in the study.

The following devices were used in the study (**Figure 1**): D1 Classic Macintosh laryngoscope (No: 7 F ETI reinforced with a stylet in endotracheal tube); D2 C-Mac video laryngoscope (Karl Storz, Tuttligen, Germany) (No: 7 F ETI reinforced with a stylet in endotracheal tube); D3 Laryngeal tube LTS-D ((VBM Medical, Noblesville, Indiana) (No: 4); D4 LMA Supreme® (LMA, North America) (No: 4); D5 i-gel® (Intersurgical, Wokingham, Berkshire, United Kingdom) (No: 4); D6 air-Q® (Mercury Medical, Clearwater, Florida) (No: 4.5).

The trainees included in the study were trained on each device; they received theoretical training and a demonstration was made on an immobilized manikin with all devices. During all applications, chest compression with a frequency between 100-120 was applied on a manikin.

First, six trainees attempted once with six devices according to their numbers. After each attempt, the application was performed with the next device. All trainees made one attempt with each device, 60 attempts were made in total. The initiation time was defined as insertion of a laryngoscope blade into the mouth

**Table 1.** Comparisons of Ti (1-10)-Ti (11-20) and Tt (1-10)-Tt (11-20) attempts of devices

| | D1 (n=60) | D2 (n=60) | D3 (n=60) | D4 (n=60) | D5 (n=60) | D6 (n=60) | P* | |
|---|---|---|---|---|---|---|---|---|
| Ti (1-10) | 6.4±4.5<br>4.9 (3.2-8.2) | 5.9±3.3<br>5.2 (3.5-7.5) | 2.1±0.7<br>1.9 (1.5-2.5) | 2.3±0.9<br>2.1 (1.7-2.9) | 1.8±0.7<br>1.7 (1.3-2.4) | 2.8±1.1<br>2.6 (2.1-3.5) | <0.001 | 1-2/3-4-5-6 |
| Tt (1-10) | 8.9±4.3<br>7.4 (5.8-10.5) | 8.4±3.3<br>7.8 (6.0-10.0) | 7.9±0.7<br>7.7 (7.4-8.3) | 6.5±0.9<br>6.3 (5.8-7.0) | 1.8±0.7<br>1.7 (1.3-2.4) | 2.8±1.1<br>2.6 (2.1-3.5) | <0.001 | 1-2-3/4/5-6 |
| Ti (11-20) | 4.6±3.0<br>3.7 (2.7-5.6) | 4.4±2.5<br>3.8 (2.6-5.4) | 1.7±0.6<br>1.5 (1.2-2.1) | 1.8±0.8<br>1.7 (1.2-2.3) | 1.4±0.5<br>1.4 (0.9-1.7) | 2.2±0.9<br>2.0 (1.6-2.5) | <0.001 | 1-2/3-4-5-6 |
| Tt (11-20) | 7.2±3.0<br>6.2 (5.3-8.2) | 6.9±2.5<br>6.3 (5.1-8.0) | 7.5±0.6<br>7.4 (7.1-7.9) | 6.0±0.8<br>5.8 (5.4-6.4) | 1.4±0.5<br>1.4 (0.9-1.7) | 2.2±0.9<br>2.0 (1.6-2.5) | <0.001 | 1-2-3/4/5-6 |

*Kruskal-Wallis (intergroup comparisons). Ti: insertion time, Tt: total time after inflation of cuff. All values are mean ± SD and median (Quartile 1-Quartile 3).

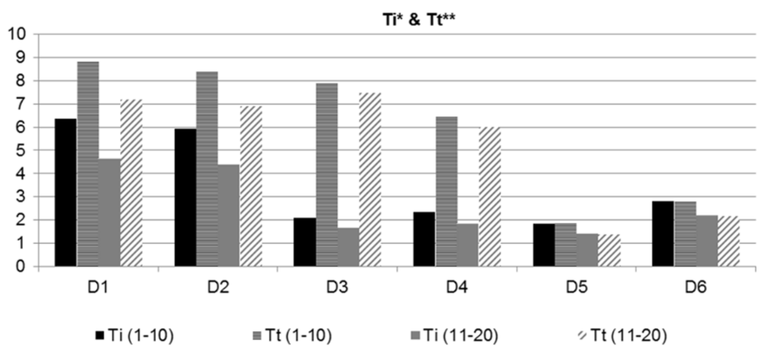


**Figure 2.** Attempt time (s) *Ti: insertion time, **Tt: total time after inflation of cuff.

corners for endotracheal intubation, and insertion of the supraglottic device from the lips for supraglottic devices. The duration until the endotracheal tube passed the vocal cords and the supraglottic device was placed were calculated (Ti). For devices with a cuff, cuffs were inflated and the total time (Tt) was recorded (endotracheal tube cuff was inflated with 5 mL of air in D1 and D2, the laryngeal tube LTS-D cuff was inflated with 70 mL of air in D3, and the LMA Supreme cuff was inflated with 40 mL of air in D4).

The placement of the endotracheal tube and the supraglottic device was evaluated after each attempt by the same tutor. Misplacements and attempts over 30 seconds were defined as failure. Eight weeks after the first attempts, all students made ten more attempts with each device used in the first attempts. The number of attempts (n) and device placement times for this attempt [Ti (n)] and total time after inflation of cuff [Tt (n)] were recorded. After completing all attempts, the trainees were asked to give scores out of 10 points for each device to identify their preference in difficult airway management.

Performance times, success rates, and points given by the paramedics to each device during CPR were statistically analyzed and compared between the six devices.

*Statistical analysis*

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) 23.0 (IBM SPSS Inc., Chicago, IL, USA). Descriptive statistical methods (frequency, percentage, average, standard deviation, median and interquartile range) were used in the analysis of study data. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to identify whether the data fitted normal distribution. In the study, the Kruskal-Wallis test was used for intergroup comparisons, and the Wilcoxon signed-rank test was used for the comparisons of attempts. In multiple comparisons where a difference was identified, Tukey's honest significant difference (HSD) test was used to determine which group/groups were the sources of the difference. Probability values of ($p$) $\alpha<0.05$ were considered significant and (p) $\alpha>0.05$ values were considered insignificant.

Power analysis: Power analysis was made using the G*Power 3.1.9.2 statistical package software; n1=60, n2=60, n3=60, n4=60, n5=60, n6=60, $\alpha=0.05$, Effect size f=0.25; power (1-β) was found as 0.97.

## Results

Among the devices, when we compared Ti (1-10) in first ten attempts, times on D1-D2 groups were found longer than with the other devices ($p<0.05$) (Kruskal-Wallis) (**Table 1**).

**Table 2.** Comparisons of Ti (10)-Ti (11) and Tt (10)-Tt (11) attempts of devices (s)

| | D1 (n=60) | D2 (n=60) | D3 (n=60) | D4 (n=60) | D5 (n=60) | D6 (n=60) | P* | |
|---|---|---|---|---|---|---|---|---|
| Ti (10) | 5.3±3.7<br>4.2 (3.1-6.1) | 5.1±3.5<br>4.1 (2.7-6.4) | 1.9±0.8<br>1.9 (1.4-2.3) | 2.2±1.0<br>1.9 (1.4-2.8) | 1.6±0.7<br>1.5 (1.0-2.1) | 2.6±1.0<br>2.5 (1.8-3.4) | <0.001 | 1-2/3-4-5-6 |
| Tt (10) | 7.8±3.7<br>6.8 (5.7-8.7) | 7.7±3.5<br>6.6 (5.2-8.9) | 7.8±0.8<br>7.7 (7.2-8.1) | 6.3±1.0<br>6.0 (5.6-6.9) | 1.6±0.7<br>1.5 (1.0-2.1) | 2.6±1.0<br>2.5 (1.8-3.4) | <0.001 | 1-2-3/4/5-6 |
| Ti (11) | 8.4±6.5<br>5.9 (4.3-9.3) | 7.8±4.4<br>7.0 (4.3-9.3) | 2.5±0.9<br>2.2 (1.9-3.0) | 2.8±1.1<br>2.6 (2.0-3.5) | 2.3±0.9<br>2.1 (1.5-3.0) | 3.4±1.7<br>3.1 (2.5-3.9) | <0.001 | 1-2/3-4-5-6 |
| Tt (11) | 10.9±6.4<br>8.4 (6.8-11.9) | 10.3±4.4<br>9.6 (6.8-11.8) | 8.3±0.9<br>8.0 (7.7-8.9) | 7.0±1.1<br>6.7 (6.2-7.7) | 2.3±0.9<br>2.1 (1.5-3.0) | 3.4±1.7<br>3.1 (2.5-3.9) | <0.001 | 1-2/3-4/5-6 |

*Kruskal-Wallis (intergroup comparisons). Ti: insertion time, Tt: total time after inflation of cuff. All values are mean ± SD and median (Quartile 1-Quartile 3).

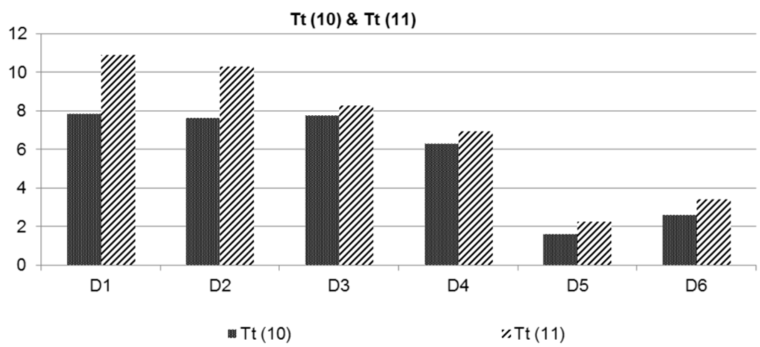


**Figure 3.** Tt (10) & Tt (11) attempt time (s).

When Tt (1-10) values were compared, there were statistically significant differences between D4 and other devices and D5-D6 and other devices. Similar statistical differences were identified in the comparisons of Ti (11-20) and Tt (11-20) in the last ten attempts with the devices (**Figure 2**).

In the first ten attempts; D1-D2-D3-D4 devices, which include a cuff, had significantly longer Tt (1-10) than Ti (1-10) (p<0.05). In a comparison of Ti (11-20) and Tt (11-20) of the last ten attempts, similar statistical differences were found (p<0.05).

When the first and last ten attempts were compared, a statistically significant difference was found between both Ti (1-10)-Ti (11-20) and Tt (1-10)-Ti (11-20) (p<0.05). The times of the first ten attempts were found longer in all devices.

When we compared the success rates among the devices, D1 had a lower success rate than the other devices in the first ten attempts (p<0.05). No statistically significant difference was identified in the comparison of success rates of all devices in last ten attempts. When the success rates of the first and last ten attempts were compared, D1 (9.73±0.66 vs. 9.98±0.13) (p=0.002) and D2 (9.90±0.30 vs. 10.0±0.0) (p=0.014) had statistically significant differences (Wilcoxon signed-rank).

The comparison of the tenth attempt and the eleventh attempt eight weeks later revealed a statistically significant difference between both Ti (10) and Ti (11) and Tt (10) and Tt (11) (p<0.05) (Kruskal-Wallis) (**Table 2**). In all devices, the times of the eleventh attempt were longer (**Figure 3**).

When the success rates were compared between the tenth and eleventh attempts, no statistically significant difference was found in any device (p>0.05) (Fisher's exact test).

In the evaluation of device preferences of the paramedics on a 10-point scale, the highest points were received by D2 (8.6±1.5) and D5 (8.4±1.6). The order of preference for the other devices was D3, D1, D4, and D6, respectively (Kruskal-Wallis).

## Discussion

During CPR, emergency healthcare providers race against time for management of the airway without delaying chest compressions. One should have adequate experience and proper airway devices for accurate and fast management of the airway [1]. ETI, which was considered as the gold standard in pre-hospital airway management, came under question in difficult airway management, primarily by inexperienced providers. Classic airway devices might not be enough in cases of difficult airways.

Many studies reported that VL and SADs, which were developed for this purpose, could be used successfully during CPR [8, 9, 13]. However, airway management time and success rate comparisons of these devices showed differences in some reports [8, 10]. Thus, emergency healthcare providers who are obligated to provide emergency airway management should know about new-generation VL and SADs and train to gain adequate skills in the use of these devices. Realistic simulation methods can be used in the training of emergency healthcare teams for airway management with new-generation devices [14]. In the present study, a manikin with a different airway, which was immobilized with a collar, was used for standardization of attempts.

C-Mac is a video laryngoscope that was developed for difficult airway management. In a study that included 300 patients who received ETI with a classic laryngoscope or C-Mac VL, C-Mac VL was found useful because of its high success rate in first attempts and the requirement for less manipulation during ETI [15]. In a study of 790 patients, Boehringer et al. reported that ETI success rates were improved and retries were decreased with C-MAC [9]. In the study of Suppan et al., a lack of evidence in C-MAC use was reported for cases of cervical vertebra immobilization [16].

For airway management, ventilation is typically provided with an Ambu-bag and valve mask, then, according to the experience of provider, ETI or an alternative device is used to ensure safe and adequate ventilation [17-20]. The classic LMA, which was produced as an alternative to ETI, had on-going "best SAD" studies since it came into service in the 1980s until today. In the meantime, other devices evolved and new devices were developed. Advantageous features such as a gastric aspiration channel increased the inner diameter, and a biting area was added to different devices and new-generation SADs became available [11, 21]. These devices, along with their advantageous features, are compared with each other for success rates, ease of use, and provider preferences. In our study, four second-generation SADs were compared with each other and with two different laryngoscopes, which were used for ETI, regarding success rates, provider preferences, and skill memories.

In the study of Gatward et al., it was shown that 50% faster airway management could be provided without delaying chest compressions during CPR with i-gel comparing with Proseal LMA, cLMA, and a tracheal tube [8]. In another study; i-gel and LMA Supreme were compared in patients with simulated difficult airways under anesthesia. In that study, both devices were found similar for placement success rates and they were reported suitable for use in patients with reduced neck mobility for emergency airway management [22]. In another study that compared LTS-D and ETI in patients who required advanced airway management by paramedics, no difference was identified in success rates and application times [23]. In a study of Henlin et al., 5 new-generation SADs were compared in 505 patients. In that study, LMA Supreme and i-gel were found superior to ProSeal LMA, LTS-D, and SLIPA when used by inexperienced providers [24]. In our study, all SADs were found superior to ETI regarding placement times. However, LTS-D and LMA Supreme devices, which include a cuff, lost their superiority for total placement time to ETI when cuffs were inflated. I-gel and air-Q, which do not include a cuff, had significantly lower total application times compared with both cuffed SADs and ETI. Similar to other studies, when the total application times were compared, the i-gel group had the shortest application time.

In a manikin study that compared ETI, laryngeal tube, Combitube, Easy tube, LMA, and i-gel, SADs were reported as a reasonable choice in emergency airway management during CPR for inexperienced providers. Although only one-third of providers applied ETI successfully in that study, all SADs were placed successfully [25]. The success rates of the classic Macintosh laryngoscope and ETI were lower than other devices only in the first ten attempts. However, no statistically significant difference was found in the success rates of devices in the latter ten attempts. According to the results of our study, we believe that providers who trained with an adequate number of attempts can provide airway management during CPR with both SADs and ETI.

Emergency healthcare teams should obtain "fast and reliable" airway management skills during CPR and prove this skill at different times. This healthcare team should follow up-to-date CPR guidelines as with all other healthcare providers and train with newly-developed devices in adequate numbers. They should also train with simulations to ensure continuity of their skill. In the study of Ander et al., the skill of SAD use was evaluated in the sixth and twelfth months after initial training. Although the placement times of these devices may vary, the general performance was reported unaffected [26]. Similar to that study, when we compared the time of the last attempt in the initial training and the first attempt time after an eight-week gap, an increase was identified in attempt times. Also, differences in success rates were not statistically significant. In another study on this subject, seven airway devices were compared during CPR by inexperienced paramedics. Device placement times and success rates were evaluated in initial training and three months later in that study. According to the results, ETI success rates of inexperienced paramedics were low on both occasions. LMA, LT-D, i-gel, Combitube, and Easy Tube were reported useful for fast, safe, and easy airway management. Apart from Proseal LMA, these five SADs had high application skill values at both time points [27]. In our study, LTS-D, LMA Supreme, i-gel, and air-Q as second- generation SADs, and the classic Macintosh laryngoscope and C-Mac video laryngoscope as ETI were compared. I-gel and air-Q had shorter application times than the other devices at both time points.

In a manikin study of Adelborg et al., Soft Seal, i-gel, and AuraOnce were compared. It was reported that these SADs could be used successfully during SADs. Eighty-five percent of participants in the study preferred i-gel [28]. In a study that compared LMA, Laryngeal tube, and i-gel in a manikin, the fastest airway management was provided with i-gel and most of the trainees preferred i-gel for airway management [29]. In another study, LMA Supreme was compared with cLMA, and it was reported as a safe alternative because it provided fast placement time during CPR. Almost all of the providers preferred LMA Supreme in that study [30]. In our study, the paramedics' order of preference was as follows: C-Mac video laryngoscope, i-gel, LTS-D, classic Macintosh laryngoscope, LMA Supreme, and air-Q.

## Limitations

Biting and tissue compression was not considered in our study. ETI and SAD application times were calculated accordingly.

The same manikin was used for the purpose of application standardization. Further human studies are required to compare the devices used in our study.

In our study, we took an 8-week break to identify the skill memory of paramedic trainees for device use. More studies are required to evaluate application times and success rates with longer breaks.

## Conclusion

In conclusion, SADs without a cuff had shorter application times than new-generation SADs with a cuff and ETI, and thus SADs without a cuff seem advantageous. Despite all the advantages, the trainees preferred to begin with VL and ETI to manage the airway during CPR. When difficult airways present during CPR, there is no difference in the success rates of SAD and ETI for experienced providers.

## Disclosure of conflict of interest

None.

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