SIGNA VITAE 2014; 9(1): 22 - 26

ORIGINAL ARTICLE

The influence of different airway management strategies on chest compression fraction in simulated cardiopulmonary resuscitation, provided by paramedics: LMA Supreme versus Endotracheal Intubation and Combitube

TOMASZ GASZYNSKI (✉)
Barlicki University Hospital
Ul. Kopcińskiego 22, 90-153 Łódź, Poland
Phone: 42 6783748
E-mail: tomasz.gaszynski@umed.lodz.pl

EWELINA GASZYNSKA
Department of Hygiene and Health Promotion, Medical University of Lodz
Poland

EWELINA GASZYNSKA • TOMASZ GASZYNSKI

ABSTRACT

Introduction. It is strongly advised by the European Resuscitation Council not to interrupt chest compressions for airway management. An alternative to tracheal intubation is the use of a supraglottic airway device (SAD) which should shorten "hands-off" time during cardiopulmonary resuscitation (CPR). Chest compression fraction (CCF) should be above 0.6 to ensure the probability of successful CPR. We compared the performance of airway management during CPR provided by paramedics using the laryngeal mask (LMA) Supreme, Combitube and endotracheal intubation (ET) in a manikin model.
Materials and Methods. Thirty sophomore students of emergency medicine school for paramedics took part in the study. The primary endpoint was to assess the influence of the type of airway management on CCF. The time to successful airway management (TA) was measured and the minute ventilation was assessed using the respirator Medumat Easy and program AMBU® CPR SOFTWARE during uninterrupted CPR. CCF was measured using CPRmeter - QCPR (Laerdal).
Results. Mean CCF was significantly better for LMA Supreme (0.8 vs 0.71 vs 0.65), mean TA was significantly shorter for LMA supreme: 16.5 sec vs 24.37 sec vs 28,3 sec, the success rate in the first attempt was 100% vs 66.6% vs 100%, mean air leak during chest compressions was 14% vs 8% vs 15% for LMA Supreme, ET and Combitube respectively.
Conclusion. The LMA Supreme is an effective tool for airway management during chest compression and provides adequate ventilation.

Key words: cardiopulmonary resuscitation, airway management, endotracheal intubation, supraglottic devices

Introduction

For securing a patient's airway during cardiopulmonary resuscitation, the European Resuscitation Council (ERC) recommends tracheal intubation. (1) This gold standard is a procedure which requires a highly qualified and experienced operator. An alternative to tracheal intubation is the use of a supraglottic airway device (SAD), which seems to be more handy and easier for those not very experienced in endotracheal intubation. In Poland, as in many other countries, paramedics deal with out-of-hospital cardiac arrest. They are trained to perform intubation, but because of the number of intubations they perform per year (on average 6-12), (2) they are not as skilled as for example anesthesiologists. Every endotracheal intubation in emergency settings is considered to be difficult, so it may take longer and lead to possible complications. As recommended by the ERC, time for airway management should be no longer than 10 sec. (1) Any interruption in chest compressions decreases the Chest Compression Fraction (CCF). CCF is defined as the

proportion of cardiopulmonary resuscitation (CPR) time spent providing chest compressions and has a very important influence on survival after cardiac arrest (CA) and CPR. (3) The highest survival has been observed in patients where 61% to 80% of CPR time was spent doing chest compressions. SADs are recommended as an alternative to endotracheal tubes (ET). They can even be inserted without interruption to chest compressions.

We hypothesize that the laryngeal mask (LMA) Supreme may be as efficient as intubation for ventilation during chest compression while performing CPR. As Combitube is still recommended as part of the airway management trolley, we decided to compare it with LMA Supreme and endotracheal intubation during chest compression on a manikin model.

Material and Methods

The study protocol was approved by the Medical University of Lodz Ethics Committee (Protocol Number:RNN/607/10/KB, Chair person: prof. P. Polakowski, 12th October, 2010). Thirty sophomores of the emergency medical school for paramedics took part voluntarily in the study. All participants had standard training in using SADs (including LMA Supreme and Combitube) and endotracheal intubation during their course at the school. The simulated CPR scenarios were: endotracheal intubation using a standard laryngoscope with a Mackintosh blade (McL), and airway management using LMA Supreme (LMA Company, GB) or Combitube (Tyco Healthcare Nellcor, Pleasanton, CA). The participants arbitrarily chose the sequence of scenarios. After the first scenario they had a break and then the same team started on the next scenario. Every participant performed airway management with both evaluated methods. Airway management was performed with necessary interruption of chest compressions on manikin Ambu MegaCode Man with a normal airway (no difficult airway simulation) lying on the ground. The time from grabbing the tool to achieving successful ventilation confirmed by a volumeter on the manikin during self-inflating bag ventilation was recorded. A size 3 blade of the McL or the LMA Supreme number 4, Combitube for adults was used in all cases. For each insertion, all airway devices and the manikin's airway were well lubricated in accordance with the instructions of the manufacturer. The internal diameter of the tracheal tube was 7.5 mm. The manikin was placed on the floor, and all trials were performed at the same level. One student performed chest compressions while the other did airway management. The frequency of chest compressions was 100/min, and the clock was used to keep it constant. The chest compression depth of 4–5 cm was confirmed by electronic measurement by AmbuMegaCode Man manikin system. LMA Supreme cuff was filled with 20 ml of air in every case. Only the first attempt was evaluated for every device. Chest Compression Fraction was measured by CPR meter (Laerdal, Norway) with Q-CPR technology. After a 2 minute session, the CCF was recorded from the measuring device.

Table 1. Participants' demographic data. Values are mean, standard deviation (SD) and range.

Parameter	Value
Gender (F/M)	18/12
Weight [kg]	60.9 SD 11.95 [45-96]
Height [cm]	169.7 SD 8.23 [152-189]

Figure 1. Study model for evaluation of air leak during ventilation and cardiopulmonary resuscitation (CPR): 1. Ambu Cardiac Care manikin, 2. Medumat Easy respirator, 3. Analog-cyber transducer, 4. Notebook with Ambu CPR SOFTWARE.

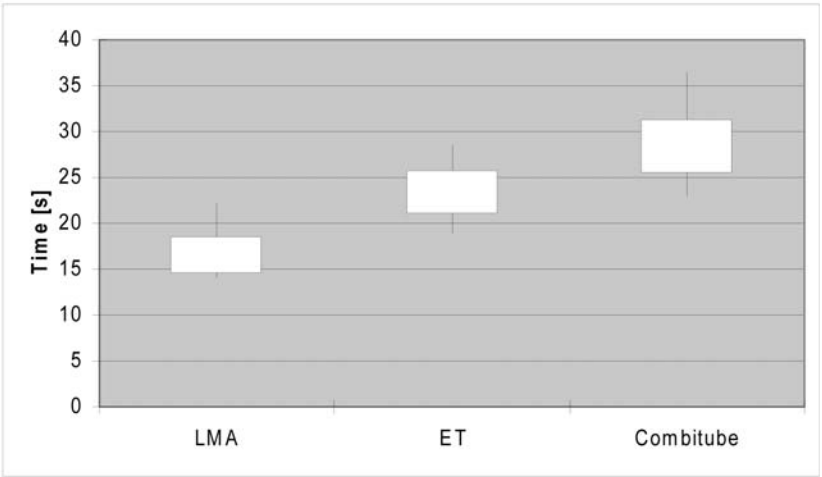
After successful airway management, mechanical ventilation was commenced with the respirator Medumat Easy (Weinmann, Germany). Using the program AMBU® CPR SOFTWARE, minute ventilation with ET or LMA Supreme was measured during continuing chest compressions for 2 minutes. For evaluation of effectiveness of ventilation we used a research model consisting of AmbuMegaCode Man manikin system connected to the computer (figure 1). The air leak during CPR for each airway device was counted using the following formula: $PM_X = 1 - (\sum^{n}{}_{i=1}\ PV_X)PV_C^{-1}$ [%], where: PM_X – air leak, PV_X- measured minute ventilation, PV_C- control minute ventilation, x- studied device, n- number of participants.

Control minute ventilation was measured using the same model and endotracheal intubation without chest compressions with parameters: Respiratory Rate RR-10 [1/min], Tidal volume VT -0,9 L.

Statistical analysis was performed using Statistica 10.0 software (Statsoft, Tulsa, OK, USA). Collected parameters were subjected to ANOVA statistical analysis. The Shapiro-Wilk test was used to assess if variables had a normal distribution and Levene test to assess the equality of variances. For comparison of success rates and for non-paired categorical data analysis the chi-squared test was used. Continuous data were analyzed with Mann-Whitney U test. A P value <0.05 was considered statistically significant.

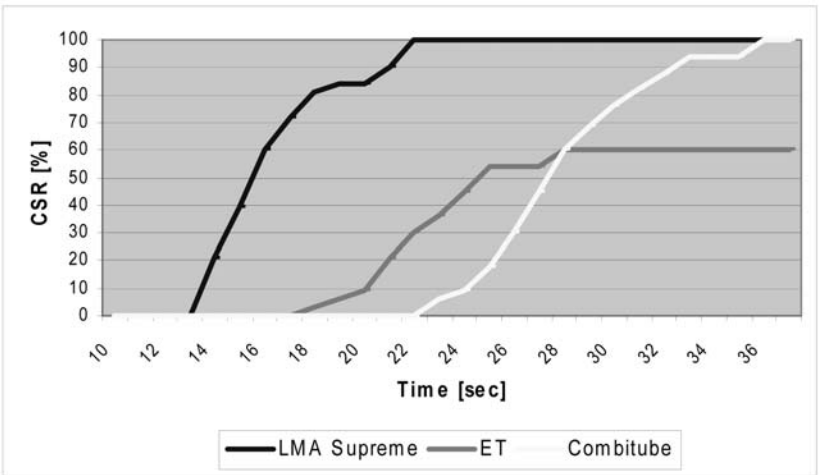
Results

Participantsždemographic data are presented in table 1. Mean CCF was significantly better for LMA Supreme and Combitube compared to ET: 0.8 (SD 0.062, Median 0.8, range 0.67-0.93) vs 0.71 (SD 0.048, Median 0.705,



ET, endotracheal tube; LMA laryngeal mask.

Figure 2. Time of successful airway management confirmed by ventilation with self-inflating bag (only first successful endotracheal tube attempts are taken into consideration, n=20/30).



ET, endotracheal tube; LMA laryngeal mask.

Figure 3. Cumulative Success Ratio (CSR) at first attempt of airway management with evaluated devices.

range 0.53-0.93) vs 0.65 (SD 0.051, Median 0.65, range 0.43-0.9) for LMA Supreme vs ET respectively and Combitube ($p<0.05$).

The mean time for successful airway management was significantly shorter for LMA Supreme, and the longest for Combitube: 16.5 (SD 0.3, Median 16.4, range 14.1-22.3 sec) vs 24.37 (SD 0.6, Median 23, range 18.9-28.6 sec) vs 28.3 (SD 3.0, Median 28, range 23-36.4 sec) for LMA Supreme, Combitube and endotracheal intubation respectively ($p<0.05$) (figure 2). The success rate in the first attempt was 100% for LMA Supreme and 66.6% for endotracheal intubation (20/10) ($p<0.05$). The Cumulative Success Ratio is presented in figure 3. Mean air leak during chest compressions was 14% for LMA Supreme and 8% for endotracheal intubation ($p<0.05$).

Discussion

Airway management is considered an essential element of both in-hospital and out-of-hospital CPR. Tracheal intubation is the most widely used method for airway management, but it is considered difficult to use for occasional users. Airway management in out-of-hospital CPR can be very demanding. The percentage of esophageal intubations in emergency settings can be up to 14%. (4) Therefore the airway device that is easier to use, has a higher rate of success and allows ventilating the patient with higher pressures (needed in CPR because of chest compressions that interfere with ventilation) is a good alternative to endotracheal intubation. LMA supreme is designed for easy insertion (curved shape), higher than other supraglottic devices' pressure ventilation (up to 37 cmH2O – "first seal"), (5) and better prevention from aspiration of gastric content ("second seal system"), (6) which is especially important in out-of-hospital CPR.

Chest compressions should not be stopped in order to maximize coronary and cerebral perfusion pressure, however, if airway management without interruption of chest compression is not possible, then CPR can be stopped. The time for endotracheal intubation in this situation should not be longer than 10 sec. (1) To minimize the risk of hypoxia, an insertion of a SAD can be carried out during cardiopulmonary resuscitation without interrupting chest compression. Gatward et al. performed a study on forty doctors and reported that chest compression did not significantly prolong the time needed to insert a SAD. (7) Median "hands-off" time was 4.5 sec. Authors also report that the time needed to insert a SAD does not depend on previous experience of the operator. (7) SADs are better than bag-mask-ventilation (BMV) during CPR regarding CCF. (8) Jensen et al. evaluated the influence of the use of a King Laryngeal Tube and BMV in simulated CPR conditions on CCF. They had similar observations to ours: CCF for laryngeal tube was 0.82. In our study we observed that CCF is significantly decreased in the case of endotracheal intubation compared to LMA Supreme insertion. This was because

of a significantly longer time of ET and significantly lower success rate at first attempt for ET (and necessity of repeating ET attempt) compared to LMA Supreme. In our study we showed that achieving proper ventilation was significantly faster in cases of LMA Supreme. The time for successful insertion of LMA Supreme during the CPR scenario was longer in our study compared to the results of Kohama et al.: 16.4 SD vs 5.8 SD 1.6 s respectively. (9) A possible explanation is that in the Kohama study LMA Supreme insertion was performed by anesthesiologists whereas in our study it was performed by paramedics. As mentioned in the introduction, anesthesiologists have more experience with airway management compared to paramedics. Longer mean "hands-off" time for endotracheal intubation comparing to SAD airway management during CPR was observed also by Gruber C et al. (10) In their study the "hands-off" time for ET was longer than in our study: 39.4 s vs 24.4 s, but for LMA shorter: 10.2 s vs 16.5 s. As for Combitube they observed a much shorter "hands-off" time than we did (7.9 s vs 28 s). Other SADs (I-Gel, Easy Tube and Laryngeal Tube) had similar "hands-off" time to LMA. In their previous study they observed even longer "hands-off" time for intubation (48 sec) and LMA (13.3 sec). (11) Hands-off time was significantly longer with the conventional endotracheal tube than with any of the other airway systems. Using supraglottic airway devices, EMTs achieved a hands-off time within the recommended time limit of 10 sec. They conclude that SADs are a reasonable airway strategy for emergency medical personnel not very experienced with ET. Our observation supports this hypothesis in the case of LMA Supreme. As for Combitube, a surprisingly long time was necessary to insert this device in our study, influencing CCF. This suggests that Combitube may not be a good option for airway management during CPR.

There are a limited number of studies evaluating the effectiveness of ventilation during CPR comparing SADs and ET. Kohama et al. measured peak pressures during ventilation and chest compressions. For LMA Supreme it was 20.6 ± 8.6 cmH_2O. (9) This should allow ventilation with LMA Supreme with minimal air leak during CPR. In our study we found that chest compressions influence minute ventilation. For LMA Supreme, the effectiveness of maintaining minute ventilation was 86% (comparing to ET 92%). In our opinion it is still acceptable and should provide adequate oxygenation during CPR. Genzwuerker et al. evaluated the laryngeal tube for ventilation during CPR. (12) They found that chest compressions caused a significant decrease in tidal volumes during ventilation with the automatic transport ventilator. Ocker et al. evaluated the influence of SAD usage: laryngeal mask and Combitube on lung ventilation and gastric inflation during CPR compared to BMV. (13) They found that both SADs were effective in maintaining MV during CPR and the incidence of gastric inflation was very low.

Endotracheal intubation in our study was significantly more difficult and had a significantly lower success rate at the first attempt. To achieve proper ventilation and oxygenation as fast as possible is especially important in out-of-hospital CPR, where patients are often already in profound hypoxia. The higher success rate and faster time to proper ventilation during CPR may be achieved using a SAD especially in the case of occasionally users. (14,15)

The effectiveness of LMA Supreme during chest compression in clinical settings was confirmed in the case report by Murdoch et al. (16) A patient who was enrolled in a study evaluating the LMA-Supreme for anesthesia had a cardiac arrest. Immediately, chest compressions were commenced. For the whole period of CPR, LMA-Supreme ensured sufficient ventilation. Signs of cyanosis or hypoxia were not observed. This suggests that the results obtained from the manikin study may draw some conclusions applicable to real emergency situations.

There are several limitations of our study: The results of manikin-based studies are limited in interpretation compared with humans, although we used a very good manikin model for airway management and ventilation. The conditions for CPR were ideal: no stress factor, no environmental factors (for example rain, limited access to the patient). We evaluated participants with clinical experience – they were last year students of the school for paramedics. Still we think that the results of our study can be valid for evaluation of airway methods in CPR for paramedics.

Conclusion

We conclude that the LMA Supreme is an effective tool for emergency airway management during CPR ensuring higher CCF and allowing adequate ventilation compared to endotracheal intubation performed by paramedics.

REFERENCES

1. Deakin CD, Nolan JP, Soar J, Sunde K, Koster RW, Smith GB, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 4. Adult advanced life support. Resuscitation 2010;81(10):1305-52.
2. Burton HJ, Baumann MR, Maoz T, Bradshaw JR, Lebrun JE. Endotracheal intubation in a rural EMS state: procedure utilization and impact of skills maintenance guidelines. Prehosp Emerg Care 2003;7(3):352-6.
3. Vaillancourt C, Everson-Stewart S, Christenson J, Andrusiek D, Powell J, Nichol G, et al. The Impact of Increased Chest Compression Fraction on Return of Spontaneous Circulation for Out-of-Hospital Cardiac Arrest Patients not in Ventricular Fibrillation. Resuscitation 2011;82(12):1501–7.
4. Nolan JD. Prehospital and resuscitative airway care: should the gold standard be reassessed? Curr Opin Crit Care 2001;7(6):413-21.
5. Van Zundert A, Brimacombe J. Correspondence: The LMA Supreme™ – a pilot study. Anaesthesia 2008;63:202-13.
6. Schmidbauer W, Bercker S, Volk T, Bogusch G, Mager G, Kerner T. Oesophageal seal of the novel supralaryngeal airway device I-Gel™ in comparison with the laryngeal mask airways Classic and ProSeal using a cadaver model. Br J Anaesth 2009;102(1):135-9.
7. Gatward JJ, Thomas M JC, Nolan JP, Cook TM. Effect of chest compressions on the time taken to insert airway devices in a manikin. Br J Anaesth 2008;100(3):351-6.
8. Jensen JL, Walker M, LeRoux Y, Carter A. Chest compression fraction in simulated cardiac arrest management by primary care paramedics: King laryngeal tube airway versus basic airway management. Prehosp Emerg Care 2013;17(2):285-90.
9. Kohama H, Komasawa N, Ueki R, Samma A, Nakagawa M, Nishi S, et al. Comparison of Supreme and Soft Seal laryngeal masks for airway management during cardiopulmonary resuscitation in novice doctors: a manikin study. J Anesth 2011; (25):98–103.
10. Gruber C, Nabecker S, Wohlfarth P, Ruetzler A, Roth D, Kimberger O, Fischer H, Frass M and Ruetzler K. Evaluation of airway management associated hands-off time during cardiopulmonary resuscitation: a randomised manikin follow-up study. Scand J Trauma Resusc Emerg Med 2013; 21:10.
11. Ruetzler K, Gruber C, Nabecker S, Wohlfarth P, Priemayr A, Frass M, et al. Hands-off time during insertion of six airway devices during cardiopulmonary resuscitation: a randomised manikin trial. Resuscitation 2011 Aug;82(8):1060-3.
12. Genzwuerker HV, Finteis T, Slabschi D, Groeschel J, Ellinger K. Assessment of the use of the laryngeal tube for cardiopulmonary resuscitation in a manikin. Resuscitation 2001 Dec;51(3):291-6.
13. Ocker H, Wenzel V, Schmucker P, Dörges V. Effectiveness of various airway management techniques in a bench model simulating a cardiac arrest patient. J Emerg Med 2001 Jan;20(1):7-12.
14. Katz SH, Falk JL. Misplaced endotracheal tubes by paramedics in an urban emergency medical services system. Ann Emerg Med 2001;37:32–7.
15. Jones JH, Murphy MP, Dickson RL, Somerville GG, Brizendine EJ. Emergency physician-verified out-of-hospital intubation: miss rates by paramedics. Acad Emerg Med 2004;11:707–9.
16. Murdoch H, Cook T M. Effective ventilation during CPR via LMA-Supreme, Anaesthesia 2008;63:316-27.