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Comparison of the airway access skills of medical students in cardiopulmonary resuscitation simulation: a randomized crossover study

Porównanie umiejętności studentów medycyny w zakresie zabezpieczenia drożności dróg oddechowych podczas resuscytacji krążeniowo-oddechowej. Badanie randomizowane krzyżowe

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Słowa kluczowe

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Summary

Introduction. Endotracheal intubation is considered to be a golden standard for securing the patients airway patency during cardiopulmonary resuscitation. The AirTraq laryngoscope is an intubating device that provides equal or better glottic visualization then conventional Macintosh or Miller laryngoscopes.

Aim. The aim of this study was to investigate the use of the AirTraq laryngoscope in cardiopulmonary resuscitation scenario with and without chest compression compared with the more conventional Macintosh laryngoscope performed by inexperienced last year medical students.

Material and methods. Forty-one last year medical students intubated the trachea of a manikin using the AirTraq laryngoscope and a Macintosh laryngoscope, in randomized order. They performed the endotracheal intubation in two distinct scenarios: scenario A where the chest compressions were paused during intubation attempt and scenario B where participants had to intubate while constant chest compressions were made. The study was designed as a randomized, cross-over study. Success rate, time to successful intubation, number of intubation attempts and difficulty score were measured.

Results. Forty-one last year medical students participated in this study. Time for successful intubation during scenario A was varied for Macintosh laryngoscope 33 (IQR: 30-41.5) and AirTraq 24 (IQR: 22-32) sec. The efficacy of the first intubation attempts were 51.2 and 65.9%, respectively. In case of scenario B, the intubation time for both laryngo-scopes was prolonged and in the case of Macintosh laryngoscope it was 47.5 (IQR: 34-59) vs. 33 (IQR: 30.5-43) sec for AirTraq. The effectiveness of the first intubation attempt for the Macintosh laryngoscope was 34.1 vs. 48.8% for AirTraq.

Conclusions. In conclusion, this study indicates that the AirTraq laryngoscope may be a good first choice in tracheal intubation for an inexperienced intubation provider during a cardiopulmonary resuscitation, due to the improved first-attempt success rate, shorter intubation time, fewer intubation attempts, improve glottic view, and ease of use reported in this study when compared with classic laryngoscope.

Streszczenie

Wstęp. Intubacja dotchawicza jest uznawana za standard zabezpieczenia drożności dróg oddechowych podczas resuscytacji krążeniowo-oddechowej. Laryngoskop AirTraq jest urządzeniem pozwalającym na lepsze uwidocznienie głośni w porównaniu z laryngoskopem z łopatką Millera lub Macintosha. **Cel pracy.** Celem badania było porównanie efektywności intubacji z wykorzystaniem AirTraq oraz laryngoskopu Macintosha w warunkach symulowanej resuscytacji krążeniowo-oddechowej z uciskaniem i bez uciskania klatki piersiowej wykonywanej przez studentów ostatniego roku studiów medycznych.

Materiał i metody. Czterdziestu jeden studentów VI roku studiów medycznych wykonywało intubację dotchawiczą symulatora pacjenta, wykorzystując laryngoskop Air-Traq oraz Macintosh. Kolejność była losowa. Intubacja dotchawicza była wykonywana w warunkach symulowanej resuscytacji krążeniowo-oddechowej pacjenta w dwóch scenariuszach: z zaprzestaniem uciskania klatki piersiowej na czas wykonania intubacji dotchawiczej (scenariusz A) oraz z nieprzerwalnym uciskaniem klatki piersiowej podczas procedury intubacji (scenariusz B). Badanie zaprojektowano jako randomizowane krzyżowe. Badano skuteczność intubacji, czas procedury, liczbę prób intubacji oraz trudności intubacji.

Wyniki. Czterdziestu jeden studentów ostatniego roku studiów medycznych uczestniczyło w badaniu. Czas intubacji podczas scenariusza A był zróżnicowany i wynosił odpowiednio 33 s (IQR: 30-41,5) w przypadku laryngoskopu Macintosha oraz 24 s (IQR: 22-32) dla AirTraq. Skuteczność pierwszej próby intubacji wynosiła odpowiednio 51,2 i 65,9%. W przypadku scenariusza B czas intubacji dla obydwu laryngoskopów uległ wydłużeniu i wynosił 47,5 s (IQR: 34-59) dla laryngoskopu Macintosha oraz 33 s (IQR: 30,5-43) dla AirTraq. Skuteczność pierwszej próby intubacji w przypadku laryngoskopu z łopatką Macintosha wynosiła 34,1%, zaś dla AirTraq – 48,8%.

Wnioski. Podsumowując, laryngoskop AirTraq może być dobrym wyborem w przypadku intubacji dotchawiczej wykonywanej przez niedoświadczony personel podczas resuscytacji krążeniowo-oddechowej. Wykorzystanie AirTraq zwiększyło skuteczność pierwszej próby intubacji, skróciło czas trwania procedury, polepszyło uwidocznienie głośni oraz ułatwiło intubację w porównaniu z laryngoskopem Macintosha.

INTRODUCTION

Intubation of endotracheal in cardiopulmonary resuscitation may be a challenge for medical personnel. A recent Advanced Cardiovascular Life Support (ACLS) guidelines published by the American Heart Association recommend that endotracheal intubation should be performed by the most experienced person and if possible without any pause during chest compressions (1, 2). Since the invention of the Macintosh and Miller laryngoscope blades in the 1940s, direct laryngoscopy has been the mainstay of endotracheal intubation. Laryngoscopes with Miller or Macintosh blades are the most popular laryngoscopes in Poland during both pre-hospital and in-hospital management of the patient (3-5). However, as the numerous publications suggest, the effectiveness of intubation in pre-hospital conditions is insufficient (6). Ducharme et al. in a study analyzing the effectiveness of direct laryngoscopy provided by paramedics in pre-hospital management present the effectiveness of the first intubation attempt with this method to be 66.7%, and the total efficacy being 81% (7). Another study by Myers et al. (8) found the total intubation efficacy to be 75%. Cavus et al. (9), presented the data which shows the total efficacy of endotracheal intubation performed by emergency physicians varies, depending on the videolaryngoscope used in 61 to 97% range. Due to the low efficacy of endotracheal intubation performed during emergency, it is reasonable to research the alternative methods of the airway patency protection which will increase the effectiveness of the first intubation attempt and shorten the duration of the procedure (10-13).

AIM

The aim of this study was to compare the endotracheal intubation effectiveness with the use of Macintosh and with the AirTraq laryngoscope in simulated cardiopulmonary resuscitation with and without chest compression scenarios performed by medical students.

MATERIAL AND METHODS

This study was approved by the Institutional Review Board of the Polish Society of Emergency Medicine (Approval number: 89.11.2017.IRB). Written informed consents were obtained from all medical students who participated in the study. The study is a continuation of the authors' research on the alternative approach for the direct laryngoscopy during endotracheal intubation in cardiopulmonary resuscitation.

Subjects

Forty-one last year medical students were included in the study. A Resusci Anne Simulator (Laerdal, Stavanger, Norway) was used to simulate intubation during cardiopulmonary resuscitation. For all intubations a size 7.5 cuffed endotracheal tube, lubricated with silicon aerosol (Laerdal, Stavanger, Norway) was used. A semi-rigid stylet of the tube was not used during comparison of the intubation difficulty among the laryngoscopes.

Study protocol

The participants of the study performed endotracheal intubation with the use of: (1) laryngoscope with Macintosh size 3 blade (gold standard), (2) AirTraq laryngoscope (PRODOL MEDITEC, Vizcaya, Spain). In the case of AirTraq laryngoscope, a special accessory with iPhone 6S phone, which was set in the video camera mode, was attached to AirTraq, which allowed the device to work as a video laryngoscope (fig. 1). The intubation performed in two scenarios: scenario A - normal airway without chest compression and scenario B - normal airway with uninterrupted chest compression. In order to standardize the challenges occurring during uninterrupted chest compressions while securing the airway patency, a chest compression system set in the constant chest compression mode was used that was during the scenario B. Each study participant had a maximum of three endotracheal intubation attempts in each scenario. Both the order of participants and the methods of intubation were randomized by Research Randomizer program, which divided the participants into four groups. The first group began endotracheal intubation with MAC during the scenario A, the second one used AirTrag for the scenario A, the third group intubated with MAC during the scenario B and the last fourth group used AirTrag for the scenario B. Detailed procedure of randomization of the study is presented on figure 2.

Measures

The primary endpoint was time to intubation. We defined intubation time as the time elapsing between the intubating devices entering the oral cavity until first successful ventilation using valve-bag-mask. We defined a failed intubation as one in which the trachea was not intubated within 60 seconds, or the tracheal tube has been inserted into the esophageal.

Additional endpoints were: first intubation attempt efficacy, total intubation efficacy, the number of esophageal intubations and the grade of the laryngeal view



Fig. 1. AirTraq videolaryngoscope

based on the Cormack-Lehane scale (14, 15). The easiness of tracheal intubation was also measured with a visual analogue scale ranging from 0 (very simple) to 100 (impossible). Details and outcomes of the three last tracheal intubation attempts performed with each device at the end of the training programme with the scenario A were taken as control data (control group) and compared with those of scenario B.

Statistical analysis

STATISTICA software ver. 13.3 (Statsoft Inc, Tulusa, OK, USA) was used for statistical analysis. A P-value < 0.05 was considered statistically significant. The times needed for the first successful ventilation (intubation time) were compared using the Wilcoxon signed



Fig. 2. Randomization flow chart of the study

rank test. To detect possible differences in success rates for ETI, the McNemar's test was used. We estimated that at least 32 people who intubate for each device would be adequate number for detection of a 33% difference in the intubation time with a power of 0.8 (alpha = 0.05).

RESULTS

Forty-one last year medical students (16 females; 39%) were included in the study and all of them completed the study. The mean age of participants was 23.8 ± 0.8 years old. None of the participants had prior experience with tracheal intubations using videolaryngoscopy.

Scenario A – intubation without chest compression

Endotracheal intubation time was shorter with the AirTraq laryngoscope than the Macintosh laryngoscope and it was 24 (IQR: 22-32) vs. 33 (IQR: 30-41.5) sec respectively (fig. 3). The overall intubation success rate for both laryngoscopes was 100%. However, the efficacy of the first intubation attempt with MAC was 51.2 vs 65.9% for AirTraq (tab. 1). The grade of glottal visualization was higher when using AirTraq than the Macintosh laryngoscope (p = 0.037). The easiness of use was not significantly different between devices (p = 0.074).

Tab. 1. Endotracheal intubation parameters for distinct laryngoscopes in scenario A – normal airway without chest compression

Parameter	Macintosh laryngoscope (n = 41)	AirTraq laryngoscope (n = 41)	p-Value
Intubation time (s)	33 (IQR: 30-41.5)	24 (IQR: 22-32)	0.013
Overall intubation success, n (%)	41 (100%)	41 (100%)	NS
No. of intubation attempt, n (%) 1 2 3	21 (51.2%) 20 (48.8%) –	27 (65.9%) 14 (34.1%) –	NS
Cormack-Lehane grade, n (%) I II III IV	16 (63.5%) 14 (34.1%) 1 (2.4%) -	31 (75.6%) 10 (24.4%) – –	0.037
Ease of use* (0-100)	27 (IQR: 20-38)	21 (IQR: 17-35)	NS

Data are median (interquartile range) or mean \pm SD or number (%). *Ease of use was represented by visual analogue scale from 0 (very simple) to 100 (impossible)

NS - not statistical significant; IQR - interquartile range

Scenario B – intubation with uninterrupted chest compression

Intubation time was significantly shorter with the Air-Traq -33 (IQR: 30.5-43) sec compared to the Macintosh laryngoscope -47.3 (IQR: 34-59) sec (p = 0.013; fig. 3). The overall intubation success rate for the Macintosh laryngoscope was 70.7 vs. 97.6% for Air-



Fig. 3. Median time to intubation

Traq (p < 0.001; tab. 2). The effectiveness of the first intubation attempt using the Macintosh laryngoscope and AirTraq was different and was 34.1 and 48.8% respectively (p < 0.001). The statistically significantly better glottal visualization was obtained in the case of AirTraq use when compared with Macintosh laryngoscope (p = 0.001). The participants also found the AirTraq way easier to use than the Macintosh laryngoscope during the continuous chest compression scenario (fig. 4).

DISCUSSION

We showed that endotracheal intubation during continuous chest compression was possible with the AirTraq when performed by a person with no prior experience. We found that last year medical students performed successful intubation in both scenarios (with and without chest compressions) more rapidly with

Tab. 2. Endotracheal intubation parameters for distinct laryngoscopes in scenario B - normal airway with uninterrupted chest compression

Parameter	Macintosh laryngoscope (n = 41)	AirTraq laryngoscope (n = 41)	p-Value
Intubation time (s)	47.3 (IQR: 34-59)	33 (IQR: 30.5-43)	0.011
Overall intubation success, n (%)	29 (70.7%)	40 (97.6%)	< 0.001
No. of intubation attempt, n (%) 1 2 3	14 (34.1%) 10 (24.4%) 5 (12.2%)	20 (48.8%) 19 (46.4%) 1 (2.4%)	0.037
Cormack-Lehane grade, n (%) I II III IV	8 (19.5%) 13 (31.7%) 12 (44.0%) 2 (4.8%)	20 (48.8%) 21 (51.2%) –	0.001
Ease of use* (0-100)	73 (IQR: 59-85)	49 (IQR: 32-59)	< 0.001

Data are median (interquartile range) or mean \pm SD or number (%). *Ease of use was represented by visual analogue scale from 0 (very simple) to 100 (impossible)

NS - not statistical significant; IQR - interquartile range



Fig. 4. Ease of use scale for different intubation techniques

the AirTraq laryngoscope than with the Macintosh laryngoscope. Intubation during continuous chest compression scenario was more difficult than conventional intubation without chest compression.

Cardiopulmonary resuscitation with uninterrupted chest compressions may be a challenge when performing the endotracheal intubation (13). In the conducted study, chest compressions lowered both the total and the first intubation attempt effectiveness when intubating with the Macintosh laryngoscope, by 29.7 and 17.1%, respectively. Performing the procedure of intubation without pause in chest compressions also prolonged the procedure by about 14.3 seconds. Numerous studies also prove that the intubation time is longer when performing direct laryngoscopy during cardiopulmonary resuscitation (13, 16-20).

AirTraq laryngoscope was invented by Pedra A. Gandarias (21). When the intubation with the use of AirTraq laryngoscope was studied, the reduction of the first intubation attempt efficacy was observed by about 17%, however the total efficacy of intubation in the case of uninterrupted chest compressions decreased by only 2.4%. The advantage of this type of video laryngoscope compared to direct laryngoscopy include better glottis visualization in situations where there is a difficult access to the airways or the patient's condition does not allow intubation

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in non-moving conditions e.g. during cardiopulmonary resuscitation, or are we dealing with the patient who has an immobilized cervical spine with a cervical collar. In the latter situation it may be necessary to open the cervical collar and perform the manual stabilization of the pine, because the AirTrag device requires a minimal mouth opening of 18 mm. AirTrag laryngoscope, as shown in this study, can be used by people with no prior experience in intubation during the cardiopulmonary resuscitation. However, as found in the literature, this device can also be used during intubation of trauma patients (22, 23), difficult airways patients (24) or in pediatric surgery (25). Additionally, as indicated by Belze et al. (24) there is no significant difference in success rates of tracheal intubation with a double-lumen tube in patients with a predicted or known difficult airway when using either a Glidescope or AirTrag device. Rendeki et al. (26) indicated that the Air-Trag was superior to the Macintosh laryngoscope in both normal and difficult airway scenarios for novice users.

This study has several limitations. The first one is that an airway manikin does not reproduce a real-life pre-hospital tracheal intubation in cardiac arrest patients. However, the use of the simulator during the studies allows for performing cross-over randomized studies in a standardized manner (27, 28). The second limitation is the inclusion of the last year medical students into the study. However, the participants had completed the module in emergency medicine and anesthesiology and had declared the ability to perform endotracheal intubation with standard laryngoscopes with Miller or Macintosh blades. The study, apart from the limitations, also has its strengths. The first one is that this is a randomized cross-over study. And secondly the chest compressions were standardized with the mechanical chest compression system LUCAS2.

CONCLUSIONS

To sum up, this study indicates that the AirTraq laryngoscope may be a good first choice for endotracheal intubation by inexperienced users during a cardiopulmonary resuscitation, due to the improved first-attempt success rate, shorter intubation time, fewer intubation attempts, improved glottic view, and easiness of use reported in this study.

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