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Evaluation of the usefulness of direct laryngoscopy and video laryngoscope training in pediatric airway management

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Abstract

Background/Objectives: This study aims to evaluate the usefulness of direct laryngoscope and video laryngoscope education in pediatric airway management of 119 paramedics.

Methods/Statistical analysis: The study subjects were 37 first-class emergency medical personnel working at two fire stations located in J area. Secure normal airways, fixation of head and cervical vertebrae, performance of endotracheal intubation and confidence in tongue edema were assessed before and after training. Collected data were analyzed using frequency, descriptive statistics, and paired t-test by SPSS 22.0.

Findings: Total endotracheal intubation scores in endotracheal intubation performance according to the type of laryngoscope was significantly higher in tongue edema situation with video laryngoscope before training (p=.024) and in head and cervical vertebral fixation situation with direct laryngoscope after training (p=.015). Endotracheal intubation time was faster in three cases of direct laryngoscope before and after training (p =.003, p=.040, p=.040), and faster in normal airway (p=.004) as well as tongue edema (p=.006) significantly. In the tongue edema, the tooth injury rate was decreased by video laryngoscope (p <.001, p = .001) before and after education and the confidence in performing endotracheal intubation was higher in direct laryngoscope (p <.001) and video laryngoscope (p<.001) after training.

Improvements/Applications: In addition to direct laryngoscopy, continuous video laryngoscope training through a variety of on-site situations is required for effective childhood airway management of 119 paramedics.

***Keywords*:** Children, Airway management, Laryngoscope, Endotracheal intubation, Paramedics

1. Introduction

Endotracheal intubation is the method of maintaining the airway in various emergencies, such as endotracheal edema, convulsions, obstruction of the upper airway by foreign bodies or blood, and difficulty breathing due to trauma, and is one of the important techniques of airway management. It can also provide ventilation without interruption of chest compressions in cardiac arrest. However, in the pre-hospital situation of 119 paramedics, there are many factors that limit the use of specialized techniques as well as limited equipment, space and various field environments[1]. Therefore, effective endotracheal intubation requires not only awareness of the need for endotracheal intubation, but also prediction of difficult airways, determination of the best intubation method, and the skill in a variety of equipment and instruments[2, 3]. Although direct laryngoscope is commonly used as the common airway maintenance equipment used for endotracheal intubation, video laryngoscope has been used recently for proper airway management in various environments at the hospital. This laryngoscope can be easily intubated even in tough situations with clear view, which is especially emphasized in difficult airway or failed intubation[4]. At the pre-hospital stage, 119 paramedics should emphasize rapid airway maintenance for patients with cardiac arrest or dyspnea due to acute or chronic illness and severe trauma patients[5]. As the use of video laryngoscope has emerged, the study of endotracheal intubation through video laryngoscope has been conducted in adults[1,5-9], but research results verifying the effectiveness of airway management education in children are difficult to find.

Children can have many complications due to respiratory problems rather than heart problems. In management of pediatric airway, the most serious complication of endotracheal intubation was cardiac arrest, minor complication being hypoxia. The incidence of complication was getting high as the number of intubation attempts increased[10]. Therefore,

119 paramedics, who need to manage airway of all ages in various field situations, need not only education about adult airway management and the use of direct laryngoscope, but also pediatric airway management and education using various laryngoscopes. This study aims to evaluate the usefulness of direct laryngoscope and video laryngoscope education in pediatric airway management and provide a basic data for improving the quality of pediatric airway management.

2. Research Methods

2.1. *Research design*

This study is the pre- and post-test design experiment of single group to verify the effectiveness of direct laryngoscopy and video laryngoscope training in pediatric airway management of 119 paramedics.

2.2. *Subjects and sampling method*

The subjects of this study were first-class emergency rescue workers at two fire stations in J city and agreed to participate in the study. The number of subjects was 36 when the significance level (α) .05, power (1-β) .50 and effect size .80 were set using G * Power 3.1.9. Forty people were selected in consideration of the dropout rate, and thirty-seven women were included, except those who dropped out.

2.3. *Research method*

2.3.1 Endotracheal intubation performance

The checklist of performance evaluation in endotracheal intubation performance checklist for children was developed by modifying and supplementing the 2018 First Class Emergency Medical Examination Practice Test Protocol to verify the reliability and validity of the expert group. It consists of endotracheal intubation score, endotracheal intubation time (within 30 seconds), tooth damage rate, and endotracheal intubation success rate in normal airway, head or cervical spine fixation and tongue edema. For details, it consists of 1 point of removal of oropharyngeal airway BVM, 2 points of Sniffing position, 1 point of opening of the mouth by finger crossing method, 3 points of pushing the tongue to one side with laryngoscope blade, 3 points of lifting mandible 45 degrees anterior and upward with the laryngoscope(checking the vocal cord)s, 3 points of endotracheal intubation(14-15cm) 3 points, 1 point of probe removal, 1 point of air injection into the cuff, syringe separation 1 point, 1 point of ventilation with bag valve (end of intubation), and 5 points(30 seconds or less of rapidity measurement). With a total of 20, the higher the score, the higher the endotracheal intubation score. In the success rate of endotracheal intubation, the higher the score, the higher the success rate. In the rate of dental injury, the lower the rate, the lower the rate of tooth damage. The shorter endotracheal intubation time means the better result.

2.3.2 Performance confidence

Performance confidence means the confidence that you can solve problems in a variety of situations, being evaluated on the Numeric rating scale (NRS) and set as 0-10 points. It was assessed by self-evaluation before and after education, with 0 being the least and 10 being the highest.

2.4 *Method of data collection*

In order to proceed with the research, the researcher visited the fire station, fully explained and approved for the purpose, procedure, predicted outcomes and possible problems of the study. The first-class emergency rescues without conflict of interest, working at fire department, agreed on the purpose, method, duration, expected effects, benefits and possible problems of participation, and guarantees of anonymity and refusal to participate. It was performed with the consent of the subject. The study period was from July 22 to July 23, 2019.

2.5 *Research Procedure*

2.5.1 Checklist in evaluation of endotracheal intubation performance

In order to evaluate the endotracheal intubation performance of children, some of the 2018 first-class emergency medical practitioners' practical examination protocols were revised and supplemented. The Content Validity Index (CVI) was obtained as 0.90 from a group of experts consisting of a professor of first aid and one first-aid emergency rescuer who has worked for more than seven years in a hospital and one first-aid emergency rescue worker who has worked for more than ten years in a fire department.

2.5.2 Research equipment

The direct laryngoscope used in this study was Macintosh laryngoscope, video laryngoscope being from GlideScope Ranger of Mass. Korea. Manikin used for endotracheal intubation was airway management trainer 250000(Laredal Medical Stavanger, Norway). The cervical vertebrae were protected using the stiff neck select collar (Laredal), and the difficult situation of tongue edema was simulated using a METI simulator(PEDIECS). The

endotracheal intubation tubes were used between 5.5 and 6.0 mm for ages 5-6.

2.5.3 Pre-training assessment

While a preliminary survey of general characteristics and performance confidence being conducted by questionnaire prior to training, normal airway, C-collar airway, and tongue edema airway were used to assess pediatric endotracheal intubation performance. Normal airway was not restricted during endotracheal intubation, and the head and cervical vertebral fixation was performed with a philadelphia brace to limit the movement of the head and cervical spine. The situation in which the field of view was restricted at intubation was created by setting the tongue edema situation in a pediatric simulator. All subjects underwent one endotracheal intubation in three situations using direct laryngoscopy and video laryngoscope, and after intubation, it was estimated as success if there was the chest elevation after two ventilations with a bag-valve mask, while the absence of chest elevation indicating failure. When the teeth of the mannequin were bent while supporting the laryngoscope blade, it was regarded as the tooth damage. If there is no damage, it is determined to be success while the damage meaning the failure. Intubation time was within 30 seconds in children because hypoxia or ischemic injury may occur due to inadequate intubation or delayed procedure[5].

2.5.4 Theory and Practice

After the preliminary evaluation, the collaborators conducted theoretical education on pediatric airway management. After theoretical education, we divided the groups into normal airway, fixation of head and cervical spine and airway with tongue edema using direct laryngoscope and video laryngoscope. The co-researchers conducted pilot training in the study subjects, corrected the deficiencies, and provided questions and answers and debriefings.

2.5.5 Post evaluation after training

Post-education evaluation was performed with the endotracheal intubation performance of children in three different situations, and the questionnaire was administered in the performance confidence.

2.6 ***Data analysis method***

The SPSS WINDOW 21.0 Program was used to analyze the collected data.

1) The frequency and descriptive statistics were used to assess the general characteristics of the subjects, 00659 the ability and confidence of endotracheal intubation in children before and after education.

2) The paired t-test was used to assess the difference between intubation and self-confidence in children before and after education.

2.7 ***Ethical consideration***

For ethical consideration of the study subjects, data were collected after review by the Institutional Review Board(IRB) of the D University Institutional Review Board(IRB No: DUC-2019-01-001-01).

3. Results

3.1 ***General characteristics of the subject***

The general characteristics of the subjects were examined in advance, and the analysis results are shown in Table 1. The number of males was 21(56.8%), the average age being 29.97 years old, the age being 14(35.1%) under 30-35 years old, and the number of first aid workers being 12(40.5%) under 1 year. In the use of direct laryngoscope and video laryngoscope, the lack of experience was 21(56.8%) and 30(81.1%), respectively. In the recent one year, there were 31(83.8%) and 16(43.2%) in the lack of experience in endotracheal intubation and specialized airway.

3.2 ***Difference in endotracheal intubation performance before and after education***

The difference in endotracheal intubation performance in three situations before and after education is shown in Table 2. Endotracheal intubation scores and time before and after training showed the statistically significant difference in normal airway (p<.001, p<.001), head and cervical vertebral fixation (p <.001, p <.001) and tongue edema (p<.001, p<.001) through normal laryngoscopy and video laryngoscope. There were the statistically significant differences of tooth injury in normal airway (p= .001, p=.002), head and cervical vertebral fixation (p<.001, p=.001) and tongue edema (p<.001, p<.001) through normal laryngoscopy and video laryngoscope. Endotracheal intubation success rate was significantly different in normal airway (p=.005, p<.001), head and cervical vertebral fixation (p=.009, p<.001) and tongue edema (p<.001, p=.001).

Table 1. General characteristics of the subjects

(n=37)

Characteristics	Categories	N(%)	Mean±SD
Gender	Male	21(56.8)	

	Female	16(43.2)	
Age	<20-25	5(13.5)	29.97±5.11
	<25-30	13(35.1)	
	<30-35	14(37.8)	
	<35-40	3(8.1)	
	>40	2(5.4)	
Paramedic career (year)	<1	12(40.5)	40.12±3.15 (months)
	<1-5	13(35.1)	
	<5-10	6(16.2)	
	>10	3(8.1)	
Experience of video laryngoscope	Yes	7(18.9)	
	No	30(81.1)	
Experience of direct laryngoscope	Yes	16(43.2)	
	No	21(56.8)	
Endotracheal intubation experience in the last year	No	31(83.8)	
	1-4	5(13.5)	
	>5	1(2.7)	
No. of special airway used in the last year	No	16(43.2)	
	<1-5	10(27.0)	
	<5-10	6(16.2)	
	>10	5(13.5)	

Table 2. Difference in endotracheal intubation performance before and after education

(n=37)

Variables	Categories	Pre-test Direct laryngoscope	Post-test Direct laryngoscope	t	*p*	Pre-test Video laryngoscope	Post-test Video laryngoscope	t	*p*
		Mean±SD	Mean±SD			Mean±SD	Mean±SD		
Intubation score	Normal airway	16.27±3.83	19.48±1.40	-5.569	<.001	15.05±3.77	18.83±2.10	-6.920	<.001
	C-collar airway	16.29±3.63	19.81±0.56	-6.175	<.001	15.67±3.35	19.10±1.80	-6.574	<.001
	Tongue edema airway	11.78±2.91	17.02±2.94	-8.895	<.001	12.91±2.50	17.16±2.51	-7.735	<.001
Intubation time (sec)	Normal airway	28.61±10.98	23.01±5.72	3.075	<.001	39.45±19.82	27.14±8.22	4.682	<.001
	C-collar airway	29.34±13.49	28.51±37.09	0.126	<.001	36.45±18.56	24.72±4.26	3.857	<.001
	Tongue edema airway	43.26±15.61	31.27±6.58	4.901	<.001	51.16±20.37	36.31±10.95	5.675	<.001
Tooth damage (n(%))	Normal airway	14(37.8)	2(5.4)	-3.723	.001	18(48.6)	6(16.2)	-3.402	.002
	C-collar airway	16(43.2)	1(2.7)	-4.954	<.001	15(40.5)	5(13.5)	-3.651	.001
	Tongue edema airway	28(75.7)	10(27.0)	-5.295	<.001	16(43.2)	0(0.0)	-5.237	<.001
Intubation success (n(%))	Normal airway	26(70.3)	35(94.6)	2.991	.005	16(43.2)	32(86.5)	5.237	<.001
	C-collar airway	28(75.7)	36(97.3)	2.744	.009	21(56.8)	34(91.9)	3.970	<.001
	Tongue edema airway	6(16.2)	21(56.8)	4.478	<.001	4(10.8)	15(40.5)	3.479	.001

3.3 *Differences of endotracheal Intubation Performance before and after education by type of laryngoscope*

The differences in endotracheal intubation performance before and after training according to the type of laryngoscope are shown in Table 3. Endotracheal intubation performance before training was high by video laryngoscope (p=.024) in tongue edema, and after the training, direct laryngoscope (p=.015) scores in head and cervical vertebral fixation were statistically high. Endotracheal intubation time was faster by direct laryngoscope in normal airway, head and cervical vertebral fixation and tongue edema (p=.003, p=.040, p=.040), and even after the training, direct laryngoscope (p=.004, p=.006) of normal airway and tongue edema was fast and showed significant difference.

Tooth damage rate was significantly low in the video laryngoscope (p<.001, p=.001) of tongue edema before and after education, and endotracheal intubation success rate was significantly high in the direct laryngoscope (p=.016) of normal airway before training.

Table 3. Differences of Endotracheal Intubation Performance Before and After Education according to Type of Laryngoscope

(n=37)

Variables	Categories	Pre-test Direct laryngoscope	Pre-test Video laryngoscope	t	*p*	Post-test Direct laryngoscope	Post-test Video laryngoscope	t	*p*
		Mean±SD	Mean±SD			Mean±SD	Mean±SD		
Intubation score	Normal airway	16.27±3.83	15.05±3.77	1.571	.125	19.48±1.40	18.83±2.10	1.445	.157
	C-collar airway	16.29±3.63	15.67±3.35	0.985	.331	19.81±0.56	19.10±1.80	2.543	.015
	Tongue edema airway	11.78±2.91	12.91±2.50	-2.359	.024	17.02±2.94	17.16±2.51	-0.245	.808
Intubation time (sec)	Normal airway	28.61±10.98	39.45±19.82	-3.131	.003	23.01±5.72	27.14±8.22	-3.044	.004
	C-collar airway	29.34±13.49	36.45±18.56	-2.130	.040	28.51±37.09	24.72±4.26	0.628	.534
	Tongue edema airway	43.26±15.61	51.16±20.37	-2.126	.040	31.27±6.58	36.31±10.95	-2.950	.006
Tooth damage (n(%))	Normal airway	14(37.8)	18(48.6)	1.276	.210	2(5.4)	6(16.2)	1.434	.160
	C-collar airway	16(43.2)	15(40.5)	-0.374	.711	1(2.7)	5(13.5)	1.672	.103
	Tongue edema airway	28(75.7)	16(43.2)	-4.157	<.001	10(27.0)	0(0.0)	-3.651	.001
Intubation success (n(%))	Normal airway	26(70.3)	16(43.2)	-2.522	.016	35(94.6)	32(86.5)	-1.138	.262
	C-collar airway	28(75.7)	21(56.8)	-1.744	.090	36(97.3)	34(91.9)	-1.000	.324
	Tongue edema airway	6(16.2)	4(10.8)	-0.702	.487	21(56.8)	15(40.5)	-1.640	.110

3.4 *Confidence in endotracheal intubation performance before and after training according to type of laryngoscope*

Confidence in performing endotracheal intubation before and after education by laryngoscope type is show in Table 4. Both direct and video laryngoscopes showed higher performance after training than before training (p<.001, p<.001).

Table 4. Differences in confidence of endotracheal intubation before and after education by type of laryngoscope

Variables	Categories	Pre-test	Pre-test	t	*p*
		Mean±SD	Mean±SD		
Confidence	Direct laryngoscope	4.54±2.07	8.76±1.27	-13.587	<.001
	Video laryngoscope	4.65±2.31	8.78±0.45	-11.840	<.001

4. Discussion

The purpose of this study was to evaluate the usefulness of various laryngoscope education of 119 paramedics and to provide basic data for qualitative improvement of pediatric airway management. As the result of analyzing the difference in endotracheal intubation performance before and after pediatric airway management education, the endotracheal intubation score and endotracheal intubation success rate were higher than before and after training in three situations with direct laryngoscope and video laryngoscope. Endotracheal intubation time was shortened after training in all three situations with direct laryngoscope and video laryngoscope. In addition, the tooth damage rate also decreased after training in direct and video laryngoscope of three situations. This is considered to be the effect of repetitive learning that subjects who have not experienced endotracheal intubation in the past year and who did not use

specialized airway equipment have been trained in the theory of pediatric airway management and practice of airway management in three situations while correcting the deficiency and providing endotracheal intubation in various situations through Q & A and debriefing. It is also a result supporting previous research results[5,11] that emphasize the importance of repetitive learning.

As a result of examining the difference of endotracheal intubation ability according to the type of laryngoscope, direct laryngoscopic and normal laryngoscopic endotracheal intubation scores before and after education were not statistically significant but were high in direct laryngoscope. In the fixation of head and cervical spine, the endotracheal intubation score was high in direct laryngoscope after training. These findings are considered to be related to the more familiar use with the equipment experienced in college. Therefore, many experiences and practices can increase the proficiency faster[11]. Therefore, it is necessary for paramedics to repeat the use of video laryngoscope as well as direct laryngoscope.

Endotracheal intubation time was rapid in direct laryngoscopy of three pre-education situations, and direct laryngoscopy intubation was also rapid in normal airway and difficult airway after training. This was similar to the results of previous studies in which endotracheal intubation time was rapid in direct laryngoscopy after education[1,5,9]. The rapid endotracheal intubation time in direct laryngoscopy before and after education is due to the proficiency of using laryngeal instrument directly affected by the first-aid paramedics with the first-class emergency medical technician certification, and it is considered that they were not used to the device because they did not have many educational experiences on difficult air way or video laryngoscope.

There was no difference in the rate of tooth damage caused by direct laryngoscope and video laryngoscope before and after training in normal airway and head and cervical vertebral fixation. The results of the study on adult airway management[7,9] showed less tooth damage in the video laryngoscope, which was different from the present study. However, Choo et al.[5] showed no difference in tooth damage rate, which is consistent with the results of this study. As the results of tooth damage rate vary according to the type of laryngoscope, it is necessary to repeat the study to verify the effect on various airway management equipment including video laryngoscope. In the case of tongue edema, the rate of dental damage in the video laryngoscope before and after training was significantly reduced. This is due to intubation performed while observing the anatomy of the inside of the airway through video in the absence of vision due to tongue edema.

The success rate of endotracheal intubation was higher in direct laryngoscopy of all conditions except for normal airway before and after education, but there was no significant difference. These results were similar to previous studies [5,7,9] that there was no difference in the rate of endotracheal intubation using direct laryngoscope and video laryngoscope after training, and Ham et al.[9] considered that it is related to the lack of proficiency in video laryngoscope as a factor. Pediatric trachea, unlike adult, has short internal diameter and narrow internal diameter, which makes it difficult to accurately position the end of the tube during endotracheal intubation[12]. In addition, while watching the screen, video laryngoscope has the advantage of acquiring the techniques to expose the anatomical structure of glottis, its periphery and glottis, and how to intubate glottis by manipulating the endotracheal tube[5]. Therefore, repetitive learning about airway management in adults and children should be emphasized. Furthermore, the effectiveness of learning will be maximized if the curriculum of emergency rescue includes the technique education of endotracheal intubation, including difficult airway and video laryngoscope for adults and children.

The confidence in endotracheal intubation according to the type of laryngoscope before and after the training was high after the training in both direct laryngoscope and video laryngoscope. When identifying changes in attitude toward endotracheal intubation in medical school students, this finding was consistent with the results of previous studies showing the greatest change in self-confidence after hands-on training[5]. In addition, 119 paramedics rarely meet patients who require intubation at the pre-hospital stage, and are relatively inexperienced due to various variables such as on-site situations, legal issues, and self-confidence, making it difficult to maintain proficiency[2,3,13]. Therefore, 119 paramedics who ought to manage airway management at various emergency situations and ages at the pre-hospital stage need continuous education on direct laryngoscope and video laryngoscope including children.

5. Conclusion

This study was attempted to evaluate the usefulness of direct laryngoscope and video laryngoscope training in pediatric airway management for 119 paramedics. The results showed that the ability of endotracheal intubation, including performance confidence, improved after direct laryngoscopy and video laryngoscope training in normal airways, head and cervical spine fixation and tongue edema. These results confirmed the importance of various experiences and repetitive practice in pediatric airway management for 119 paramedics. In addition, this study proved that the diversity and the continuity of education should be emphasized for effective airway management of children, including adults, at the emergency site of 119 paramedics. Therefore, the continuous training of video laryngoscope as well as direct laryngoscope is needed to improve the ability to cope effectively with pediatric emergencies and to prevent complications in various situations of 119 paramedics. In addition, this study suggests the development of educational programs and teaching-learning methods using various tools of pediatric airway management, and the follow-up

research to confirm the effects.

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