

# COMPARISON OF THE MILLER AND MACINTOSH LARYNGOSCOPES IN SIMULATED PEDIATRIC TRAUMA PATIENT: A PILOT STUDY

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## ABSTRACT

**INTRODUCTION:** Airway management in pediatric trauma patients is challenging. Direct laryngoscopy is the gold standard for endotracheal intubation in emergency and trauma patients. The aim of the present study was to evaluate the performance of Miller (MIL) and Macintosh (MAC) laryngoscopes when employed in emergency pediatric intubation scenarios.

**METHODS:** This was a prospective, randomized, crossover, single-center study on novice physicians recruited on a voluntary basis. Each participant performed endotracheal intubation using Miller or Macintosh laryngoscopes during two airway scenarios: Scenario A — normal airway; Scenario B — difficult airway, defined as scenario in which the patient was placed on backboard with neck immobilization performed using rigid cervical collar. The order of use of one or other of the devices was randomized with a ratio of 1:1. The primary endpoint was the first attempt success rate.

**RESULTS:** The effectiveness of the first intubation attempt in Scenario B for MAC was 36.8%, for MIL — 44.7%; while in Scenario A for MAC this was 36.8%, for MIL — 44.7%. During Scenario A, the median duration time of intubation using MIL was 24.5 s [IQR; 21–32.5] and 23 s [IQR; 20.5–31] for MAC. During Scenario B, median intubation time with the MAC laryngoscope was 40.5 [IQR; 36.5–47] s, and with MIL 37.5 [IQR; 33–44.5] seconds.

**CONCLUSIONS:** We concluded that in trauma pediatric patients the Miller laryngoscope is associated with higher first attempt success rates than the Macintosh laryngoscope. These data suggest that for patients with cervical spine immobilization, the Miller laryngoscope should be the preferred method of intubation in emergency medicine conditions.

**KEY WORDS:** endotracheal intubation, simulation, pediatric, trauma, efficacy

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## INTRODUCTION

Securing a clear airway in children compared with adults can be a challenge for medical staff due to the anatomical differences present, including a shorter neck, a relatively larger head or larger and more cranially located epiglottis [1, 2]. During a laryngoscopy, the larynx, both in young children and infants, often seems to be located more anteriorly [3]. In this situation it may be helpful to keep the

head tilted and to shift the tongue to the left out of the line of sight. However, such maneuvers within the cervical spine are accepted only in non-traumatic patients. In the case of trauma patients (both adults and children), the immobilization of the cervical spine in order to reduce the possibility of injury is essential [4–6]. This limitation could result in the worsening of glottis visibility and less effective endotracheal intubation [5, 6]. During endotracheal

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intubation in children, most health professionals commencing endotracheal intubation in a direct laryngoscopy use a straight Miller laryngoscope blade. However, as indicated in the scientific literature, in children above 2 years of age the curved Macintosh blade may also be used [7–9]. However, regardless to the chosen method of the endotracheal intubation in pediatric patients, it should be noted that intubation should be done by the most experienced team member as more than three or four unsuccessful intubation attempts may result in bleeding and edema and eventually lead to the phenomenon in which each subsequent intubation attempt increases the bleeding and swelling, leading to a situation defined by the Difficult Airway Society as “cannot intubate, cannot ventilate”.

The aim of this study was to compare the efficacy of endotracheal intubation using Macintosh and Miller laryngoscopes in simulated cervical trauma pediatric patient conditions.

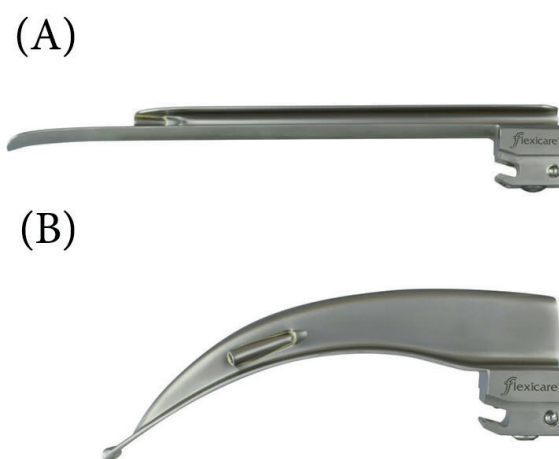
## MATERIAL AND METHODS

### Study design

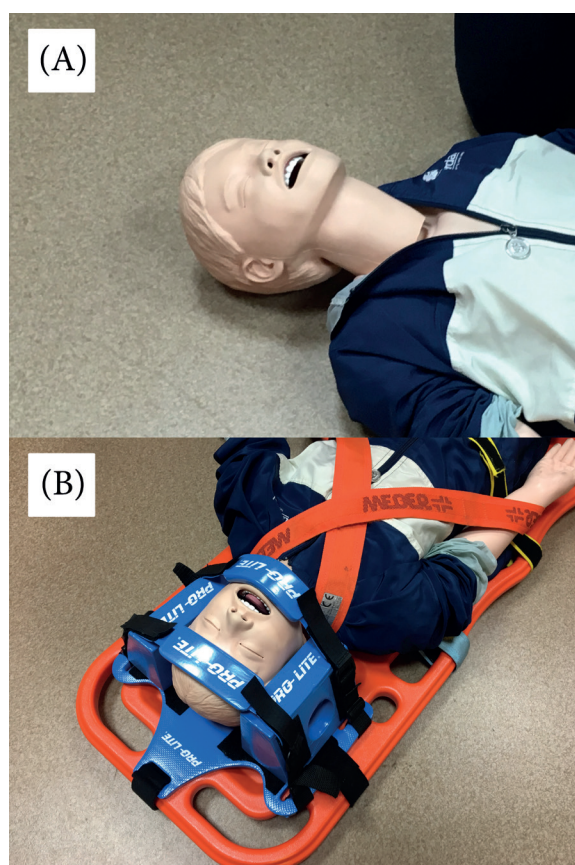
Approval from the Institutional Review Board of the Polish Society for Disaster Medicine (Approval no. 21/04/2016.IRB) and verbal informed consent from each participant were obtained before the study. Physicians included in the study were recruited on a voluntary basis. Inclusion criteria were that they had to be graduate physicians completing a post-graduate internship course in Emergency Medicine. This prospective, randomized, cross-over manikin study was performed in July 2016. Brief standardized prior training was given to each physician. The study devices consisted of the Miller laryngoscope (MIL) with a size 2 blade and the Macintosh laryngoscope (MAC) also with a size 2 blade (Fig. 1). We used a 5.0 cuffed endotracheal tube (ETT) for each intubation attempt. We also use a 6 French outer diameter malleable Slick stylet (Teleflex Medical, Research Triangle Park, NC, USA).

The participants performed endotracheal intubations with each device in two scenarios:

- Scenario A: normal airway scenario;
- Scenario B: difficult airway scenario. To simulate a trauma patient, manikin was placed on the board, and a hard cervical collar was applied to the manikin with its head fixed in a neutral position (Fig. 2).



**FIGURE 1.** Laryngoscope blades used in the study: (A) Miller blade; (B) Macintosh blade



**FIGURE 2.** Scenarios used in the study: (A) normal airway scenario; (B) difficult airway scenario

To simulate the scenario of a multi-trauma patient, a standardized airway manikin with a regular airway was used (MegaCode Kelly™; Laerdal, Stavanger, Norway).

Each participant performed a total of 10 intubation attempts with the two intubation devices in a normal airway scenario. The order of partici-

pants and intubation devices were random. For this purpose, we use Research Randomizer software to divide participants into four groups. The first group started with MIL in Scenario A, with the second using MIL in Scenario B, the third using MAC in Scenario A, and the fourth using MAC in Scenario B (Fig. 3). Participants were offered the maximum one intubation attempt with each device. After performing the procedure, participants had 10 minutes break for a rest, and then performed an intubation using another technique.

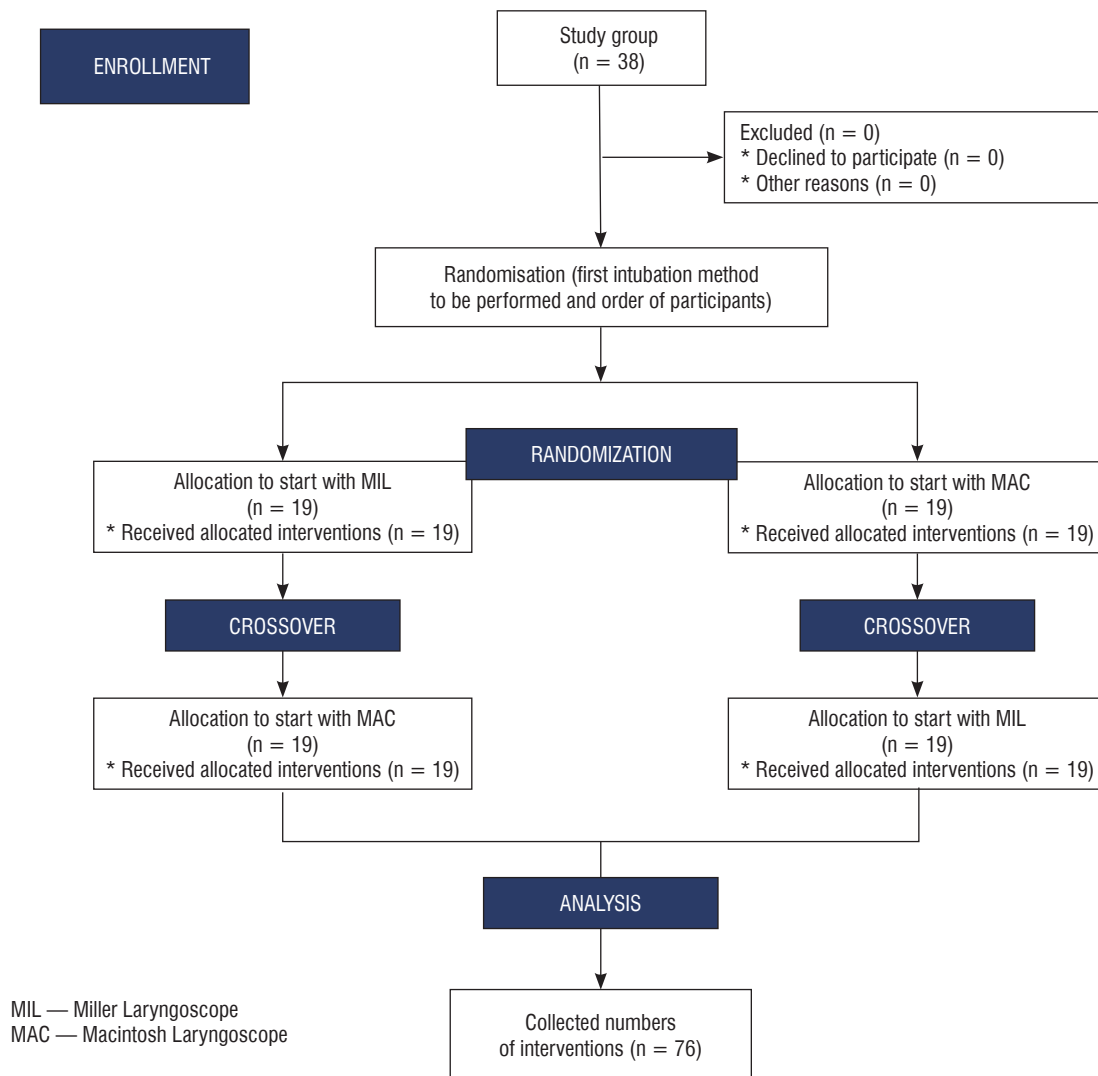
**Outcomes**

The primary endpoint was time to intubation (TTI), defined as the time in seconds from insertion of the device between the teeth to first ventilation. Successful intubation was verified when the lungs were inflatable by an Ambu bag. Failed intubation was

defined as when the trachea was not intubated in the first attempt or the intubation attempt required more than 60 s [10, 11]. After each scenario, the participants were asked to grade glottis visualization using the Cormack-Lehane laryngoscopic grading scale (Grade 1 to Grade 4) [12], and to mark the ease of intubation on a 10-point visual analog scale (VAS; 1 — very difficult; 10 — very easy).

**Statistical analysis**

All procedures were recorded using a GoPro HERO 5 camera (GoPro GmbH, Munich, Germany), and all of the time variables were precisely analyzed by reviewing the recorded data. Statistical calculations were performed using the Statistica 12.5EN statistical software (StatSoft, Tulsa, OK, USA). Values of  $p < 0.05$  were considered significant. Categorical variables were presented as frequencies,



**FIGURE 3.** CONSORT (Consolidated Standards of Reporting Trials) flow diagram

and continuous and ordinal variables as medians with an interquartile range (IQR). We compared qualitative variables by using Fisher's exact test and the Kruskal-Willis test, and the quantitative variables by using Student's test. All statistical tests were two-sided.

## RESULTS

The study involved 38 novice physicians participating in a compulsory course in emergency medicine. All participants declared their ability to perform endotracheal intubation using direct laryngoscopy for both adults and pediatric patients. The median age of participants was 25 [IQR; 24.5–26] years.

### Normal airway scenario

During the endotracheal intubation in normal airways (Scenario A), the effectiveness of the first endotracheal intubation attempt using MIL and MAC was varied and amounted to 76.3% vs. 78.9%, respectively (Tab. 1). The median duration time of intubation using MIL was 24.5 s [IQR; 21–32.5] and was slightly shorter compared to the MAC 23 s [IQR; 20.5–31] (Fig. 4). Visualization of the glottis, as well as the ease of intubation were comparable between these two devices.

### Difficult airway scenario

In difficult airways scenario where the manikin was placed on the spinal board and a rigid cervical collar used, the effectiveness of the first intubation attempt for MAC was 36.8%, and for MIL — 44.7%. The difference in the effectiveness of the first attempted intubation was statistically significant ( $p = 0.023$ ). The median duration of intubation during the Scenario B with the MAC laryngoscope was 40.5 s [IQR; 36.5–47], and with MIL 37.5 s [IQR; 33–44.5] ( $p = 0.011$ ). The endotracheal intubation using MIL was associated with better visualizing of the glottis compared to the Macintosh laryngoscope

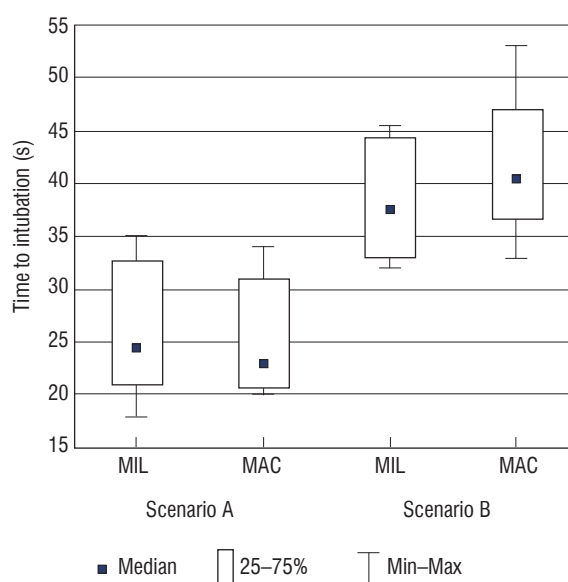


FIGURE 4. Median intubation time

(Tab. 2). A similar relationship was observed when the scale of ease of the implementation of the procedure was analyzed (VAS).

## DISCUSSION

The study demonstrated that cervical spine immobilization during simulated endotracheal intubation using a laryngoscope with the Miller blade was associated with higher efficiency than intubation with the Macintosh laryngoscope.

Landy and Nossaman indicated that laryngoscopy with the Miller blade is highly effective and safe in patients undergoing general anesthesia for elective surgery with a low incidence of difficult laryngoscopy and difficult orotracheal intubation [13]. Varghese and Kundu, evaluating intubation among twenty children aged 1–24 months, indicated that the Miller and the Macintosh blades provide similar laryngoscopic views and intubating conditions. Varghese and Kundu's study showed that

Table 1. Intubation during scenario A

Variable	Miller laryngoscope	Macintosh laryngoscope	P-value
First attempt success rate	76.3%	78.9%	$p = 0.775$
Time to intubation (s)	24.5 [IQR; 21–32.5]	23 [IQR; 20.5–31]	$p = 0.658$
Cormack & Lehane grade			$p = 0.855$
1	30 (78.9%)	28	
2	8 (21.1%)	10 (26.4%)	
3	–	–	
4	–	–	
VAS score	6 [IQR; 5.5–8]	5.5 [IQR; 5–7.5]	$p = 0.44$

Variable	Miller laryngoscope	Macintosh laryngoscope	P-value
First attempt success rate	44.7%	36.8%	p = 0.045
Time to intubation (s)	37.5 [IQR; 33–44.5]	40.5 [IQR; 36.5–47]	p = 0.011
Cormack & Lehane grade			p = 0.023
1	4 (10.5%)	–	
2	23 (60.5%)	21 (58.3%)	
3	11 (29%)	16 (39.1%)	
4	–	1 (2.6%)	
VAS score	5 [IQR; 3.5–6]	3.5 [IQR; 3–5]	p = 0.013

when a limited view is obtained, a change of blade provided a better glottis view. Placing the tip of the Miller blade in the vallecula provides satisfactory intubating conditions in this age group [7]. The advantage of the Macintosh compared to Miller blade in children under 2 years of age has also been indicated by other authors [9, 14]. In our study we analyzed endotracheal intubation with the use of a manikin presenting a 6-year-old child. In their study, Inal et al. [15] compared the efficacy of endotracheal intubation using the Miller laryngoscope with the TruView EVO2 optical laryngoscope. The study was conducted on 50 2–8-year-old pediatric patients presenting for surgery requiring endotracheal intubation. Their results suggest that when compared to the Miller laryngoscope, the TruView EVO2 laryngoscope appears to improve the view of the glottis although it requires a longer time for tracheal intubation to be performed. However, their Intubation Difficulty Scores (IDS) were similar [15].

Many studies have shown the prevalence of videolaryngoscopy compared with direct laryngoscopy in different clinical situations [16–19]. In studies published by Szarpak et al., the use of videolaryngoscopy compared with direct laryngoscopy during endotracheal intubation in children under simulated CPR settings was associated with a higher efficiency of the first intubation attempt and a shorter procedure time [20, 21]. In turn, Eisenberg et al., in a retrospective cohort study on endotracheal intubations in children aged 0–18 years in a pediatric ED between 2004 and 2014, examined 452 endotracheal intubations and which showed no difference between direct laryngoscopy and videolaryngoscopy with regard to first-pass intubation success rate, complication rate, and successful intubation rate by Emergency Department health care professionals in children undergoing endotracheal intubation in a pediatric Emergency Department

[22]. In turn, Hippard et al. showed higher success rates and shorter intubation times with the Miller blade compared to either videolaryngoscope which may reflect one's greater experience in direct laryngoscopy [23]. However, due to the availability of the laryngoscopes with Miller or Macintosh blades, these devices are most often used in Poland, both in emergency departments and by Emergency Medical Service teams [4].

Our study has several limitations. First we used a standard manikin with a standard anatomical design, which might not adequately simulate emergency clinic conditions. However, only the use of manikin allows one to perform randomized crossover trials on the participants with limited experience in the field of clinical endotracheal intubation. Simulated conditions allow one to perform a study without prejudice to the health of potential patients. Secondly, the participants knew the scenario before evaluation. Thirdly, the severity of dental trauma was not considered.

The main strengths of our study are the number of novice physicians included in this trial and the randomized, crossover design of this study.

## CONCLUSIONS

We conclude that endotracheal intubation with the use of the Miller laryngoscope in trauma pediatric patients is associated with higher first attempt success rates than the Macintosh laryngoscope. Our results suggest that for patients with cervical spine immobilization, the Miller laryngoscope should be the preferred method of intubation in emergency medicine conditions.

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**Conflict of interest:** None declared.

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