Videolaryngoscope for Teaching Neonatal Endotracheal Intubation: A Randomized Controlled Trial

Ahmed Moussa, MD, MMEd, Yvon Luangxay, MD, Sophie Tremblay, MD, MSc, Julie Lavoie, RN, Guylaine Aube, RN, Eve Savoie, RT, Christian Lachance, MD

OBJECTIVE: To assess whether the videolaryngoscope (VL) is superior to the classic laryngoscope (CL) in acquiring skill in neonatal endotracheal intubation (ETI) and, once acquired with the VL, whether the skill is transferable to the CL.

METHODS: This randomized controlled trial, in a level 3 Canadian hospital, recruited junior pediatric residents who performed ETI in the NICU. The primary outcome was success rate of ETI. Secondary outcomes were time to successful intubation, number of bradycardia episodes and lowest oxygen saturation during procedure, occurrence of mucosal trauma, reason for ETI failure, and recognition of problems related to ETI by supervisor and resident.

RESULTS: In phase 1, 34 pediatric residents performed 213 ETIs by using either VL or CL. Intervention groups were comparable at baseline. The success rate was higher (75.2% vs 63.4%, \( P = .03 \)), and time to successful intubation was longer, in VL group (57 vs 47 seconds, \( P = .008 \)). In phase 2, 23 residents performed 55 ETIs using CL. The success rate of residents in VL group performing ETI by using the CL was 63% (compared with 75% in phase 1, \( P = .16 \)).

CONCLUSIONS: When learning ETI, the success rate is improved with the VL. Time to successful intubation is longer, but the difference is not clinically significant. When switched to the CL, residents' success rate slightly decreased, but not significantly. This suggests that residents retain a certain level of ETI skill when switched to the CL. The VL is a promising tool for teaching neonatal ETI.

WHAT'S KNOWN ON THIS SUBJECT: Acquisition of neonatal endotracheal intubation (ETI) skill in trainees is challenging, given the anatomic details of the neonatal airway and limited clinical opportunities. The videolaryngoscope could be a valuable teaching modality. Only preliminary clinical experience has been described in newborns.

WHAT THIS STUDY ADDS: Pediatric residents have a higher success rate and reach competence level more rapidly when learning neonatal ETI with the videolaryngoscope. Once acquired, neonatal ETI skill is maintained when residents perform the procedure by using a classic laryngoscope.

Dr Moussa wrote the first draft and revised the manuscript; Drs Moussa and Lachance contributed to conception and design of the study and interpretation of data; Drs Moussa, Luangxay, Tremblay, and Lachance contributed to analysis of data; Drs Luangxay, Tremblay, and Lachance, Ms Lavoie, Mr Aube, and Ms Savoie revised the article critically for important intellectual content; and all authors contributed to acquisition of data, approved the final version of the article, and agree to be accountable for all aspects of the work and ensure that questions relating to accuracy or integrity of any part of the work are appropriately investigated and resolved.

This trial has been registered at www.clinicaltrials.gov (identifier NCT01394783).

DOI: 10.1542/peds.2015-2156

Accepted for publication Dec 8, 2015

Address correspondence to Ahmed Moussa, MD, MMEd, Department of Pediatrics, University of Montreal, CHU Sainte-Justine, 3175 chemin Cote Sainte-Catherine, Montreal, QC, Canada H3T 1C5. E-mail: ahmed.moussa@umontreal.ca
North American certifying bodies require that residents graduating from pediatrics training programs are able to competently perform neonatal endotracheal intubation (ETI). However, less than two-thirds of program directors believe that their residents are capable of performing this skill. Reported success rates of neonatal ETI are 33% to 63% depending on the resident’s level of training. Competence, usually defined as a 75% to 80% success rate, is therefore not reached by trainees. Given the increased number of trainees, restricted duty hours, increased use of noninvasive ventilation, and the presence of other health professionals performing ETIs, the number of ETI opportunities for residents has become limited. Furthermore, neonatal ETI is not a simple procedure to acquire. In addition to the neonate’s limited respiratory reserve, difficulties in performing ETI lie in the small size of the mouth and airway of the infant and the particular anatomy of the larynx. This limited visibility presents a challenge even for the experienced clinician. Moreover, as with neonatal resuscitation skills, competency in ETI is at risk for skill decay with time. Ensuring and assessing ETI skill retention remain current educational challenges.

The videolaryngoscope (VL) was introduced to adult and pediatric medicine more than a decade ago. It incorporates a fiber-optic camera lens into the light source of a laryngoscope blade, effectively positioning the laryngoscopist’s eye at the tip of the blade and extending the viewing angle to 80°, compared with the 15° view offered by the classic laryngoscope (CL). The VL is connected to a 12-inch video monitor that displays a magnified image. Video-assisted intubation is increasingly recognized as the method of choice in teaching ETI because of the magnified view it offers simultaneously to both trainees and supervisors. Mannequin studies have reported improved success rates of ETI and decreased time to intubation with the VL. Clinical studies are limited to preliminary experience where infants as small as 530 g were intubated with the VL. To the best of our knowledge, there are no published human studies comparing VL to CL for acquiring the skill of neonatal ETI in the NICU.

This study aimed to assess whether VL is superior to CL in acquiring skill in neonatal ETI in the NICU and whether the skill acquired with the VL is transferable to use of the CL. We hypothesized that the use of VL would increase the success rate of ETI by 20% and that the skill acquired with VL would be transferable to the use of CL.

METHODS

Setting and Population

This study took place at Centre Hospitalier Universitaire Sainte-Justine from July 2011 to December 2013. Centre Hospitalier Universitaire Sainte-Justine, a tertiary care mother-child hospital affiliated with University of Montreal, houses a NICU with 65 beds and 30 ventilated patients at any time. Each year, there are 3500 deliveries, half of them high risk.

All residents registered in the first 3 years of the pediatrics program of the University of Montreal were recruited to participate in the study. All ETIs attempted by residents in the NICU were included in the study. ETIs performed on patients with major oral, cervical, or upper airway malformations, emergency ETIs with the inability to prepare the VL on time, and unexpected difficult ETIs (need of an anesthetist to secure airway) were excluded from the study.

This study was approved by the institution’s Research Ethics Committee. Trainees were contacted by the research coordinator for consent before the start of the study. Parents of infants were contacted by the research coordinator either antenatally or on admission to the NICU if the infant was at risk for needing ETI. A waiver of consent was granted for emergency ETI immediately upon admission to the NICU, and deferred parental consent was requested afterward to retain intubation data in the study records.

Study Design

This was a nonblinded randomized controlled trial with crossover of only the experimental group. Residents were initially randomized to intubate either with VL (experimental group) or CL (control group) with a 1:1 allocation by referring to a table of random numbers stratified by year of residency training. After consent, residents were given sealed envelopes with their allocation group. In phase 2, all residents used CL for ETI. In phase 1, each resident was expected to perform ≥3 ETIs, highlighting progression of success rate with time. To achieve the desired sample size and for feasibility of the study, residents performed a maximum of 7 ETIs in the initial phase. After the seventh ETI with the VL, residents were changed to the CL for phase 2. The approved protocol for the study required that subjects who performed <3 ETIs be excluded from data analysis.

ETI Training

First-year residents learn neonatal ETI at the simulation center before starting residency. The procedure is explained and demonstrated on a mannequin (Laerdal Neonatal Intubation Trainer, Laerdal Medical, Toronto, Canada) with a CL, and residents practice on the same mannequin several times. Further training is done in the clinical setting.
on real patients in an opportunistic manner. In both situations, they are supervised by a neonatologist or a subspecialty resident, who provides guidance, coaching, and constructive feedback. Residents who consented to the study and were randomized to the VL group were additionally familiarized, by the principal investigator, to the use of VL in the simulation center. They did not get supplemental ETI skill training.

**ETI Procedure**

For each ETI, a neonatologist or a subspecialty resident, a nurse, and a respiratory therapist were present. Patient monitoring included noninvasive arterial blood pressure, electrocardiogram, and pulse oximeter. Devices used included CL (Rusch, Teleflex Medical, Markham, Canada) with Miller blade size 00, 0, or 1 and C-MAC VL (Karl Storz, Tuttingen, Germany) with blade size 0 or 1. VL was used to perform ETI under indirect vision with use of the video monitor for guidance. Although the C-MAC VL offers better view and lighting, its physical attributes are very similar to the CL.

Premedication is standardized in our NICU and consists of atropine 20 μg/kg given rapidly, fentanyl 4 μg/kg given over 3 to 5 min, and succinylcholine 2 mg/kg given rapidly. Face mask ventilation ensuring adequate oxygenation was done before and between attempts. Tube placement validation was done by auscultation and a carbon dioxide detector, and a chest radiograph was performed to assess position of the tip of the endotracheal tube (ETT).

**Data Collection**

For each resident, the following data were collected: training level, past neonatology training, and number of neonatal ETIs previously attempted. For each ETI, patient data collected were birth weight, gestational age, gender, postnatal age, current weight, required inspired fraction of oxygen, number of ventilated days, and previous ETIs. Collected ETI event data were indication of ETI, number of attempts, duration of attempt, final position of tip of ETT, reason for failed intubation, lowest oxygen saturation during procedure, occurrence of bradycardia (heart rate <80 beats per minute), occurrence of mucosal trauma, naso- or orotracheal ETI, and premedication used. A survey consisting of seven 5-point Likert scale questions was distributed to the resident and supervisor after each ETI. The survey assessed the resident's level of confidence in attempting ETI and the supervisor's level of ease in recognizing problems with laryngoscopy, ETT insertion, and placement.

**Definitions**

ETI was successful if the ETT was placed through the vocal cords into the trachea in ≤3 attempts. This was confirmed by change in color of the carbon dioxide detector, vapor in the ETT, thoracic expansion, assessment of bilateral lung air entry, absence of air entry in the stomach by auscultation, and improvement of patient clinical parameters. Time to successful intubation was defined as time from insertion of the laryngoscope blade in the mouth until it was pulled out.22 Esophageal intubation was diagnosed when clinical signs were against a successful ETI including presence of air entry in the stomach during auscultation.22 Right bronchial main stem intubation was diagnosed on chest radiograph. A trial was counted as 1 attempt if the laryngoscope blade was inserted into the patient's mouth.21

**Statistical Analysis**

Prospectively collected data of a quality improvement initiative regarding ETI in our unit has shown that residents in their first 3 years of pediatrics training obtained an average success rate of 55% by using the CL (unpublished data, A.M.). For phase 1, a minimal sample size of 89 ETIs per group was calculated to demonstrate an increase of 20% of the success rate (55% to 75%) in the experimental group (VL), with an α level of 0.05 and statistical power of 80%. We planned to obtain 100 ETIs per group for a total of 200 ETIs. Success rates were analyzed using generalized estimated equations, which take into account clustering at the individual level. Time to successful intubation and continuous demographic and secondary outcome variables were analyzed by using the Mann-Whitney test. Categorical demographic and secondary outcome variables and survey questions were analyzed by using Fisher exact test.

**RESULTS**

Thirty-seven residents were eligible, enrolled, and randomized in July 2011 and 2012. Of these, 34 completed phase 1 of the study by June 2013 and performed a total of 213 ETIs on 194 patients (Fig 1). In December 2013, phase 2 of the study was stopped, as all enrolled residents had terminated their core curriculum neonatology rotations. Twenty-three residents completed phase 2 and performed a total of 55 ETIs on 50 patients.

Demographics of residents are presented in Table 1. There were no differences in baseline experience in neonatology or with neonatal ETI or in time frame between simulation training and first NICU rotation. Clinical characteristics of patients and specifications of ETIs are presented in Table 2. There were no differences in patient clinical characteristics. Most ETIs were performed for respiratory failure, more than two-thirds were nasotracheal, and all used premedication.
Primary Outcome

The overall success rate was higher for the VL group compared with the CL group (75.2% vs 63.4%, likelihood ratio $-1.20$ [95% confidence interval $-2.31$ to $-0.10$], $P = .03$). The cumulative success rate of each individual intubation is presented in Fig 2. The success rate of the VL group started at 69%, increased to 82% at the second ETI, and steadily continued to improve with subsequent ETIs, reaching 91% at the seventh ETI. The success rate of the CL group started significantly lower at 33% and crossed the 80% mark at the seventh ETI.

Secondary Outcomes

The median duration of successful ETI was 57 (interquartile range [IQR] 41–85) seconds for the VL group compared with 45 (IQR 33–63) seconds for the CL group ($P = .008$). The median duration for each individual successful intubation is presented in Fig 3. Both groups follow a similar pattern; duration is shorter at the first ETI, increases at the second, and subsequently decreases with ongoing ETIs.

Other secondary outcomes are presented in Table 3. There were no significant differences in median number of attempts for each intubation, number of bradycardia episodes, and lowest oxygen saturation during intubation. There were significantly more mucosal trauma events in the CL group. ETI failure was mostly related to difficulty in glottis visualization and patient instability in the CL group.

Results of the residents’ and supervisors’ questionnaires are presented in Table 4. Residents in the VL group reported more often that support provided by the supervisor allowed correction of a specific technical error. Supervisors of residents in the VL group reported more easily recognizing problems related to glottis visualization and insertion of the ETT. They also had more assurance that the ETT was in adequate position.

Transfer of Skill

In phase 2, the success rate of residents in the VL group now performing ETI using the CL was 63% (compared with 75% in phase 1, $P = .16$). The success rate of residents...
in the CL continued to improve to 77% (compared with 63% in phase 1, \(P = .10\)).

**DISCUSSION**

Our first finding is that residents in the early phase of their training have a higher success rate in neonatal ETI when using VL compared with CL. Howard-Quijano et al randomized novices to intubate adults using either VL or CL and also showed an increase in success rate (69% vs 55%) in the VL group.\(^{22}\) The VL blade provides 129 times greater illumination and a wider viewing angle than the CL.\(^{15,24}\) It also offers precious teaching opportunities.
through better identification and recognition of anatomy from the magnified view, and the possibility for both teacher and trainee to share the same visual landmarks, allowing guidance of the resident throughout the procedure. In addition, VL offers more accurate information on procedure failure than does recollection after use of CL. Indeed, in our study, almost half of ETI failures in the CL group were due to difficulties in glottis visualization. Furthermore, residents and supervisors reported that the VL allowed recognition of problems related to glottis visualization or insertion of ETT and correction of technical errors. Weiss et al also described how VL helped teachers recognize and solve problems related to direct laryngoscopy and provided information to teachers regarding difficulties with tube insertion.

Our second finding is that competency in neonatal ETI, defined as reaching a success rate of 75% to 80%, is acquired more rapidly with the VL. At the first intubation episode, residents in the CL group have a success rate similar to that reported in the literature, which was significantly lower than in the VL group. In addition, the CL group reaches competency by the seventh ETI, whereas the VL group does so by the second intubation. This finding is in line with the DeMeo et al study, which showed that residents (using the CL) reached competency after 5 to 7 ETI opportunities depending on the outcome of their first 2 intubations. In our study, supervisors reported easier recognition of technical problems with the VL, allowing them to help residents to correct their errors, leading to improved success rates in the first ETI episodes. In the context of limited ETI opportunities for trainees, VL thus offers the possibility to reduce the gradient of the learning curve and acquire competency more rapidly.

Our final finding is that residents trained with the VL have a reasonable success rate when transferred to the CL. The success rate of ETI with the CL in residents trained with the VL does slightly decrease, although not significantly. In addition, residents maintain a success rate that is higher than the first intubation opportunity of the CL group in phase 1. The level of competence is essentially maintained. This transfer in skills is explained by similar design of VL and CL intubation blades and also by similarities of the psychomotor movements necessary when performing ETI with either technology. Low et al have described knowledge transfer retained from video intubations in a randomized trial of 50 trainees who learned ETI on an adult mannequin by using VL or CL and were assessed on a mannequin using CL. The group trained with VL needed fewer attempts to intubate the trachea, made fewer repositioning maneuvers, caused less dental trauma, showed increased confidence in ETI placement, and were better at identifying anatomic structures of the airway. To our knowledge, our study is the first clinical study after the best view is obtained, as the VL has a much narrower field of vision than the human eye. In this study, time to successful intubation in both groups was longer than the 30 seconds suggested by the Neonatal Resuscitation Program. Although the difference of ETI duration between the 2 groups is statistically significant, it might not be clinically relevant. There were an equivalent number of clinically relevant bradycardia episodes, and the lowest median oxygen saturation was similar. A longer but successful intubation is preferable to shorter but repeated, possibly traumatic, attempts to complete an ETI. In fact, in this study, there were significantly more episodes of mucosal trauma in the CL group.
describing transfer of neonatal ETI skill from VL to CL.

There are limitations to this study. Because it is exceptional for our pediatric residents to intubate outside the NICU, this exposition was not controlled for. Phase 2 of the study had to be terminated with a smaller than expected sample size because of a decrease in number of ETIs in our unit (change of practice in airway management and skill shared with neonatal nurse practitioners) and the end of residents’ neonatology rotations. Increasing the number of ETIs in phase 2 of the study could have influenced final results. However, the sample size needed to demonstrate a significant decrease in success rate by 15% (with \( \alpha \) of 0.05 and power of 80%) would be 152 intubations per study group. This number was not achievable in the reality of our NICU, where residents have limited ETI opportunities. Our study could not address the usefulness of the VL for teaching ETI in infants weighing <750 g, as the size 0 (smallest available) blade of the VL is too big for these neonates. However, in our unit, only experienced residents intubate these tiny infants.

CONCLUSIONS

While learning ETI in the NICU, the success rate is improved and competency is reached more rapidly with the VL, and residents retain a certain level of ETI skill when switched to the CL. The VL is thus a promising tool for teaching neonatal ETI and possibly plays an important role in solving the problem of technical skill acquisition of pediatric residents while insuring patient safety. It should also allow residents to remain competent in other settings where a VL may not be available.

ACKNOWLEDGMENT

The authors thank Dr Ana-Maria Carceller for her contribution in reviewing the research protocol and for her support during the entire research process.

ABBREVIATIONS

CL: classic laryngoscope
ETI: endotracheal intubation
ETT: endotracheal tube
IQR: interquartile range
VL: videolaryngoscope

REFERENCES


7. O’Donnell CPF, Kamlin CO, Davis PG, Morley CJ. Endotracheal intubation attempts during neonatal resuscitation: success rates, duration, and adverse effects. Pediatrics. 2006;117(1). Available at: www.pediatrics.org/cgi/content/full/117/1/e16

8. DeMeo SD, Katakam L, Goldberg RN, Tanaka D. Predicting neonatal intubation competency in trainees. Pediatrics. 2015;135(5). Available at: www.pediatrics.org/cgi/content/full/135/5/e1229


10. Mosley CM, Shaw BN. A longitudinal cohort study to investigate the...
retention of knowledge and skills following attendance on the Newborn Life support course. Arch Dis Child. 2013;98(8):582–586


18. Vanderhal AL, Berci G, Simmons CF. Video assisted endotracheal intubation: role in teaching and acquiring skills in era of decreasing DR and NICU time during residency training. E-PAS2007:617907.2


Videolaryngoscope for Teaching Neonatal Endotracheal Intubation: A Randomized Controlled Trial
Ahmed Moussa, Yvon Luangxay, Sophie Tremblay, Julie Lavoie, Guylaine Aube, Eve Savoie and Christian Lachance
Pediatrics 2016;137; originally published online February 12, 2016; DOI: 10.1542/peds.2015-2156

Updated Information & Services
including high resolution figures, can be found at:
/content/137/3/e20152156.full.html

References
This article cites 19 articles, 4 of which can be accessed free at:
/content/137/3/e20152156.full.html#ref-list-1

Subspecialty Collections
This article, along with others on similar topics, appears in the following collection(s):
Medical Education
/cgi/collection/medical_education_sub
Teaching/Curriculum Development
/cgi/collection/teaching_curriculum_dev_sub
Fetus/Newborn Infant
/cgi/collection/fetus:newborn_infant_sub
Neonatology
/cgi/collection/neonatology_sub

Permissions & Licensing
Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:
/site/misc/Permissions.xhtml

Reprints
Information about ordering reprints can be found online:
/site/misc/reprints.xhtml
Videolaryngoscope for Teaching Neonatal Endotracheal Intubation: A Randomized Controlled Trial
Ahmed Moussa, Yvon Luangxay, Sophie Tremblay, Julie Lavoie, Guylaine Aube, Eve Savoie and Christian Lachance

*Pediatrics* 2016;137; originally published online February 12, 2016;
DOI: 10.1542/peds.2015-2156

The online version of this article, along with updated information and services, is located on the World Wide Web at:
/content/137/3/e20152156.full.html