Original Article

Efficacy and safety of videolaryngoscopy-guided verbal feedback to teach neonatal and infant intubation. A prospective randomised cross over study

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ABSTRACT

Background and Aims: Neonatal endotracheal intubation is challenging due to the miniature anatomy, which is distinct from adults and reserves only less oxygen and time before desaturation begins. As a result, teaching neonatal intubation becomes fraught with difficulties. This study aimed to determine the efficacy and safety of videolaryngoscopy-guided verbal feedback compared to conventional laryngoscopy verbal feedback in neonatal and infant intubation. **Methods:** In this prospective randomised cross over study, 24 trainees were randomly allocated to two groups, video-assisted verbal feedback followed by conventional verbal feedback (V/C) and conventional verbal feedback followed by video-assisted verbal feedback (C/V). one hundred forty-four ASA grade I-II patients aged 1 day to 6 months requiring general anaesthesia with endotracheal intubation were included. Each trainee performed three intubations with one technique and switched to other technique to perform three more intubations. Primary outcome was first attempt success rate and secondary outcomes were time to best view, time to intubation, ease of intubation, manoeuvres used and complications. **Results:** Overall first attempt intubation success rate was higher with video-assisted verbal feedbacks compared to conventional verbal feedback (83.3% vs. 44.4%, *P* value = <0.001). The time to best view (19.8 s vs. 26.8 s, *P* value = <0.001) and intubation (30 s vs. 41.7 s) was achieved faster with video-assisted part of the study. **Conclusion:** Our study results show that video-assisted verbal feedback to trainees resulted in high intubation success rate and reduced complications like oesophageal intubation and desaturation in neonatal and infant intubations.

Key words: Cross over study, endotracheal intubation, infant, videolaryngoscopy

INTRODUCTION

Neonatal endotracheal intubation is one of the procedural skills, which is challenging for novices to acquire because of limited opportunities to perform neonatal intubations. The large occiput, cephalad position of the neonatal larynx, the large overhanging epiglottis and the large tongue increase the difficulty in gaining airway access in neonates. The increased oxygen consumption and low-oxygen reserves increase their propensity to rapid haemoglobin desaturation.[1] The adverse respiratory effects are responsible for the largest proportion of perioperative critical events.[2] Multiple attempts at intubation and failed intubation are the important and avoidable predecessors of morbidity and mortality during anaesthesia. With an already ambitious task at hand, it is often very difficult to provide guidance to trainees for their initial attempts

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at intubation, especially limited by a restricted view of the airway.

Videolaryngoscopes (VLs) use camera technology to visualise airway structures and facilitate endotracheal (ET) intubation. Video-assisted intubation is increasingly recognised as the method of choice for teaching ET intubation because of the magnified view it offers simultaneously to both trainees and supervisors.[3,4] This study aimed to determine the efficacy and safety of videolaryngoscopy-guided verbal feedback compared to conventional laryngoscopy verbal feedback in neonatal and infant intubation.

METHODS

The prospective randomised cross over study was conducted at a tertiary care teaching university hospital after approval from the Institutional Ethics committee on 14/03/2018 (letter no.IEC (II)/OUT/325/18). CTRI registration number is CTRI/2018/04/012914. Trainees of anaesthesiology who had two years of experience in intubating adults and older children but were inexperienced in neonatal and infant intubation (<5 intubations), and with no experience in using a VL scope in neonates and infants were included in the study. After obtaining written informed consent from parents, 144 ASA grade I-II patients aged 1 day to 6 months requiring general anaesthesia with endotracheal intubation were included. Patients with a difficult airway and preterm or formerly preterm infants were excluded. Written informed consent was taken from all the trainees prior to the start of the study. The study was performed in accordance with the 2013 Declaration of Helsinki.

All the trainees were shown a video describing neonatal and infant airway anatomy and intubation techniques, both direct and videolaryngoscopy. Total 24 trainees were randomly allocated into two groups, i.e., intubation with video-assisted verbal feedback followed by conventional verbal feedback (Group V/C) and intubation with conventional verbal feedback followed by video-assisted verbal feedback (Group C/V). Crossover of intubation technique was done in both the groups. According to the group allocated, each trainee performed three intubations with the first technique, then three with the other technique. In group V/C, each trainee performed the first three intubations with video-assisted verbal feedback, then the next three intubations with conventional verbal feedback. Similarly, each trainee performed the first three intubations with conventional verbal feedback and then switched to video-assisted verbal feedback to perform the next three intubations in group C/V [Figure 1]. All the intubations were performed using C-MAC videolaryngoscope (Karl Storz GmbH & Co. KG, Tuttlingen, Germany) with Miller blade 0 or 1, to nullify the equipment bias. Each child underwent intubation only once, with either of the techniques depending on randomisation.

Irrespective of group allocation, all the trainees received verbal feedback during the procedure. During the video-assisted portion of the study, the trainees were allowed to view the videolaryngoscope screen and also received feedback from an instructor using the real-time images from the videolaryngoscope; instructors could use the monitor to confirm the trainee's progress. During the conventional (non video-assisted) part of the study, the video images were not available to the trainee as well as the instructor; the instructor had to peep over the trainee's shoulder to see the laryngoscopic view. A drape was used to cover the monitor screen.

Primary outcome was the first attempt intubation success rate. Secondary outcomes included the time to best view (time interval from insertion of the laryngoscope blade into the patient's mouth until trainee's verbal declaration that best view for intubation is achieved), time to intubation (defined as the time interval from insertion of the laryngoscope blade into the patient's mouth until the appearance of end tidal carbon dioxide on the capnograph trace), any complications associated with laryngoscopy and intubation like trauma and oesophageal intubation, and any manoeuvre used during intubation like external laryngeal manipulation and use of stylet. Ease of procedure was assessed by the intubating anaesthesiologist at the end of the procedure using visual analogue scale (VAS), 0 being very easy and 10 being very difficult.

The attempt was terminated if there was a fall in heart rate (<100 in neonates and <80 in infants), time for intubation >60 s, hypoxia with oxygen saturation <92% or more than two attempts. The patient was then mask ventilated with 100% oxygen and intubated by a senior anaesthesiologist.

The sample size was calculated based on the similar previous studies, wherein 69% of intubation attempts were successful with video-assisted verbal feedback compared to 55% using the conventional technique. Considering the power of study as 80%, type-1 error rate (alpha) as 5% and a superiority margin between the two groups as 25%, the sample size for this study was calculated to be 110 patients.

The data were collected and compiled using Epi info 7.2. The qualitative variables were expressed in terms of proportions and the difference between the two proportions was tested by Chi-square or Fisher exact test. The quantitative variables were either expressed in percentages or in terms of mean/median and standard deviation/inter quartile range. The difference between two means was tested by *t*-test/Mann–Whitney U test. All analyses were two tailed and the significance level was set at 0.05.

RESULTS

Twenty-four trainees were eligible, enrolled and randomised in two groups and attempted a sum total of 144 intubations in 144 patients [Figure 1]. There was no difference in prior neonatal intubation experience in each group [Table 1]. Clinical characteristic of patients and specification of ET intubation are presented in [Table 2]. There was no difference in patients' characteristics.

The overall success rate of first attempt at intubation was higher for videolaryngoscopy (VL) compared to conventional laryngoscopy (CL) (83.3% vs. 44.4%), likelihood ratio 1.98, $P = <0.001$, thereby implying a statistical significance.

In individual groups, V/C group showed a success rate of 80.5% during VL verbal feedback, whereas during CL verbal feedback, it was 41.6% ($P = <0.0007$). In group C/V, during CL verbal feedback, success rate was 47.2%, whereas during VL verbal feedback, it was 86.1% ($P = <0.0004$) which was statistically significant. The mean duration of time to best view was 19.8 s for the video-assisted verbal feedback compared with 26.8 s for conventional verbal feedback ($P < 0.001$); the difference being statistically significant. The mean duration of successful intubation was 30 s for the video-assisted verbal feedback compared with

Table 1: Prior neonatal intubation experience of trainees

Prior neonatal intubation experience (number of intubations)	Number of trainees	
	Group V/C	Group C/V
0	6	6
1	2	2
2	2	1
3	1	1
4	1	2

V/C – Video-assisted verbal feedback followed by conventional verbal feedback, C/V – Conventional verbal feedback followed by video-assisted verbal feedback

Table 2: Demographic characteristics of the patients

Characteristics	VL	CL	*P*
Age (days), mean±SD	122±29	91±23	0.104
Gender			0.37
Male, *n* (%)	45 (62.5)	50 (69.4)	
Female, *n* (%)	27 (37.5)	22 (30.5)	
Weight (kg), median (IQR)	3.4 (2.4-5)	3.8 (2.8-5)	0.25
ASA Grade			
Grade-1, *n* (%)	41 (56.9)	40 (55.5)	0.86
Grade-2, *n* (%)	31 (43)	32 (44.4)	
ETT (size ID mm), mean±SD)	3.5±0.5	3.5±0.5	0.76

SD – Standard deviation, *n* – Number, IQR – Inter quartile range

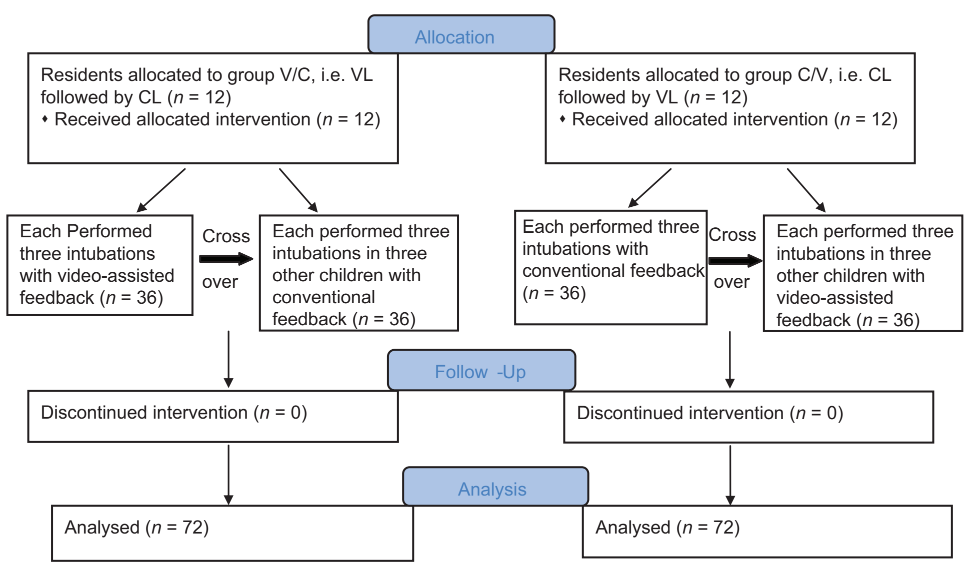

Figure 1: CONSORT 2010 flow diagram

41.7 s for conventional verbal feedback ($P < 0.001$); the difference was statistically significant.

Other secondary outcomes are shown in Table 3. The total number of patients in which intubation failure occurred and a senior anaesthetist was required to intubate was 9 in each group. There were no oesophageal intubations during video-assisted verbal feedback, whereas 17 oesophageal intubations occurred in the conventional verbal feedback, which was statistically significant, $P < 0.001$. Trainees reported a significant degree of ease in laryngoscopy and intubation (VAS score) when verbal feedback were video assisted compared to conventional (4.1 vs. 6.6, $P < 0.001$). There were significantly more events of desaturation and use of external laryngeal manipulation and stylet during conventional verbal feedback. There were no significant differences in trauma or bradycardia episodes. Various reasons for intubation failure are depicted in Figure 2.

DISCUSSION

Securing the airway in neonates and infants is a challenging task in itself. To add to this, trainee anaesthesiologists have limited opportunities to perform intubations in this vulnerable group. Teaching neonatal intubations to trainees becomes an arduous task, with the miniature structures and limited view available to the instructor. So, a device that gives real time improved and magnified images, on a screen, that can be seen by the instructor is not only an effective teaching tool, but also minimises patient risks. The ability to record the event and subsequently review the tape with the learner is unique and helpful in the learning process.

Table 3: Secondary outcome measures

Outcome	VL	CL	*P*
TTBV* (seconds)	19.8 (2.8)	26.8 (4.2)	<0.001
TTI# (seconds)	30 (3.46)	41.7 (5.9)	<0.001
VAS score (ease)	4.1 (1.36)	6.6 (1.1)	<0.001
Ext laryngeal manipulation, *n* (%)	34 (47.2)	59 (81.9)	<0.001
Stylet, *n* (%)	14 (19.4)	29 (40.2)	<0.006
Oesophageal intubation, *n* (%)	0 (0)	17 (23.6)	<0.001
Trauma, *n* (%)	2 (2.7)	5 (6.9)	0.24
Bradycardiaepisodes, *n* (%)	4 (5.5)	8 (11.1)	0.22
Desaturation episodes, *n* (%)	8 (11.1)	28 (38.8)	0.001
Minimum SpO_2%, median (IQR)	72 (76-69)	70 (72-65)	0.23

Data are expressed as mean (SD) unless indicated otherwise. *Time to best view #Time to intubation

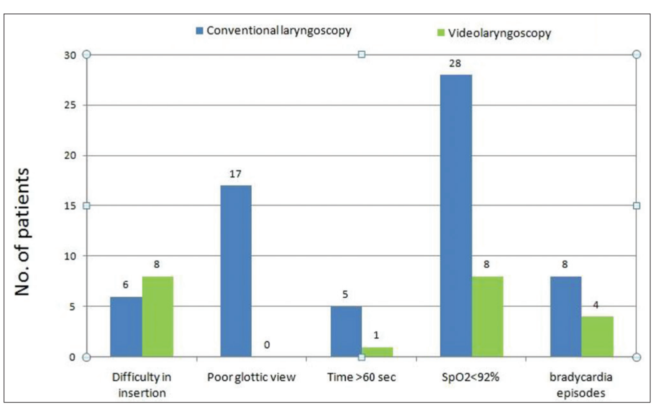

Figure 2: Reasons for intubation failure in the two techniques

Videolaryngoscopes have been introduced for paediatric patients in the last decade. Devices like CMAC®, Glidescope®, Airtraq™, TruView™, McGrath™and Bullard laryngoscopes are available in pediatric sizes. They offer the advantage of a larger field of vision and lesser cervical spine movement, thus allowing the laryngoscopist to look around the corners.[4] We studied the CMAC videolayngoscope specifically because of the similarity of its Miller and Macintosh blades with our conventional laryngoscope.[5] As a result, it has a potential to be used as a teaching tool for both direct as well as indirect laryngoscopy. CMAC® (Karl Storz GmbH & Co.KG, Tuttlingen, Germany) incorporates a fibreoptic camera lens into the light source of a laryngoscope blade, effectively positioning the laryngoscopist's eye at the tip of the blade.[6] It provides an angle of view of 80° compared to 15° in a conventional laryngoscope. The electronic unit sits in a handle attached to the laryngoscope blade and is connected by a wire to a portable TFT video monitor.

In our study, we enrolled twenty-four trainee anaesthesiologists in a cross over design to nullify the bias due to differences in the skills of individual anaesthesiologists. We chose the CMAC videolaryngoscope since the blade closely resembles the Miller blade of conventional laryngoscope. The same device was used as conventional laryngoscope with the screen covered because we wanted to assess the difference made by appropriate verbal feedback. A change of device could have introduced a bias. The overall success rate of first attempt at intubation was much higher for videolaryngoscopy (VL) compared to the conventional laryngoscopy (CL). This is similar to the studies conducted by Michael-Andrew Assad *et al*. and Moussa *et al*.[7,8] The magnified view of the larynx available to the instructor made it easier to make suggestions and communicate with the intubating anaesthesiologist, which was unavailable in the CL group. This study did not assess whether the improved rate of successful intubation when using a videolaryngoscope resulted in retention of the skill when the operator was unassisted. However, Moussa *et al*. showed that success rates of residents who learned intubation using videolaryngoscopy were maintained when they converted to classic laryngoscopy.[8]

In our study, the best view as well as successful intubation was achieved faster with the VL than with the CL. This is in contrast to the studies conducted by Assaad *et al*. and Vanderhal *et al*. in neonatal mannequins as well as by Moussa *et al*. and Vlatten*et al*. in neonates and children, respectively.[3,6-8] They attributed it mainly to the time required to insert the endotracheal tube after the best view was obtained. Also small movements of the ETT was translated to large changes on the video screen. The meta-analysis conducted by Sun[9] in paediatric population also demonstrated that compared to CLs, paediatric VLs, except for paediatric Airtraq, were associated with improved glottic visualisation in children either with normal airways or with potentially difficult intubations. However, the time to intubation was prolonged. The difficulty in insertion of ETT in CMAC can be circumvented by using the groove of the straight blade as the ETT track rather than insertion from the corner of the mouth.[5]

In our study, there were no oesophageal intubations with the VL technique, whereas 17 oesophageal intubations occurred with CL technique, which is statistically and clinically significant. An oesophageal intubation is unlikely to lead a negative patient outcome if it is readily recognized. However, it can lead to gastric inflation and further hampering of effective ventilation in a neonate who is already at a physiological disadvantage. Also it leads to a termination of the trainee's intubation attempt, which impedes learning. Assaad *et al*. found that oesophageal intubations decreased using the VL compared with the CL.

We also found that there were significantly more events of desaturation, use of external laryngeal manipulation and stylet with the CL. There were no significant differences in trauma or bradycardia episodes. The VAS score was lower with use of VLs than the CLs. Thus, the novice anaesthesiologists found it easier to intubate with the CMAC than with the CL. This can be not only due to the improved visualisation but also due to the precise verbal feedback and assistance by the senior anaesthesiologist.

Better and magnified views from the tip of the videolaryngoscope along with better interaction and precise feedback from the instructor allow higher success rates than conventional laryngoscopy. Knowledge of the laryngoscopist's view reassures the instructor that the intubation attempt is safe and reducing the anxiety associated with neonatal intubation due to the inherent risks. Thus, the instructor can be more patient while teaching neonatal intubation. The introduction of a videolaryngoscopy system should be considered at academic centres and sites that provide airway management training.

A limiting factor in the use of this equipment is that it may not be feasible in all training locations due to the added cost and decreased portability of the videolaryngoscopy equipment when compared with a standard laryngoscope. The extra time required for setup and cleaning adds to the cost and can prolong the procedure.

Our study has few limitations. Each trainee had a limited number of intubation attempts with each method, three with each; hence, transferability of skill could not be assessed. Second, we tested only CMAC™ videolaryngoscope; therefore, results may not apply to other videolaryngoscopes.

CONCLUSION

Our study results show that video-assisted verbal feedback to trainees resulted in high first intubation success rate. The conventional laryngoscopy group had a significantly higher rate of complications like oesophageal intubations and desaturation. Magnified view of the larynx available to instructor as well as the intubating anaesthesiologist made it easier to guide during intubation making it a useful teaching tool.

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Conflicts of interest

There are no conflicts of interest.

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