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ORIGINAL RESEARCH

Combined laryngo-bronchoscopy intubation approach in the normal airway scenario: a simulation study on anesthesiology residents

Luigi La Via[1,*], Simone Messina[2], Federica Merola[3], Francesco Tornitore[2], Giulia Sanfilippo[2], Cristina Santonocito[1], Alberto Noto[4], Federico Longhini[2], Marinella Astuto[1,†], Filippo Sanfilippo[1,*,†]

[1] Department of Anaesthesia and Intensive Care, A.O.U. Policlinico-San Marco, site "Policlinico G. Rodolico", 95123 Catania, Italy
[2] School of Anesthesia and Intensive Care, University "Magna Graecia", 88100 Catanzaro, Italy
[3] School of Anesthesia and Intensive Care, University of Catania, 95100 Catania, Italy
[4] Department of Anesthesia and Intensive Care, University of Messina, 98100 Messina, Italy

***Correspondence**
luigi.lavia@unict.it
(Luigi La Via);
filippo.sanfilippo@unict.it
(Filippo Sanfilippo)

† These authors contributed equally.

Abstract

Simulators aid airway training and also familiarization with new devices and techniques. Direct laryngoscopy (DL) is the most used method for endotracheal intubation (ETI), followed by video-laryngoscopy (VLS). The combined use of laryngoscopy with fiberoptic bronchoscope (combined laryngo-bronchoscope intubation, CLBI) has been proposed but its performances in novices and the best timing for introduction during training remain not explored. We performed a randomized, crossover study evaluating the CLBI approach in simulated normal airway scenario. Ninety-six anesthesia residents performed ETI with four approaches: DL, Glidescope®, McGrath® and CLBI. Residents were allowed maximum 3 attempts (up to 60 seconds each). Main outcomes were success rate (SR) and time-to-intubation corrected for SR (cTTI). Subgroup analysis was performed separating residents according to their experience (junior, n = 60; senior, n = 36). At first attempt, DL had higher SR (97%) than CLBI (50%, $p < 0.001$), Glidescope® (84%, $p = 0.01$) and McGrath® (67%, $p < 0.001$). After 3 attempts, ETI failure was higher for CLBI (19%) than with Glidescope® (2%, $p < 0.001$) or DL (1%, $p < 0.001$). CLBI showed longer cTTI (72(112) sec) than other devices (all $p < 0.001$: Glidescope® 25(23) sec, McGrath® 30(67) sec, DL 15(9) sec). The CLBI was the only approach performing better in senior as compared to junior residents ($p = 0.03$). In a normal airway simulation scenario, anesthesiology residents had lower SR and longer cTTI with CLBI technique as compared to DL and VLS. Our results suggest that CLBI could be introduced at senior stage of training, after DL and fiberoptic bronchoscope skills have been consolidated.

Keywords

Direct laryngoscopy; Endotracheal intubation; Fiberoptic bronchoscope; Manikin; Simulation; Video-laryngoscopy

1. Introduction

Endotracheal intubation (ETI) is an essential skill for anesthesiologists but it is practiced also by other healthcare professionals (paramedics, nurses, emergency and intensive care physicians). Indeed, ETI is used not only for provision of general anesthesia, but also in the emergency scenarios where airway control is needed [1].

Experience is essential to master the ETI technique, especially when airway management is performed in difficult scenarios. A part from clinical training (*i.e.*, during residency), learning opportunities regarding ETI are offered by the use of simulation, which aims at increasing operator's confidence with airway management under both normal and difficult conditions [2]. Moreover, simulation allows familiarization with new devices for airway management, and it has been recently adopted to improve confidence with standard procedures performed under the constraints of wearing personal protective equipment [3].

The direct laryngoscope (DL) remains the most commonly used device for ETI. The DL could be relatively difficult to learn for beginners [4, 5] and proficiency deteriorates over time if DL is not routinely practiced [6]. Alternative devices for airway management are available on the market. In particular, video-laryngoscopes (VLSs) have been developed to improve glottic visualization in patients where conventional DL has proven difficult [7, 8]. Learning curve with VLS could be faster than DL and VLSs may provide greater chances of successful ETI by novice personnel [9–14]. However, the performances of VLS are largely influenced not only by the operator's experience but also from the characteristics of the device itself: angle of the VLS blade, presence of a channel for the endotracheal tube (ETT), position of the monitor, *etc*. Practically, while the visualization of vocal cords is usually improved by VLS, directing the ETT through the vocal cords may be more challenging with these devices [15].

Recently, the simultaneous use of DL (or VLS) with the fiberoptic bronchoscope (FOB)—also known as combined laryngo-bronchoscope intubation (CLBI) approach—has been clinically suggested as alternative technique [16–22]. With such approach, the DL (or VLS) enables smooth introduction of the FOB in the pharyngeal region; in turn, the FOB allows precise guidance of the ETT through the vocal cords. A simulation study showed good results of CLBI technique performed by experienced anesthesiologists (n = 18) as compared to DL and VLS (McGrath®) in a scenario of difficult airway [23]. Similarly, a smaller simulation study (n = 8) showed that combined use of VLS (Airtraq®) and FOB enables faster ETI in difficult airway scenarios as compared to Airtraq® alone [24]. However, the performances of the CLBI technique in non-experienced hands remain to be investigated in larger samples.

We hypothesized that younger doctors have fast learning curves with FOB and may have good proficiency with CLBI approach already during the first years of training. Therefore, we conducted a simulation study aiming at assessing performances of the CLBI technique in a population of anesthesiology residents, comparing this technique with the other commonly used approaches for airway management and ETI (DL and VLS). We secondarily aimed at acquiring information on the best timing for the introduction of this technique during the anesthesiology training.

2. Materials and methods

This study was designed as a randomized, crossover manikin trial, and conducted between January and February 2022 at the "Cristian Ilardi" Simulation Center of the School of Anaesthesia, Intensive Care and Pain Therapy of the University of Catania.

2.1 Study participants

Ninety-six anesthesia residents of the five years of the residency in Anaesthesia, Intensive Care and Pain Therapy, and rotating at the University of Catania participated in this simulation study. All residents had variable clinical experience in adult ETI with the different airway devices, and they were asked to report the approximate number of procedures they already performed.

2.2 Study development

We used the same airway manikin (Larry Intubation Trainer, Armstrong Medical Inc., 575 Knightsbridge Parkway, P.O. Box 700, Lincolnshire, IL 60069-0700). The manikin was set with a normal airway scenario and placed on a rigid table in a lighted room. For each participant, the manikin was positioned at the height of the xiphoid process.

All the residents received a standardized 15-minute teaching on the manikin anatomy, on the study methods and on all the devices of the study (including video demonstrations on the use of these devices). After the teaching session, every participant had 15 minutes to practice ETI with the study devices.

Four devices were studied for ETI, and their sequence followed a randomized order (sealed envelopes). Each participant was not allowed to watch each other in order to avoid any teaching bias. The following four techniques for airway management were tested:

A. DL using a Macintosh laryngoscope blade size 3 (Mercury Medical, Clearwater, FL, USA).

B. VLS with distant monitor (VLS-DM) with Glidescope (Glidescope Verathon Inc. 20001 North Creek Parkway Bothell, WA 98011 USA).

C. VLS with screen on device (VLS-SoD) with the McGrath MAC blade X3 (McGrath; Aircraft Medical Ltd, UK); and.

D. CLBI approach with the same Macintosh DL and the use of a disposable bronchoscope (aScope™ 4 Broncho Regular endoscope, Ambu A/S Baltorpbakken 13 DK-2750 Ballerup, Denmark). As shown in Fig. 1, before attempting the ETI with the FOB, the operator performs a DL and then passes the device to the second operator that has the only duty to hold it in place to facilitate the passage of the FOB in the upper airway region.

All ETI were performed using a lubricated ETT with a 7.5-mm internal diameter. For the VLS procedures, a semi-rigid stylet was already inserted in the ETT to obtain a hockey-stick shape. A stylet was available on request for the DL. The manikin and the ETT were periodically wetted with a lubricant.

Six independent operators (LLV, SM, FM, FT, GS and FS) carried the study. The same author (LLV) provided the standardized teaching sessions, while the others were in charge of organizing the flow of residents, performing the randomization and assessing performances in terms of success and time.

2.3 Outcomes

We tested two primary outcomes, (a) the success rate (SR) and (b) the corrected time to intubation (cTTI).

With regards to the SR, each participant had up to three attempts to perform ETI for each device/technique. Successful ETI was declared if confirmed by chest rise after bag insufflation by one of the research team. We registered ETI failure when the attempt lasted longer than 60 seconds or the ETT was placed in the esophagus.

Regarding the cTTI, recording with a chronometer started when the operator grasped the device and lasted until the participant stated the ETT passed the vocal cords. The absolute value of the time to intubation was then corrected (cTTI) for the number of attempts, by adding 60 seconds for each failed attempt. For instance, an intubation occurring at the 33rd second of the 2nd attempt had a cTTI of 93 seconds (33 + 60 seconds for the first failed attempt). In case of three failed attempts a count of 180 seconds was imputed. As secondary endpoint, we analyzed the uncorrected TTI (uTTI) which is the absolute TTI taken by the successful attempt only, without correction for the SR. Our decision to use the cTTI instead of the uTTI is based on the importance of accounting for previously failed attempts. Indeed, each failure exposes the patient to increased risks of desaturation, bleeding and secretions. For instance, using the uTTI a hypothetical device

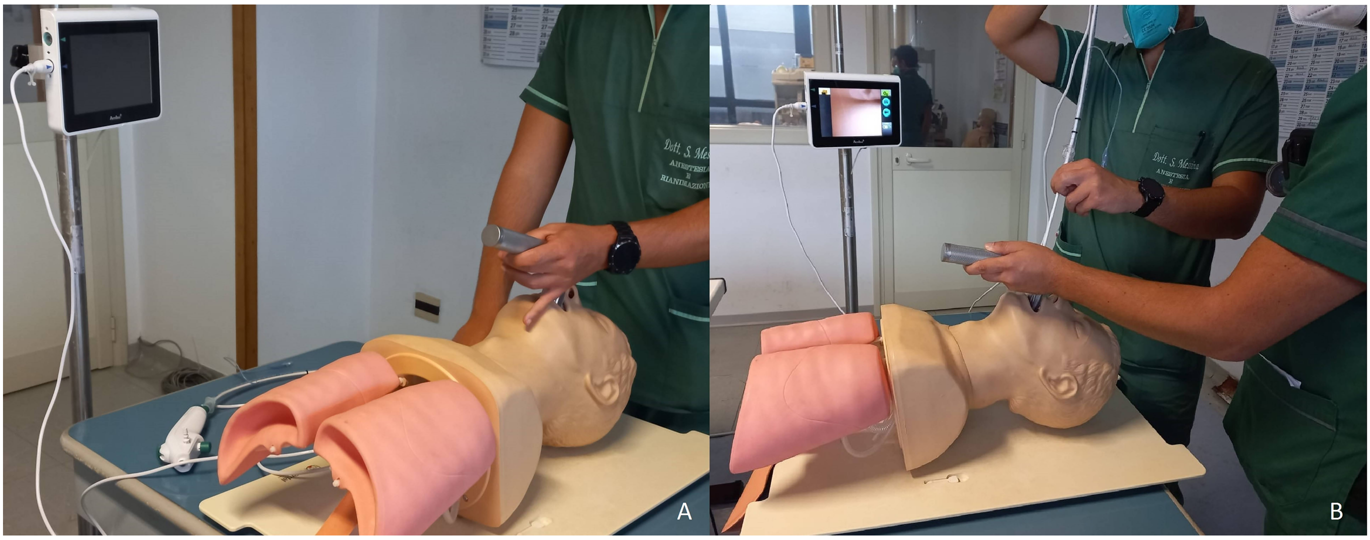

FIGURE 1. CLBI. A: Direct Laryngoscopy with Macintosh blade; B: Combined laryngo-bronchoscope intubation.

with low SR but short TTI would seem outperforming as compared to devices with longer TTI but greater SR.

Other variables recorded were: subjective estimate of the number of procedure performed with each device, glottic view in terms of Cormack-Lehane classification [25] and POGO (percentage of glottis opening, ranging from 0% to 100%) system [26]. Although not formally validated, we asked the Cormack-Lehane and f for the CLBI too. At the end of each airway scenario, each resident was asked to rate ease of ETI using all techniques on a 10-point Likert scale ranging from 1 (very difficult) to 10 (very easy).

2.4 Statistical analysis

Data distribution was investigated with Kolgomorov-Smirnoff test; data were reported as numbers (percentages) for the categorical variables, whilst the continuous variables were described in terms of mean and standard deviation or as median and interquartile range (IQR) according to their distribution. Differences for continuous variables (*i.e.*, cTTI) were investigated using the paired t-Student test or the Wilcoxon rank test for paired data according to data distribution, whilst analyses for categorical variables were conducted using the Fisher's exact test. Differences between groups were considered significant if p value was below 0.05.

3. Results

The participants of the study had a mean age of 29.7 ± 3.1 years and 39% were males (n = 37). In particular, we enrolled 33, 27, 12, 11 and 13 residents for the first, second, third, fourth and fifth year of their training, respectively. The population characteristics and their experience with each device are reported in Table 1. Of note, on average there was no experience with the CLBI approach in the overall population. The experience with VLSs was negligible in the junior resident population, whilst 5 to 10 VLS procedures were self-reported on average by the senior residents.

Table 2 describes the performances of each device in terms of SR, cTTI and uTTI. Results are shown for the overall participants, and also for the two subgroups of junior and senior residents. The highest SRs (at 1st, 2nd and 3rdattempt) were found for the DL, followed by VLSs (Glidescope® and McGrath®, respectively); the lowest SRs were recorded for the CLBI approach. Similar findings were observed for the cTTI.

Table 3 shows the analyses conducted comparing performances of devices (cTTI and SR both at 1st and 3rd attempt) in the overall population. All the comparisons yielded significant results for the cTTI and the SR at 1st attempt, with the DL being the best performing device followed in order by Glidescope®, McGrath® and CLBI approach. The SR at the 3rd attempt did not show differences in two analyses only: the comparison between DL and Glidescope®, and the one between McGrath® and CLBI.

Table 4 reports the ease of use and the Cormack-Lehane and POGO scores for all the devices, both for the overall participants and for the subgroups according to their training level.

The sensitivity analyses conducted on uTTI (time recorded for successful intubations not corrected for failures) mostly confirmed the primary results obtained on the cTTI. The only difference was that uTTI was not different between Glidescope® and McGrath® devices (p = 0.10 instead of p = 0.006).

4. Discussion

Our simulation study was conducted in a population of 96 anesthesiology residents at different stage of training. Our main focus was to evaluate the performances of the CLBI approach in a population of residents, gathering also initial information on the best timing for introduction of this technique during the anesthesiology training. Indeed, the CLBI seems a promising method and has been implemented in several reports [16, 17, 27–31]. From conceptual perspectives, it seems intuitive to combine the advantages of DL/VLS (in terms of visualization of the airways) with the possibility to finely guide the ETT with a FOB. For such reasons, it is not surprising the recent development of new devices aiming at

TABLE 1. Characteristics of the residents participating in the study.

	Overall (n = 96)	Junior residents (n = 60)	Senior residents (n = 36)
Males	37 (39%)	26 (43%)	11 (31%)
Age	29.7 ± 3.1	28.8 ± 2.4	32.5 ± 3.3
Estimated number of procedures			
Direct Laryngoscope	43 (200)	15 (38)	325 (225)
Glidescope	0 (5)	0 (0)	5 (21)
McGrath	1 (8)	0 (1)	10 (16)
CLBI	0 (0)	0 (0)	0 (1)

Gender, age and estimated experience with each device are reported. CLBI: combined laryngo-bronchoscope intubation.

TABLE 2. Performances of each device in terms of success rate (SR), corrected and uncorrected time to intubation (cTTI and uTTI, respectively).

	Direct Laryngoscope		Glidescope		McGrath		CLBI	
SR at 1st attempt								
Overall	92/96 (96%)		81/96 (84%)		64/96 (67%)		48/96 (50%)	
Junior	56/60 (93%)	0.29	49/60 (82%)	0.40	39/60 (65%)	0.82	26/60 (43%)	0.14
Senior	36/36 (100%)		32/36 (89%)		25/36 (69%)		22/36 (61%)	
SR at 2nd attempt								
Overall	94/96 (98%)		90/96 (94%)		79/96 (82%)		67/96 (70%)	
Junior	58/60 (97%)	0.53	55/60 (92%)	0.41	50/60 (83%)	0.79	38/60 (63%)	0.11
Senior	36/36 (100%)		35/36 (97%)		29/36 (81%)		29/36 (81%)	
SR at 3rd attempt								
Overall	95/96 (99%)		94/96 (98%)		85/96 (89%)		78/96 (81%)	
Junior	59/60 (98%)	1.00	58/60 (97%)	0.53	54/60 (90%)	0.74	45/60 (75%)	0.06
Senior	36/36 (100%)		36/36 (100%)		31/36 (86%)		33/36 (92%)	
cTTI								
Overall	15.3 (9.4)		25.3 (22.6)		29.8 (67.1)		72.4 (111.9)	
Junior	16.3 (10.9)	0.13	28.0 (33.9)	0.16	31.9 (65.3)	0.66	98.4 (127.0)	0.03
Senior	14.6 (7.3)		22.8 (14.5)		27.4 (61.7)		51.5 (72.4)	
uTTI								
Overall	15.1 (9.0)		24.4 (14.8)		22.4 (17.0)		40.5 (15.4)	
Junior	15.5 (10.1)	0.22	24.9 (16.4)	0.34	23.6 (14.6)	0.90	41.1 (12.5)	0.76
Senior	14.6 (7.3)		22.3 (10.7)		19.2 (19.9)		39.3 (16.6)	

Results are shown for the overall participants (with differences between devices shown separately in Table 3), and also for the two subgroups of junior and senior residents (differences shown in this table).
CLBI: combined laryngo-bronchoscope intubation.

TABLE 3. Differences between device performances in terms of success rate (SR), corrected and uncorrected time to intubation (cTTI and uTTI, respectively) in the overall population.

cTTI	Direct Laryngoscope	Glidescope	McGrath
Direct Laryngoscope			
Glidescope	<0.001		
McGrath	<0.001	0.006	
CLBI	<0.001	<0.001	<0.001
SR at 1st attempt			
Direct Laryngoscope			
Glidescope	0.010		
McGrath	<0.001	0.007	
CLBI	<0.001	<0.001	0.030
SR after 3rd attempt			
Direct Laryngoscope			
Glidescope	1.000		
McGrath	0.005	0.020	
CLBI	<0.001	<0.001	0.230

CLBI: combined laryngo-bronchoscope intubation.

TABLE 4. Subjective evaluation on the ease of use of each device (in a Likert-scale from 1 to 10) and the Cormack-Lehane and POGO (percentage of glottis opening) scores for all the devices.

	Overall (n = 96)	Junior residents (n = 60)	Senior residents (n = 36)
Ease of use (Likert scale 1–10)	Median (IQR)	Median (IQR)	Median (IQR)
Direct Laryngoscope	9 (2)	9 (3)	10 (1)
Glidescope	7.5 (4)	7 (4)	9 (3)
McGrath	7 (4)	6 (4)	9 (4)
CLBI	5.5 (4)	4 (5)	6 (3)
Cormack-Lehane grade	1-2a-2b-3-4	1-2a-2b-3-4	1-2a-2b-3-4
Direct Laryngoscope	72-20-3-1-0	40-16-3-1-0	32-4-0-0-0
Glidescope	76-15-2-2-1	45-11-1-2-1	31-4-1-0-0
McGrath	78-18-0-0-0	45-15-0-0-0	33-3-0-0-0
CLBI	72-15-4-2-3	42-10-3-2-3	30-5-1-0-0
POGO score	Median (IQR)	Median (IQR)	Median (IQR)
Direct Laryngoscope	100 (20)	90 (21)	100 (6)
Glidescope	100 (20)	100 (20)	100 (16)
McGrath	100 (10)	100 (20)	100 (0)
CLBI	100 (20)	100 (20)	100 (5)

Results are described both for the overall participants and for the two subgroups according to the training level. CLBI: combined laryngo-bronchoscope intubation. IQR: interquartile range.

combining these techniques (*i.e.*, Provu Video-stylet®).

In a previous simulation study of difficult airways, the CLBI technique produced interesting results when performed by experienced anesthesiologists. In our study, performances of CLBI approach were investigated in less experienced personnel (residents of anesthesiology), starting from an easier simulation scenario (normal airways). We initially hypothesized that younger doctors may have fast learning curves with FOB and thus may be proficient with the CLBI approach. However, we failed to show advantages in the introduction of this CLBI approach in the early stage of training, and in general results of CLBI methods were inferior to the ones obtained with DL and VLSs. Although it was somewhat expected to find longer cTTI for CLBI in normal airway scenario, we found that SR of CLBI was only 50% at the 1st attempt and increased up to 81% by the 3rd attempt; therefore, roughly one participant in five was not able to perform ETI with this approach after three attempts. Even if our results need external validation, our study suggests that CLBI should be reserved to a more advanced stage of anesthesiology training. Indeed, in the subgroup analyses on cTTI according to the experience, the only significant difference was found for the CLBI approach, where senior residents had significantly faster cTTI than junior ones. Moreover, although not significant, a trend in this direction was seen also for the SR, where senior residents had greater SR by the 3rd attempt with the CLBI approach (92%) as compared to junior trainee (75%, $p = 0.06$). Thus, our results seem supporting that a greater degree of experience is needed before implementing the CLBI approach. However, it seems not strictly necessary to introduce training on CLBI at late stage of anesthesiology residency for a couple of reasons. First, 14 of the 18 CLBI failures by the 3rd attempt were reported for the first year of training, whilst the remaining 4 were seen for the second (n = 1), third (n = 1) and fourth (n = 2) years of training. Second, when considering the visualization of the vocal cords, results of the CLBI technique were not dissimilar from those of DL and VLSs, suggesting that the main difficulty was advancing the ETT due to absence of skills in manipulation of the tip of the FOB. Therefore, teaching the CLBI approach could be considered relatively early, maybe from the second or the third year of anesthesiology residency, as long as training with FOB has already started. On separate note, it should be considered that CLBI approach could be an intriguing technique for teaching younger residents as this technique allows good supervision during the intubation process, with mentor and resident sharing the same view on the screen. Even though we did not explore this item, a previous study showed that supervisors could more easily teach and assess the success of the novices using the CLBI method [32]. Conversely, DL does not allow simultaneous sharing of the view between resident and teacher, and therefore its teaching could be more complex.

We did not find significant differences in cTTI and SR between categories of residents when assessing performances according to the use of DL and the two VLSs. Nonetheless, as the junior residents had longer median cTTI (and generally lower SR) as compared to senior residents, albeit it is possible that this result is difference was not significant because of due to a relatively low sample size.

Another result deserving comments is that DL was the best performing device, both in term of SR and cTTI. The finding of superiority of DL in our study was mostly expected and likely driven by the greater confidence with DL as compared to the other devices and techniques, as shown by the subjective estimation on the number of procedures performed. In this regards, performances followed the experience of the operators with each device. Considering that visualization of the vocal cords was similar between DL and VLSs, it is likely that VLSs suffered from lower experience in directing the ETT after visualization of the glottis, even though a stylet was inserted in the ETT. The superiority of DL as compared to VLS for novice personnel is not a novel finding. Indeed, Savoldelli *et al.* [10] found that DL had the shortest TTI as compared to other three VLSs (Airtraq®, Glidescope®, McGrath®). Similarly, Ruetzler *et al.* [33] showed that in personnel without experience in VLS, the DL had the highest SR and the shortest TTI in the normal airway scenario. Similar findings were reproduced by Eismann *et al.* [34] that found the highest SR and the lower TTI in DL as compared to VLSs (Storz cMac®, Storz dBlade® and Ambu King Vision®), but their results were reverted in case of difficult airways. However, other studies conducted in personnel with low or no airway experience have found that VLS have similar [35] or better [36, 37] SR and/or TTI as compared to DL. Several aspects may influence these results, ranging from the characteristics of the study population to the difficulty of airway management, from the experience with DL to the characteristics of the VLS used.

There are some strengths and several limitations in our study. The main strength of our study was the relatively large sample size as compared to most of the studies in the simulation setting. Another strength is the precision in the analysis which was conducted with the cTTI, a parameter accounting for previously failed attempts, thus avoiding a hypothetical bias where a device with low SR but short TTI would seem outperforming as compared to devices with longer TTI but greater SR. Of note, other studies have been vague on the way they handled the timing for failed attempts. A third strength of our study was the randomization process in the use of the devices.

There are several limitations in our study. First, it is a single center study that requires external validation. Second, although our population may look somewhat homogeneous (young doctors in training), their experience in the airway management was very variable, as described by the number of estimated procedures they performed with each device. Interestingly, the overall experience with CLBI approach was almost negligible and may explain the relatively low SR by the 3rd attempt. A second session of retraining is planned at 6 to 9 months to evaluate retention of skills. Third, some residents were familiar with the simulator as they join the faculty for advanced cardiac life support and other activities of our simulation center. Fourth, although the role of simulation in the field of airway management cannot be overemphasized and a recent meta-analysis [38] supports the role of simulation training for advanced airway management in medical education, our study suffers from all the issues related to the simulation setting. In brief, simulation scenarios cannot reproduce the real-life challenges in airway management due to presence of secretions and bleeding (among others), as well as to the emotional stress felt by the operator (*i.e.*, anxiety due to progressive desaturation, ongoing resuscitation, *etc.*) [14, 39, 40]. Moreover, similarity between manikins and the real anatomy has been questioned both in adult and pediatric settings [41–43].

5. Conclusions

In a simulation setting of normal airways, residents in anesthesiology had significantly lower success rate and longer time to intubation with the combined laryngo-bronchoscopy approach as compared to direct and video-laryngoscopy. However, most of the failures with combined laryngo-bronchoscopy approach by the 3rd attempt were seen in residents of the first year of training, suggesting that training in this technique may be implemented during the anesthesiology training. The best performances obtained by the direct laryngoscopy reinforce the importance of previous experience with the airway device.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

LLV, FS and MA—designed the research study. SM, FM, FT and GS—performed the research. FS and AN—analyzed the data. LLV, CS and FL—wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study received a waiver from the local Ethical Committee (Committee Catania 1—Catania, Italy). All participants gave their written informed consent to participate to the study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Filippo Sanfilippo is serving as one of the Editorial Board members of this journal. We declare that Filippo Sanfilippoh had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to CM.

REFERENCES

[1] Stevenson AGM, Graham CA, Hall R, Korsah P, McGuffie AC. Tracheal intubation in the emergency department: the Scottish district hospital perspective. Emergency Medicine Journal. 2007; 24: 394–397.

[2] Kennedy CC, Cannon EK, Warner DO, Cook DA. Advanced airway management simulation training in medical education: a systematic review and meta-analysis. Critical Care Medicine. 2014; 42: 169–178.

[3] Sanfilippo F, Tigano S, La Rosa V, Morgana A, Murabito P, Oliveri F, *et al*. Tracheal intubation while wearing personal protective equipment in simulation studies: a systematic review and meta-analysis with trial-sequential analysis. Brazilian Journal of Anesthesiology. 2022; 72: 291–301.

[4] Mulcaster JT, Mills J, Hung OR, MacQuarrie K, Law JA, Pytka S, *et al*. Laryngoscopic intubation: learning and performance. Anesthesiology. 2003; 98: 23–27.

[5] Wamg HE, Reitz SR, Hostler D, Yealy DM. Defining the learning curve for paramedic student endotracheal intubation. Prehospital Emergency Care. 2005; 9: 156–162.

[6] Malik MA, O'Donoghue C, Carney J, Maharaj CH, Harte BH, Laffey JG. Comparison of the Glidescope®, the Pentax AWS®, and the Truview EVO2® with the Macintosh laryngoscope in experienced anaesthetists: a manikin study. British Journal of Anaesthesia. 2009; 102: 128–134.

[7] Kim JK, Kim JA, Kim CS, Ahn HJ, Yang MK, Choi SJ. Comparison of tracheal intubation with the airway scope or Clarus video system in patients with cervical collars. Anaesthesia. 2011; 66: 694–698.

[8] Shippey B, Ray D, McKeown D. Use of the McGrath® videolaryngoscope in the management of difficult and failed tracheal intubation. British Journal of Anaesthesia. 2008; 100: 116–119.

[9] Maharaj CH, Costello JF, Higgins BD, Harte BH, Laffey JG. Learning and performance of tracheal intubation by novice personnel: a comparison of the Airtraq and Macintosh laryngoscope. Anaesthesia. 2006; 61: 671–677.

[10] Savoldelli GL, Schiffer E, Abegg C, Baeriswyl V, Clergue F, Waeber J. Learning curves of the Glidescope, the McGrath and the Airtraq laryngoscopes: a manikin study. European Journal of Anaesthesiology. 2009; 26: 554–558.

[11] Maharaj CH, McDonnell JG, Harte BH, Laffey JG. A comparison of direct and indirect laryngoscopes and the ILMA in novice users: a manikin study. Anaesthesia. 2007; 62: 1161–1166.

[12] Savoldelli GL, Schiffer E, Abegg C, Baeriswyl V, Clergue F, Waeber JL. Comparison of the Glidescope, the McGrath, the Airtraq and the Macintosh laryngoscopes in simulated difficult airways*. Anaesthesia. 2008; 63: 1358–1364.

[13] Park J, An S, Park S, Nahm FS, Han S, Kim J. Comparison of a new video intubation stylet and McGrath® MAC video laryngoscope for intubation in an airway manikin with normal airway and cervical spine immobilization scenarios by novice personnel: a randomized crossover study. BioMed Research International. 2021; 2021: 1–7.

[14] Sanfilippo F, Messina S, Merola F, Tigano S, Morgana A, Dimagli A, *et al*. Endotracheal intubation during chest compressions in the pediatric simulation setting: a systematic review and meta-analysis. Signa Vitae. 2022; 18: 94–102.

[15] Oh JY, Lee JH, Kim YY, Baek SM, Jung DW, Park JH. A comparative study of glottis visualization according to the method of lifting the epiglottis in video laryngoscopy: indirect and direct lifting methods. Anesthesia and Pain Medicine. 2021; 16: 196–200.

[16] Sanfilippo F, Chiaramonte G, Sgalambro F. Video laryngoscopes and best rescue strategy for unexpected difficult airways: do not forget a combined approach with flexible bronchoscopy! Anesthesiology. 2017; 126: 1203.

[17] Sgalambro F, Sanfilippo F, Santonocito C, Caltavuturo C, Grillo C. Virtual laryngoscopy and combined laryngoscopic—bronchoscopic approach for safe management of obstructive upper airways lesions. British Journal of Anaesthesia. 2014; 113: 304–306.

[18] Nedrud SM, Baasch DG, Cabral JD, McEwen DS, Dasika J. Combined video laryngoscope and fiberoptic nasal intubation. Cureus. 2021; 13: e19482.

[19] Kim SM, Kim HJ. Successful advancement of endotracheal tube with combined fiberoptic bronchoscopy and videolaryngoscopy in a patient with a huge goiter. SAGE Open Medical Case Reports. 2020; 8: 2050313X20923232.

[20] Yukihiro Imajo, Komasawa N, Fujiwara S, Tsuji E, Minami T. Efficacy of a Bronchofiberscope in combination with the GlideScopee in a difficult airway patient. Masui. The Japanese Journal of Anesthesiology. 2016; 65: 1013–1015. (In Japanese)

[21] Sowers N, Kovacs G. Use of a flexible intubating scope in combination with a channeled video laryngoscope for managing a difficult airway in the emergency department. The Journal of Emergency Medicine. 2016; 50: 315–319.

[22] Murabito P, Astuto M, Sanfilippo F, La Via L, Vasile F, Basile F, *et al*. Proactive management of intraoperative hypotension reduces biomarkers of organ injury and oxidative stress during elective non-cardiac surgery: a pilot randomized controlled trial. Journal of Clinical Medicine. 2022; 11: 392.

[23] Sanfilippo F, Sgalambro F, Chiaramonte G, Santonocito C, Burgio G, Arcadipane A. Use of a combined laryngo-bronchoscopy approach in difficult airways management: a pilot simulation study. Turkish Journal of Anaesthesiology and Reanimation. 2019; 47: 464–470.

[24] Nishikawa K, Hukuoka E, Kawagishi T, Shimodate Y, Yamakage M. Efficacy of the Airtraq® laryngoscope with a fiberoptic bronchoscope compared with that of Airtraq® alone for tracheal intubation: a manikin study. Journal of Anesthesia. 2011; 25: 93–97.

[25] Krage R, van Rijn C, van Groeningen D, Loer SA, Schwarte LA, Schober P. Cormack-Lehane classification revisited. British Journal of Anaesthesia. 2010; 105: 220–227.

[26] Levitan RM, Ochroch EA, Rush S, Shofer FS, Hollander JE. Assessment of airway visualization: validation of the percentage of glottic opening (POGO) scale. Academic Emergency Medicine. 1998; 5: 919–923.

[27] Sanfilippo F, Sgalambro F, Astuto M. Management of difficult airways: which is the safest approach after reviewing virtual laryngo-tracheo-bronchoscopy imaging? Anesthesiology. 2015; 122: 469.

[28] Gomez-Rios MA, Nieto Serradilla L. Combined use of an Airtraq® optical laryngoscope, Airtraq video camera, Airtraq wireless monitor, and a fibreoptic bronchoscope after failed tracheal intubation. Canadian Journal of Anaesthesia. 2011; 58: 411–412.

[29] Greib N, Stojeba N, Dow WA, Henderson J, Diemunsch PA. A combined rigid videolaryngoscopy-flexible fibres copy intubation technique undergener al anesthesia. Canadian Journal of Anesthesia. 2007; 54: 492–493.

[30] Liao X, Xue FS, Cheng Y, Li RP. Rescue intubation by combined use of video laryngoscopy and Bonfils fiberscope in patients with difficult airway. Saudi Medical Journal. 2013; 34: 970–971.

[31] Sharma D, Kim LJ, Ghodke B. Successful airway management with combined use of Glidescope® videolaryngoscope and fiberoptic bronchoscope in a patient with cowden syndrome. Anesthesiology. 2010; 113: 253–255.

[32] Hung WT, Yang MW, Lin CY. Evaluation of learning effectiveness in endotracheal intubation by the use of a laryngoscope in combination with a flexible fiberoptic bronchoscope. Acta Anaesthesiologica Sinica. 2001; 39: 129–133.

[33] Ruetzler K, Imach S, Weiss M, Haas T, Schmidt AR. Comparison of five video laryngoscopes and conventional direct laryngoscopy: Investigations on simple and simulated difficult airways on the intubation trainer. Die Anaesthesiologie. 2015; 64: 513–519.

[34] Eismann H, Sieg L, Etti N, Friedrich L, Schröter C, Mommsen P, *et al*. Improved success rates using videolaryngoscopy in unexperienced users: a randomized crossover study in airway manikins. European Journal of Medical Research. 2017; 22: 27.

[35] Piepho T, Weinert K, Heid FM, Werner C, Noppens RR. Comparison of the McGrath® series 5 and GlideScope® ranger with the macintosh laryngoscope by paramedics. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2011; 19: 4.

[36] Yi IK, Kwak HJ, Lee KC, Lee JH, Min SK, Kim JY. Comparison of McGrath, Pentax, and Macintosh laryngoscope in normal and cervical immobilized manikin by novices: a randomized crossover trial. European Journal of Medical Research. 2020; 25: 35.

[37] Rendeki S, Keresztes D, Woth G, Mérei Á, Rozanovic M, Rendeki M, *et al*. Comparison of VividTrac®, Airtraq®, King Vision®, macintosh laryngoscope and a custom-made Videolaryngoscope for difficult and normal airways in mannequins by novices. BMC Anesthesiology. 2017; 17: 68.

[38] Kennedy CC, Cannon EK, Warner DO, Cook DA. Advanced airway management simulation training in medical education: a systematic review and meta-analysis. Critical Care Medicine. 2014; 42: 169–178.

[39] Doleman B, Blackwell J, Karangizi A, Butt W, Bhalla A, Lund JN, *et al*. Anaesthetists stress is induced by patient ASA grade and may impair non-technical skills during intubation. Acta Anaesthesiologica Scandinavica. 2016; 60: 910–916.

[40] Sanfilippo F, Martucci G, La Via L, Cuttone G, Dimarco G, Pulizzi C, *et al*. Hemoperfusion and blood purification strategies in patients with COVID-19: a systematic review. Artificial Organs. 2021; 45: 1466–1476.

[41] Schebesta K, Hüpfl M, Ringl H, Machata A, Chiari A, Kimberger O. A comparison of paediatric airway anatomy with the SimBaby high-fidelity patient simulator. Resuscitation. 2011; 82: 468–472.

[42] Schebesta K, Hüpfl M, Rössler B, Ringl H, Müller MP, Kimberger O. Degrees of reality: airway anatomy of high-fidelity human patient simulators and airway trainers. Anesthesiology. 2012; 116: 1204–1209.

[43] Blackburn MB, Wang SC, Ross BE, Holcombe SA, Kempski KM, Blackburn AN, *et al*. Anatomic accuracy of airway training manikins compared with humans. Anaesthesia. 2021; 76: 366–372.

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