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Use of a Combined Laryngo-Bronchoscopy Approach in Difficult Airways Management: A Pilot Simulation Study

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Abstract

Objective: There are several airway devices available for difficult tracheal intubation (DTI) management, but the failure rate remains high. The use of laryngoscopy to facilitate the fibreoptic-bronchoscope intubation (CLBI) has been increasingly reported in DTI situations, but it has not been formally studied yet.

Methods: We designed a single-centre simulation study on DTI (neck rigidity and tongue oedema) comparing three techniques: direct laryngoscopy (DL), video-laryngoscopy (VLS) and CLBI. Eighteen anaesthesiologists naïve to VLS/CLBI approaches, participated in the study. The primary outcome was the intubation rate at the first attempt. Secondary outcomes were an overall time-to-intubate (TTI) and time-to-ventilate (TTV), success at the second and third attempt and ease of intubation as evaluated by a subjective 5-point Likert scale.

Results: The CLBI technique had a higher success rate at the first attempt than DL (66% vs 22%, $p=0.007$), while VLS did not (44%, $p=0.16$). A trend towards higher success at the third attempt was found for both VLS and CLBI vs DL ($p=0.07$ and $p=0.06$, respectively). The VLS had a shorter overall TTV than DL (88±60 vs 121±59 sec, respectively, $p=0.04$) and a trend towards a shorter TTI (81±61 vs 116±64 sec, respectively, $p=0.06$). The CLBI approach showed a non-significantly lower TTI/TTV as compared to DL ($p=0.10$ and $p=0.16$, respectively). Anaesthesiologists judged that the intubation with VLS (3.7±1.0) and CLBI (3.8±1.0) was easier than with DL (1.7±0.8, both $p<0.001$).

Conclusion: In a simulated DTI scenario, CLBI had a higher success rate at the first attempt than DL, while VLS did not. By the third attempt, both rescue techniques had a trend towards a higher success rate than DL. The CLBI technique seems a promising alternative for the management of DTI.

Keywords: Difficult tracheal intubation, fibreoptic intubation, manikin, tongue oedema, video-laryngoscope

Introduction

There are several millions of surgical interventions performed annually worldwide (1), and endotracheal intubation is the gold standard in protecting airways of the anaesthetised patient. Under elective conditions, the strategy for performing an endotracheal tube (ETT) insertion depends on the anticipated procedure difficulty, which relies on both the physical examination and patient history.

When a 'difficult airway' is expected, awake intubation with the aid of fibreoptic bronchoscopy (FOB) is a commonly adopted strategy (2-4), although a relatively high failure rate has been reported (5, 6). When difficulties are not anticipated, intubation is performed with the aid of direct laryngoscopy (DL), which allows the glottis visualisation in most cases. However, the failure of DL puts patients at a life-threatening risk; indeed, the issues with regard to airway management are among the greatest source of mortality and morbidity related to anaesthesia (7-9).

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In case of an unanticipated difficult tracheal intubation (DTI), the use of FOB as a rescue technique is not recommended, unless a supra-glottic airway device has been inserted to ventilate the patient, and it can be used as a conduit for advancing the FOB into patient's trachea (10). Several devices have been developed for rescue intubation, and video-laryngoscopes (VLS) are among the most studied. Although various VLS have shown high success rates in DTI (11-13), their failure rates are not negligible and severe adverse events have been reported (14). In general, no rescue device on its own has shown consistently a nearly 100% success. Promising results in the occurrence of an unanticipated DTI have been described with a combined approach using a laryngoscope (DL or VLS) to facilitate the introduction of FOB (15-19) or a rigid bronchoscope (20, 21).

With this background, in a simulated DTI scenario, we aimed to evaluate the intubation success with two rescue techniques (VLS and combined laryngo-bronchoscopy intubation-CLBI) as compared with DL. We hypothesised that both rescue approaches would have been superior to the DL and similar to each other.

Methods

We designed a single-centre prospective crossover study under simulated conditions of difficult airways with a manikin scenario of a rigid neck and tongue oedema. We evaluated the intubation with three different techniques: DL with standard Macintosh blade, VLS (*McGrat MAC Enhanced Direct Laryngoscope, Medtronic*) and CLBI (combining the use of a standard laryngoscope and a fibreoptic bronchoscope *PortaView LF-TP, Olympus*). The study did not involve humans or animals, and we were informally notified of no need of Ethical Committee approval for this internal study. The physician participants provided consent to the study.

Population characteristics

Our centre deals with all solid organ transplants and high-risk major abdominal, thoracic and cardiac surgery, and there is a 16-bedded intensive care unit (ICU). The target population comprised all anaesthesiologists working in our centre.

All the anaesthesiologists in our centre had no previous experience with the VLS or CLBI technique in the past 5 years. The intubating laryngeal mask airway had been the primary rescue technique used by our group for unanticipated DTI; a VLS device was not available at the time of the study, and the CLBI approach had been used sporadically by thoracic surgeons. Most anaesthesiologists had only basic skills performing bronchoscopies during thoracic cases in the operating room and/or during percutaneous tracheostomies in the ICU.

Simulation scenario

A simulated scenario of DTI was reproduced using the *Simman (Laerdal)* at the Simulation Centre (*Centro di Simulazione 'Renato Fiandaca'*) hosted in our hospital (accredited with the American Heart Association). The DTI was simulated by simultaneously activating the 'decreased cervical range of motion' and 'tongue oedema' options in the simulator.

Study design

We organised small groups (two to three anaesthesiologists at time) and gave them a 5-minute presentation on study aims and outcomes evaluated. Subsequently, we explained in other two brief sessions the rescue techniques: VLS and CLBI. No training was performed prior to the assessment, and instructions on VLS were restricted to how to handle and turn the light on.

For each technique, every anaesthesiologist had up to three intubation attempts-maximum of 60 seconds each, a cut-off already reported by others (22). All anaesthesiologists started with DL with standard a Macintosh blade; subsequently the order of VLS and CLBI approaches were randomised.

In the case of DL, anaesthesiologists were given the chance to choose a Macintosh blade Size 3 or 4, an ETTs 7.0 to 8.0 cm in diameter, and they were allowed to require the aid of stylet. For the VLS approach, we already suggested to start with an ETT armed with a stylet, but modelling of the ETT shape was left to the physician. For the CLBI approach, we used the so-called passive technique, where the anaesthesiologist, before manoeuvring the FOB was in charge of introducing the DL in the mouth and then passing it to another operator (F.Sg.), whose only role was to hold it 'as handed'. An ETT size 6.5 cm in diameter was preloaded over the FOB.

Outcomes of interest

Our primary outcome in the evaluation of the three techniques was the success rate at the first attempt (%). We also analysed five secondary outcomes: success rates at the second and third attempt (both %); ease of intubation judged by each anaesthesiologist on a five-point Likert scale (1 to 5: very easy, easy, average, difficult, very difficult); the overall time-to-intubation and time-to-ventilation (TTI and TTV respectively, measured in seconds). For the latter two parameters, the chronometer was started once the anaesthesiologist took the laryngoscope; the two time counts were stopped when the ETT passed the vocal cords (TTI), and after the bag-tube ventilation was confirmed by the chest rise (TTV). Each failed attempt was counted as 60 seconds. We also compared the Cormack–Lehane grade (I, II, III, IV) between the DL and the VLS.

An exploratory sub-group analysis was performed dividing the anaesthesiologists according to the years of experience (<10 and ≥10 years after the completion of specialty training).

Statistical analysis

Since no simulation or clinical studies, to the best of our knowledge, have been conducted evaluating the CLBI technique, this investigation represents a pilot study, and a formal sample size calculation is hardly feasible. Nonetheless, the authors discussed the expected success rate for CLBI and for the DL in simulated conditions, and based on this assumption, a sample size calculation was hypothesised. Most authors (five out of six) expected a 10% success rate on the first attempt with DL; on the other hand, consensus on the CLBI success rate was not uniform (three propended for 50%, one for 55% and two for 60%). Based on these opinion, and on values set for α=0.05 and β=0.80, the sample size was calculated with the *Openepi* version 3 software (23), and it produced a sample size of 14–20 anaesthesiologists.

Statistical analyses of the results were performed using the Statistical Package for the Social Sciences (SPSS Inc.; Chicago, IL, USA) Statistics 17 for Windows. Continuous variables are presented as the mean±standard deviation or as median and interquartile range (IQR), according to their distribution. Categorical variables are reported as the number and percentage (%). The parametric t-student and analysis of variance tests were used for variables with normal distribution; when data were not normally distributed, the non-parametric Kruskal–Wallis test was performed for the variable's comparison and the Mann–Whitney U test was then used to detected differences among couple of groups. A chi-squared test was used for the comparison of categorical variables. All tests were two sided, and a *p*-value <0.05 was considered to be statistically significant.

Results

Out of 22 anaesthesiologists, four could not join the study due to annual leaves (n=1) and busy overnight on-call for transplant activity (n=3), leaving finally a population of 18 anaesthesiologists at different levels of experience (range, 1–31 years from the certificate of completion of specialty training).

Success rate at the first attempt was significantly higher with CLBI as compared to DL (66% vs 22%, p=0.007). The success rate of VLS was 44%, with no differences with the other two techniques (vs DL p=0.16, vs CLBI; p=0.18).

There was also a trend towards a lower success rate with DL at the third attempt, as compared with both VLS and CLBI (p=0.07 and p=0.06, respectively). The VLS technique had a shorter TTV (p=0.04) and a trend towards shorter TTI than DL (p=0.06). The CLBI approach showed a non-significantly lower TTI, as compared to the DL. All the results and comparisons are shown in Table 1.

The Cormack–Lehane grade was improved by VLS as compared with DL: 1 (IQR 1) vs 3 (IQR 1.75) respectively (p<0.0001).

The anaesthesiologists judged the ease of intubation with the VLS (2.3±1.0) and CLBI (2.2±1.0) techniques higher than

Table 1. Results of the study outcomes comparing three techniques for airway management

	DL	VLS	CLBI	p	
Success at first attempt	4/18	8/18	12/18	DL vs VLS	p=0.16
	(22%)	(44%)	(66%)	DL vs CLBI	p=0.007
				VLS vs CLBI	p=0.18
Success at second attempt	10/18	13/18	13/18	DL vs VLS	p=0.30
	(55%)	(72%)	(72%)	DL vs CLBI	p=0.30
				VLS vs CLBI	p=1.00
Success at third attempt	10/18	15/18	16/18	DL vs VLS	p=0.07
	(55%)	(83%)	(89%)	DL vs CLBI	p=0.06
				VLS vs CLBI	p=0.63
TTI (sec) overall	116±64	81±61	85±59	DL vs VLS	p=0.06
				DL vs CLBI	p=0.10
				VLS vs CLBI	p=0.46
TTV (sec) overall	121±59	88±60	92±58	DL vs VLS	p=0.04
				DL vs CLBI	p=0.16
				VLS vs CLBI	p=0.42

DL: direct laryngoscopy; VLS: video-laryngoscopy; CLBI: combined laryngo-bronchoscopy intubation; TTI: time to intubation; TTV: time to ventilation

Table 2. Results of the study outcomes comparing the anaesthesiologists according to their clinical experience with the cut-off of 10 years from the completion of specialty training. Two groups were compared for each intubation technique

	DL		p	VLS		p	CLBI		p
	<10y n=9	≥10y n=9		<10y n=9	≥10y n=9		<10y n=9	≥10y n=9	
Success at first attempt	3/9 33%	1/9 11%	0.27	3/9 33%	5/9 56%	0.34	8/9 89%	4/9 44%	0.04
Success at second attempt	7/9 78%	3/9 33%	0.06	6/9 67%	7/9 78%	0.60	8/9 89%	5/9 56%	0.11
Success at third attempt	7/9 78%	3/9 33%	0.06	7/9 78%	8/9 89%	0.53	9/9 100%	7/9 78%	0.13
TTI (sec) overall	91±59	142±61	0.09	90±62	72±63	0.56	63±47	108±65	0.11
TTV (sec) overall	99±55	144±57	0.10	96±60	80±63	0.58	71±48	114±63	0.12
Ease of intubation	1.9±0.9	1.5±0.5	0.31	3.3±1.0	4.1±0.8	0.08	4.2±1.1	3.4±0.9	0.11
Cormack–Lehane grade	3 (IQR 1)	3 (IQR 2)	0.83	2 (IQR 1)	1 (IQR 0)	0.11	-	-	-

DL: direct laryngoscopy; VLS: video-laryngoscopy; CLBI: combined laryngo-bronchoscopy intubation; TTI: time to intubation; TTV: time to ventilation; IQR: interquartile range

DL (4.3±0.8, both p<0.001), with no differences between VLS and CLBI (p=0.74).

The exploratory analyses performed dividing the anaesthesiologists according to their experience is shown in Table 2. We found a significantly higher intubation at the first attempt with the CLBI approach by more junior anaesthesiologists (<10 years of experience, n=8/9, 89%) as compared to more senior ones (n=4/9, 44%, p=0.04). Younger anaesthesiologists showed a trend towards a higher success rate of intubation with DL as compared with more senior colleagues at the second and third attempt (both p=0.06).

Regarding the ease of procedure, younger anaesthesiologists had a trend of preference for the CLBI approach (4.2±1.1 vs 3.4±0.9 in more senior anaesthesiologists, p=0.11). On the contrary, more senior anaesthesiologists rated VLS with non-significantly higher scores (4.1±0.8) as compared with the younger group (3.3±1.0, p=0.08). All other results were non-significantly different.

Discussion

To the best of our knowledge, this is the first study evaluating the feasibility of CLBI in a simulated scenario of DTI ('decreased cervical range of motion' and 'tongue oedema'). We decided a scenario of 'difficult visualisation' without a pharyngeal/laryngeal obstruction because the issues in visualisation are the most common scenario for unanticipated DTI, while the obstruction due to masses/tumours are usually elicited by the preoperative assessment.

The main finding of our study was the higher success rate at the first attempt by the CLBI approach as compared with DL, which partially confirmed our initial hypothesis. On the contrary, VLS failed to show a significant increase of intubation success at the first attempt as compared with DL, although this result should be interpreted cautiously due to the pilot design of the study and to the staff inexperience with the device. Interestingly, both rescue techniques showed a trend towards a higher success rate by the third attempt as compared to DL (p=0.07 for VLS and p=0.06 for CLBI), which can be partially ascribed to a learning curve. Although intubating at the second or third attempt would be a very reasonable target in case of an unanticipated DTI, results of a simulated scenario after few attempts may not be realistic (i.e. achieved in the absence of secretions/blood).

About one in five anaesthesiologist was able to intubate at the first attempt with DL, and this was double than expected. Although a difficult visualisation of the glottis was confirmed (Cormack–Lehane Grade 3.1), the higher-than-expected success rate at the first attempt with DL is not entirely surprising since it is well known that difficult scenarios simulation may fail (24), and participants achieve the difficult goal. Moreover, blind intubation is a possibility, and even if guidelines recommend against the 'blind' insertion of ETT or *bougie* (risk of trauma/bleeding and low chances of success) (25), clinicians may try to pass the ETT in the simulated scenario because they do not perceive the risk may harm a patient. The difficulty of intubation in our scenario was further confirmed by a successful intubation rate at the third attempt of only 55% with DL (in most cases with the aid of a stylet), and approximately 85% with rescue techniques.

Several manikin studies have been performed on the use of VLSs under a range of difficult airways conditions, and they included different populations [anaesthesiologists (26, 27), medical students (28), nurses (29), non-medical personnel (30)]. Interpreting our results, it should be kept in mind that we focused on anaesthesiologists naïve to the two rescue techniques, showing the feasibility and ease of such approaches even in staff not experienced with the technique. Our pilot study represents the initial evaluation of the potentialities of the CLBI technique.

We also evaluated the ease of intubation and both rescue techniques were similarly judged easier than DL, which on average was regarded between difficult and very difficult, confirming again the difficulty of our scenario.

Although the VLS success was not significantly superior to DL, it improved significantly the glottis visualisation. This is not surprising (VLS are designed for improving glottis visualisation), but a better visualisation does not always translate into intubation success due to different axis between the optical visualisation of the vocal cords and ETT introduction. For this reason, it is suggested to start VLS with a pre-armed ETT (stylet) to facilitate its orientation (22), and we followed this recommendation, but the modelling of the ETT curvature was left to each participant. Most VLS failures were imputable to difficulties in choosing the right angulation, and this issue would likely improve with practice. Our results do not apply to channelled-blade VLS that guide the ETT through the vocal cords.

The better performance of the CLBI approach at the first attempt as compared with DL can be explained by the easy ETT introduction once the glottis is identified. The need of a second operator for performing the CLBI technique should not be seen as a limitation to its implementation. Indeed, the first operator introduces a laryngoscope, which is just to be held in place by a second person (no need for airway training). Several guidelines suggest to ask for help after failed laryngoscopy (10) and the availability of another airway-trained operator is not a limitation, even for the 'active' approach, where the first operator performs laryngoscopy and leaves to the other operator the FOB manipulation.

Our results should be considered promising considering that anaesthesiologists were naïve to both rescue techniques, and they should encourage further research. We see four keypoints before introducing CLBI in clinical practice: 1) There is need for larger studies possibly replicating ours in a larger scale; 2) prompt availability of FOB could be an issue in some institutions, but it represents a recommended standard in the operating room, and the availability of FOB may be cost-effective as compared with other expensive devices; 3) it is important to change the anaesthesiologist's mindset in case of unanticipated DTI, avoiding repeated DL attempts before switching to the CLBI technique, to minimise secretions/blood; and 4) it is pivotal to break cultural barriers related to the confidence with FOB, especially during difficult scenarios. Even if an FOB is readily available and ventilation is easy, not all anaesthesiologists may feel confident when manoeuvring an FOB during an unanticipated DTI. This problem can be gradually resolved only by acquiring confidence with the FOB at an early stage of training, under supervision and in non-difficult scenarios.

We can envisage that in the future FOB will be gradually seen as a basic skill for the anaesthesiologist's airway curricula. With this regard, in our exploratory analysis, dividing the anaesthesiologists in two groups according to the time from completion of their specialty training, we found that younger anaesthesiologists had a significantly higher success rate at the first attempt with the CLBI approach, and they favour CLBI over VLS; such result may be explained by a greater exposure to FOB during training in younger generations. On the other side, senior anaesthesiologists preferred VLS, achieving a better Cormack–Lehane grade than younger colleagues. Their preference may be explained by a better familiarity with the laryngoscope tool rather than with FOB, and possibly by a lower degree of training in FOB in the past generations of anaesthesiologists. Nonetheless, we do not feel appropriate to over-interpret such results since sub-group analyses are by definition exploratory and should be interpreted cautiously, also due to a reduced sample size. It is advisable that larger studies addressing the potential usefulness of the CLBI approach should perform such sub-group analyses according to the experience of anaesthesiologists, in order to verify if younger generations of anaesthesiologists have higher attitude in manoeuvring the FOB.

Anaesthesiologists sought for decades the 'holy grail' in a single airway device, unfortunately facing unacceptable failure rates. The CLBI approach is an inexpensive and safe rescue strategy that deserves to be fully evaluated in simulated and clinical studies, keeping in mind its intrinsic limitations, especially when large volumes of secretions, blood or vomitus fill the upper airways.

Study limitations

This is a single-centre pilot study on a specific DTI simulated scenario, and likely underpowered. The first and most important limitation lays intrinsically in the simulation scenario, where the differences with real difficult airways cannot be fully eliminated. Among these, the presence of secretions and bleeding cannot be reproduced. Moreover, we focused on a limited number of naïve anaesthesiologists, and results may be different in other populations.

Secondly, the 60-second cut-off for declaring a failed attempt was arbitrary, and a longer cut-off time could have increased success rates, especially for the two rescue techniques, because anaesthesiologists less familiar with the use of VLS or FOB may have had a higher success rate with some extra time.

Conclusion

In a DTI manikin scenario, we found that a combined laryngo-bronchoscopy intubation had a higher success rate than DL at the first attempt, while VLS did not. By the third attempt, both rescue techniques had a trend towards a higher success rate than DL. More research is warranted on the use of combined laryngo-bronchoscopy intubation in view of promising preliminary results.

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