

## ORIGINAL CONTRIBUTION

# Maintenance of basic endotracheal intubation skills with direct or video-assisted laryngoscopy: A randomized crossover follow-up study in inexperienced operators

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## Abstract

**Background:** Laryngoscopy is a difficult skill to acquire and maintain and even more so by less frequent users. Numerous studies have compared limitations of direct laryngoscopic (DL) and video-assisted laryngoscopic (VL) techniques for endotracheal intubation in different scenarios, but individual retention over time of intubation skills with either technique has, to our knowledge, never been reported. The primary aim of this study was to evaluate to what extent recently acquired basic skills of endotracheal intubation, based on DL or VL, are being maintained over time by inexperienced operators.

**Methods:** This randomized crossover follow-up study was designed to compare endotracheal intubation with direct (McIntosh blade) versus video-assisted (hyperangulated blade) laryngoscopy by 20 undergraduate medical students in identical manikins three months after brief basic intubation training with no further intubation practice.

**Results:** No significant differences in skills retention were found between DL and VL regarding the time for successful intubation or number of adverse events. However, the first intubation was significantly slower regardless of the technique compared with the last one three months earlier. Furthermore, DL was slower and associated with more incidents of esophageal intubation and dental manipulation than was VL.

**Conclusions:** Although basic intubation skills seem to be similarly well maintained over time regardless of the laryngoscopic technique, endotracheal intubation with VL by inexperienced operators is faster and associated with fewer adverse events than is DL after a three-month period with no further intubation training.

## KEYWORDS

direct laryngoscopy, endotracheal laryngoscopy, intubation, video-assisted

## INTRODUCTION

For healthcare professionals with infrequent clinical practice of endotracheal intubation in emergency settings outside the operating

room, it seems particularly important to primarily use a technique enabling intubation skills to be rapidly achieved and well maintained.

Several studies comparing endotracheal intubation with direct laryngoscopy (DL) or video-assisted laryngoscopy (VL) in various

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kinds of patients and settings have been published in recent years with diverging results. According to a recent meta-analysis,<sup>1</sup> there is no difference in clinical outcome between those techniques, but a recent systematic Cochrane review<sup>2</sup> has reported the use of VL to be associated with better glottic view, less mechanical trauma, and fewer intubation failures, particularly in patients with a difficult airway. Another study has shown higher first-attempt success with VL applied by less experienced operators in general ward settings.<sup>3</sup>

In a recent randomized controlled paired crossover study in operators with no previous experience of laryngoscopy,<sup>4</sup> endotracheal intubation in airway manikins based on VL with a hyperangulated blade was found to be easier to learn and safer to use than based on DL with a McIntosh blade. Intubations based on VL were found to be both faster and associated with fewer adverse events.<sup>4</sup>

However, the ability to maintain basic practical skills of endotracheal intubation are less well understood, and results of studies comparing individual retention of those skills differ.<sup>5,6</sup> The main objective of this randomized paired crossover follow-up study was to evaluate, in airway manikins, to what extent basic skills of endotracheal intubation with DL and with VL are being maintained over a three-month period of time with no further intubation training.

## SUBJECTS AND METHODS

### Study setting

This study was carried out according to institutional guidelines of good clinical practice at the Clinical Research Center, Scania University Hospital and Lund University, Malmö, Sweden, after approval (Dnr 2012/173) of the study design by the regional human research ethics review board, Lund, Sweden.

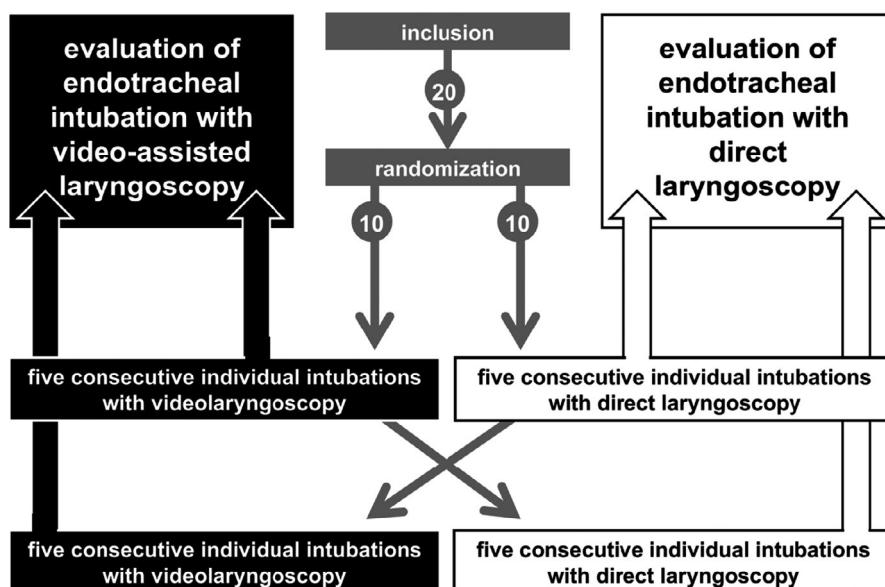
### Study participants

Informed oral and written consent was obtained from 20 volunteer subjects, all of them undergraduate fourth- to seventh-term medical students at Lund University, included in this randomized paired crossover study. The study was undertaken 3 months after completion of another simulation-based randomized paired crossover study,<sup>4</sup> designed to compare to what extent basic skills of endotracheal intubation with DL (McIntosh blade) or VL (hyperangulated blade) are being acquired by users with no previous experience of laryngoscopy. In that study, each participant was briefly guided on either technique by watching structured, similarly recorded, brief instructional films once immediately before independently making ten consecutive attempts at endotracheal intubation with DL and with VL in identical airway manikins. All study participants in this study confirmed that they would refrain from further intubation training until the follow-up evaluation three months later.

### Study design

After having confirmed no further intubation training, each study participant was randomized to carry out five consecutive intubation attempts with DL followed by five attempts with VL or vice versa—neither preceded by formal instructions or advice—in identical airway manikins (RescueAnne, Laerdal AS) positioned supine in identical hospital beds in similar adjacent rooms in the study setting (Figure 1).

Standard 7.0-mm endotracheal tubes, prepared with plastic-covered stylets, were used. Tubes and manikin airways were regularly lubricated according to recommendations by the manikin manufacturer. Macintosh size 3 laryngoscope blades were used in all DL, and hyperangulated adult standard blades (Glidescope, Verathon Medical) in all VL, study interventions.



**FIGURE 1** Schematic view of the randomized paired crossover study design

## Study outcome measures

The primary (time for successful intubation) and secondary (intubation failure, esophageal intubation, dental manipulation) study outcome measures were recorded by a study investigator (EG or ND) according to a structured protocol in each study participant.

The time required for intubation was defined as the time recorded from oral insertion of the laryngoscope blade until verified intrapulmonary inflation of air through the inserted endotracheal tube. Successful intubation was defined as intrapulmonary inflation of air through the endotracheal tube within five mins. Intubation failure was defined as an attempt at intubation exceeding five mins. Esophageal intubation and dental manipulation, indicated by click sounds in the airway manikin, were recorded as adverse events.

To assess and compare individual maintenance of intubation skills between the DL and VL techniques, primary and secondary outcome measures individually recorded at follow-up with DL and VL, respectively, were compared with corresponding measures associated with the five last (of ten in total) individual attempts at intubation before the time interval without intubation training.<sup>4</sup>

## Data analysis

Based on paired crossover study design, a number of 20 evaluable study participants had been calculated to be required for statistical confirmation, with 80% power and 95% probability, of a  $5.0 \pm 7.5$ -second change in individual mean time for successful intubation with VL and with DL, respectively, over this three-month period of no further intubation training.

Their individually calculated mean time for five intubations, and their reorded time for the first one, with DL and VL, together with corresponding numbers of intubation failures and adverse events (esophageal intubation, dental manipulation), were compared with corresponding data obtained from their five last intubations and their last one in our previous study.<sup>4</sup> Corresponding data was also calculated for all participants in the original study to assess to what extent the random sample of participants in the follow-up study could be considered to represent those in the original one.

All study data was recorded in Microsoft Excel spreadsheets (Microsoft Corp.) and analyzed with the Statistical Package for the Social Sciences (SPSS), version 22.0, statistical software (IBM Corp.). Descriptive nonparametric data is reported as median and interquartile range (IQR), and proportions are reported with 95% confidence interval (CI).

Changes in individual mean time for five consecutive intubations with DL and with VL, respectively, were compared with the Wilcoxon signed-rank sum test. Corresponding changes in numbers of failed intubation, esophageal intubation, and dental manipulation were compared with the Fisher exact test, and 95% CI was calculated according to Wilson. Those tests were also used to statistically compare corresponding follow-up data obtained with DL and with

VL. A probability ( $p$ ) level of  $<0.05$  was considered to be statistically significant.

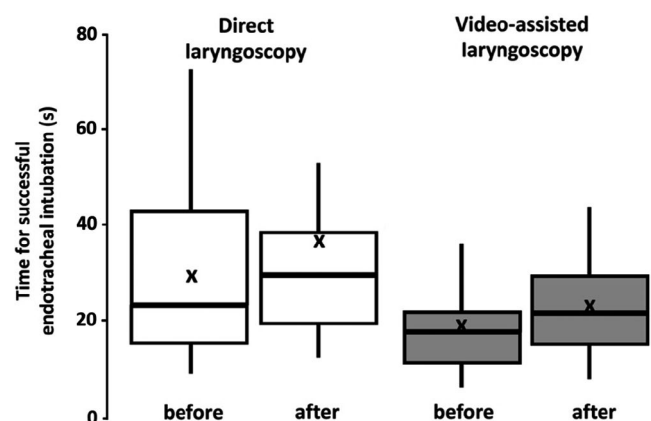
## RESULTS

### Time for intubation

Study data on in total 100 follow-up intubations with DL and 100 follow-up intubations with VL was obtained within a single-week study period in 20 (eight female) subjects aged  $23 \pm 2$  years. The individual mean time for five successful intubations increased nonsignificantly from 27 (IQR = 19–45) to 33 (IQR = 23–40) seconds with DL ( $p > 0.300$ ) and from 21 (IQR = 15–25) to 24 (IQR = 19–32) seconds with VL ( $p = 0.152$ ) compared with before the nontraining period (Figure 2). However, the mean time for five follow-up intubations was significantly ( $p = 0.023$ ) longer with DL than with VL despite no corresponding difference ( $p > 0.300$ ) before that period.

The corresponding median (IQR) time required for successful first-attempt intubation increased significantly with both techniques—from 20 (28–16) to 33 (58–28) s with DL ( $p = 0.0024$ ), and from 19 (22–15) to 37 (53–30) s with VL ( $p = 0.0008$ ).

In our previous study,<sup>4</sup> there were no differences ( $p > 0.300$ ) in the mean time required for, or the numbers of failed intubation, esophageal intubation, and dental manipulation associated with the last five (of ten) intubations carried out with DL and with VL by all study participants compared with those also participating here.



**FIGURE 2** Time recorded for follow-up intubation with direct laryngoscopy (white) and video-assisted laryngoscopy (gray), undertaken according to a randomized paired crossover study design schedule in identical airway manikins by 20 undergraduate medical students with no previous experience of either technique. Individual mean time values calculated for the last five (of ten) intubations after brief structured instructions were compared with corresponding data for five follow-up intubations carried out three months later with no further training or instructions. Median values are indicated by bold horizontal lines, interquartile ranges by boxes, total ranges by vertical lines, and mean values by crosses

## Adverse events

Although the numbers of esophageal intubation with DL almost doubled after the nontraining period ( $p = 0.136$ ), the numbers of intubation failure, esophageal intubation, and dental manipulation associated with DL and VL did not change significantly (Table 1). Nevertheless, those nine dental manipulations ( $p < 0.001$ ) and 17 esophageal intubations recorded ( $p = 0.003$ ) were all found to have been associated with DL.

## DISCUSSION

### General remarks

This is the first randomized paired crossover study designed to evaluate to what extent individually acquired basic skills of endotracheal intubation based on DL or VL are being maintained over time. Recently, endotracheal intubation with VL has been reported to have a steeper learning curve than with DL – in agreement with previous findings in residents<sup>7</sup> – and also to be associated with fewer adverse events in the hands of inexperienced operators.<sup>4</sup> In this study, the maintenance of basic intubation skills by some of those operators, found to be representative with respect to their original individual outcome measures, was determined by corresponding reevaluation after a three-month interval with no intubation training.

### Main findings and previous data

Few previous studies have compared different techniques of endotracheal intubation with respect to skills retention. Our main finding of no significant major change in mean time for successful intubation with DL or VL after three months without intubation training is in agreement with longer time for intubation by nonexperts after a six-month period,<sup>5</sup> and with two of three tested videolaryngoscopes after a one-month period,<sup>6</sup> of no further intubation training.

The lack of significant changes in the mean time for intubation with DL and with VL by inexperienced operators after compared with before this nontraining period appears to indicate no considerable difference in individual retention of intubation skills achieved with similarly structured basic intubation training based on DL or VL, although the first follow-up intubation was significantly slower than the last original one regardless of intubation technique.

Other conclusions can, however, be drawn from the numbers of adverse events associated with follow-up intubation based on DL or VL. Our finding that all of them – failed or esophageal intubation together with dental manipulation – were exclusively associated with the use of DL, whereas no single one resulted during VL, might rather be considered to reflect a higher margin of safety with VL for infrequent use by inexperienced operators. Accordingly, better overall proficiency has been reported with VL for clinical intubation by less experienced users.<sup>5</sup> Although the numbers of esophageal intubation and dental manipulation associated with DL or VL before the nontraining period did not differ significantly, they did so afterwards, indicating that some individual abilities to prevent such adverse events were actually lost over time with DL, but not with VL, in agreement with previous clinical findings in less experienced operators.<sup>5</sup> The shorter time for intubation and lack of adverse events with VL might reflect its better glottic view,<sup>8</sup> particularly when also taking the limited experience of the operators into consideration.

### Study design

A major advantage of this randomized paired crossover study design is that results obtained after and before the nontraining period could be statistically evaluated and compared in the same individuals. Another benefit is that the individual teaching of basic skills of endotracheal intubation with DL and VL in the original study<sup>4</sup> had been based on structured and equivalently recorded and provided instructions only.

Furthermore, although airway manikins necessarily do not match humans, and aspects like potential damage to pharyngeal soft tissue cannot be evaluated, their identical airway structures enable

**TABLE 1** Recorded numbers of failed intubation, esophageal intubation, and dental manipulation associated with attempts at endotracheal intubation with direct laryngoscopy and video-assisted laryngoscopy in identical airway manikins by 20 undergraduate medical students with no previous experience of either technique, evaluated with a randomized paired crossover study design

	direct laryngoscopy			video-assisted laryngoscopy		
	Before nontraining period	After nontraining period	p-value	Before nontraining period	After non training period	p-value
Intubation failure	0	1		0	0	
Esophageal intubation	8	17	0.136	2	0	>0.300
Dental manipulation	9	9	> 0.300	5	0	0.060
Attempts at intubation	100	100		100	100	

Note: Study data obtained from the last five (of ten) intubations after brief structured instructions (before) and corresponding study data from five intubations carried out three months later with no further intubation training or instructions (after) is reported. The two-tailed Fisher exact test was used to statistically compare proportions of adverse events with DL or VL after versus before the nontraining period.

comparison of different study interventions to be less influenced by potential confounders. Accordingly, individual basic skills of airway management including endotracheal intubation are considered to be more effectively and safely acquired and maintained in a simulation-based environment.<sup>9</sup>

## LIMITATIONS

Despite being statistically representative of all participants in the previous (original) study,<sup>4</sup> our low number of follow-up study participants might imply higher risk of statistical type 2 error, i.e., lower ability to statistically confirm small actual differences between the study interventions.

Although airway manikins are frequently being used for basic intubation training, their inability to reflect human anatomy in enough detail and their lack of interindividual variability may still limit their applicability for professional intubation training. Generalizability of our main findings is also limited by the fact that a hyperangulated laryngoscope blade is not the default choice for intubation with VL in all emergency settings.

## CONCLUSIONS

In conclusion, this randomized paired crossover study in airway manikins indicates that video-assisted laryngoscopy may have advantages regarding both time and safety for endotracheal intubation by less experienced operators also after a three-month period with no further intubation training or practice. Future studies should be designed to evaluate and define in more detail training requirements to acquire and maintain more optimal professional skills for endotracheal intubation with direct laryngoscopy and with video-assisted laryngoscopy.

## CONFLICTS OF INTEREST

The authors have no potential conflicts of interest to disclose.

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