Tracheal intubation skill retention using a McGRATH[®] MAC video laryngoscope with real-time feedback by faculty in novice first-year residents: A randomized controlled trial

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Research Article

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Abstract

Background

During endotracheal intubation training, only providing verbal guidance to students may result in inadequate recognition of the inner larynx and cause delays in mastering endotracheal intubation. Therefore, we introduced a deliberate practice approach to the education of residents in endotracheal intubation. For this purpose, a video laryngoscope was used to give the residents detailed feedback of the anesthesiology faculty. We hypothesized that if the anesthesiology faculty could provide sufficient and precise feedback of the larynx through the video monitor, the residents' intubation skills would be retained for a more extended period.

Methods

This cluster randomized controlled study enrolled first-year residents who completed a two-month rotation at our department. Each rotation group (2–4 residents) was assigned to the Macintosh laryngoscope (ML) group or the McGrath MAC video laryngoscope (MML) group. Endotracheal intubation skills were evaluated on a simulated mannequin immediately after the rotation, three months later, and six months later. The primary endpoint was the time required for intubation. The secondary endpoint was the percentage of glottic opening (POGO) score.

Results

Forty-six residents participated in this study and were assigned to the ML group (n = 23) or the MML group (n = 23). The time required for intubation was significantly shorter in the MML group than in the ML group. The POGO score did not show any significant differences between the two groups; however, the POGO score of the MML group had a relatively narrower confidence interval than the ML group.

Conclusions

When comparing endotracheal intubation training using the Macintosh laryngoscope and video laryngoscope, the McGrath MAC video laryngoscope shortened the intubation procedure and facilitated long-term skill retention.

Trial registration

Clinical registry and trial number, URL: <https://www.umin.ac.jp>, UMIN000036643 date of registration: 2019/05/03, This study was retrospectively registered.

Background

The Macintosh laryngoscope, a device commonly used for endotracheal intubation education, allows only the operator to visualize the larynx inside directly. For this reason, it is difficult for the anesthesiology

faculty to provide detailed feedback to residents during training. In addition, despite successful intubation, the quality of the intubation process cannot be verified, which further makes it difficult to provide feedback for improvement.

On the other hand, video laryngoscopes allow residents and the anesthesiology faculty to verify real-time images on the video monitor. Many studies have reported that using a video laryngoscope reduced the endotracheal intubation time and improved the view of the larynx.[1–4] However, few studies have investigated the level of endotracheal intubation skill retention when using a video laryngoscope.[5, 6]

We hypothesized that if the anesthesiology faculty could provide sufficient and precise feedback of the larynx through the video monitor, the residents' intubation skills would be retained for a more extended period. To test this hypothesis, we conducted this randomized control trial that compared the endotracheal intubation skill retention of the McGRATH MAC laryngoscope with that of the Macintosh video laryngoscope in first-year residents rotating at the Department of Anesthesiology.

Methods

This study included first-year residents who started a two-month rotation at the Department of Anesthesiology between April 2017 and March 2020. The study received ethical approval for the use of an opt-out methodology for patients. Written informed consent was obtained from the first-year residents before enrolment in this study. This study was approved by the Jikei university ethics committee (approval number, 26–044 (7549))

We conducted a cluster randomized control trial because each group consisted of two to four residents who rotated every two months. Randomization was performed with a balanced randomization schedule and a predefined random number table. Each rotation resident was assigned to either the Macintosh laryngoscope (ML) group or McGRATH® MAC (Covidien Japan Inc., Tokyo, Japan) laryngoscope (MML) group. This study adheres to the applicable Consolidated Standards of Reporting Trial Statement and The Ottawa Statement on the Ethical Design and Conduct of Cluster Randomized Trials.

In the ML group, the larynx could only be viewed by residents during the actual intubation. The residents explained their field of view, and the anesthesiology faculty provided feedback based on the residents' explanations. In the MML group, the residents were encouraged not to look at the video monitor but the larynx under direct vision, while the anesthesiology faculty viewed the monitor and provided timely feedback.

Endotracheal intubation skill retention was investigated immediately after completing the rotation at the Department of Anesthesiology, three months later, and six months later.

To standardize the evaluations, first-year residents performed the intubations on a mannequin rather than a human. We also used an endotracheal intubation device that was not used in both groups during the rotation period.

The high-fidelity simulator SimMan® 3G (Laerdal Medical Japan Co., Ltd., Tokyo, Japan) and the video laryngoscope C-MAC® (KARL STORZ Endoscopy Japan K.K., Tokyo, Japan) were selected for the evaluation of endotracheal intubation skill retention.

SimMan was used for the following reasons: 1) intubation conditions can be standardized while the laryngeal exposure varies during patient intubation, thus influencing the difficulty; and 2) an evaluation environment similar to the actual clinical setting can be created because it is a whole-body manikin with an intricate laryngeal structure. The height of the SimMan head was set at 6 cm, and the neck flexion was set at the same angle as the pillow. The SimMan airway setting was kept at the default status and did not require any adjustments. A 7.5-mm Mallinckrodt™ Hi-Lo tracheal tube (Mallinckrodt Inc., Covidien Japan Inc., Tokyo, Japan) was made to shape and standardized with an intubating stylet following a photograph of the actual size.

C-MAC was used as the intubation device because the C-MAC laryngoscope has a Macintosh-type blade and allows faculty members to verify the field of view on the monitor through a camera attached at the tip of the blade. The monitor is separated from the blade and completely shielded from the view of first-year residents.

The primary outcome was a retention of endotracheal intubation skills evaluated as endotracheal intubation time. The secondary outcome was the percentage of glottic opening (POGO) scale [7] scores over the observation period.

The time required for intubation was defined as when the resident touched SimMan until the tip of the endotracheal tube passed through the glottis. Intubation was considered a failure if the tube was not passed through the glottis within 60 seconds. In cases of failure, data from the second successful intubation were analyzed. In addition, the POGO scale was visually evaluated by faculty members based on the image displayed on the C-MAC monitor.

Statistical Analysis

Sample size calculation was performed using G*Power version 3.1.9.3 for Macintosh (Heinrich-Heine-Universität, Düsseldorf, Germany). The parameters were based on our experience and data from past studies: $\alpha = 0.05$, power of test = 0.8, effect size $f = 0.25$, which is estimated to be moderate, and the absence of correlation among repeated measures (Corr. ≈ 0). Repeated-measures ANOVA was performed for statistical analysis of the primary endpoint.[8, 9] As a result, the calculated sample size was 44 subjects (22 in each group).

The number of dropouts was estimated to be 1 in each group. Moreover, the researchers of this study confirmed the inclusion and exclusion criteria and assignment. Thus, the final sample size was 46 subjects (23 in each group).

Data analysis was conducted using JMP® Pro 13.1.0 for Macintosh (SAS Institute Inc., Cary, NC, USA). The background characteristics of both groups are expressed as medians and interquartile ranges for continuous variables and as numbers and percentages for frequencies. Variables used in primary and secondary analyses are expressed as means, standard deviations, and 95% confidence intervals. A repeated-measures ANOVA was conducted for both primary and secondary analyses. The data were blinded before analysis by a trial statistician.

Results

Forty-six residents participated in this study. With cluster randomization, 23 residents were assigned to either the ML or the MML groups (Fig. 1). There were no dropouts after the randomization. The gender, age, and the number of endotracheal intubation procedures performed during rotation in the anesthesiology department did not differ between the two groups (Table 1).

Table 1
Participants' background characteristics

	Macintosh group	McGRATH MAC group	p-value
Gender (male/female)	16/7	18/5	0.63
Age (SD)	25.6 (1.45)	25.7 (1.20)	0.75
Number of endotracheal intubations (SD)	75.7 (8.92)	78.6 (6.12)	0.16

The time required for intubation was significantly shorter in the MML group than in the ML group at all time points (immediately after completing the rotation the in anesthesiology department, 6.0 sec, p = 0.03; 3 months later, 10.2 sec, p = 0.001; 6 months later, 10.2 sec, p = 0.006) (Table 2).

Table 2
Time required for performing an intubation immediately after training, and three months later and six months later after training

	Number of residents	Mean (95%CI) [sec]	p-value
Immediately after training			
Macintosh	23	28.0 (23.6–32.4)	
McGRATH MAC	23	22.0 (17.1–27.0)	0.0305
Three months later			
Macintosh	23	29.7 (25.1–34.2)	
McGRATH MAC	23	19.5 (15.7–23.3)	0.0014
Six months later			
Macintosh	23	31.6 (26.2–37.1)	
McGRATH MAC	23	21.4 (17.2–25.6)	0.0064

A repeated-measures ANOVA was performed to confirm whether the individual's ability to perform the intubation was retained over time, demonstrating that the intubation time was significantly shorter in the MML group than in the ML group ($p = 0.002$) (Fig. 2).

Intubation was re-attempted by three residents in the ML group and one resident in the MML group immediately after completing the rotation in anesthesiology and two residents in the ML group three months later. There were no re-attempts at the six-month time point.

The POGO is a scale used for assessing airway visualization during tracheal intubation and represents the glottis opening, ranging from 0–100%. A higher percentage indicates that the operator can observe more vocal cords. The mean values of the POGO scale were not significantly different between the two groups at any time point ($p = 0.51$). However, the confidence interval was narrower, and the values tended to be higher in the MML group (Fig. 3).

Discussion

This study demonstrated that endotracheal intubation training using a McGRATH MAC video laryngoscope shortened the endotracheal intubation time and facilitated long-term skill retention compared with the traditional Macintosh laryngoscope. Maharaj et al. reported that the endotracheal intubation skill of novice medical students deteriorated more when using an Airtraq laryngoscope on a mannequin compared with the Macintosh laryngoscope.[6] Another study examined the endotracheal intubation skill retention of novice medical students using video laryngoscopes after simulation training on a mannequin. They reported that there was no significant difference in the median intubation time at the end of the initial training between video laryngoscopy and Macintosh laryngoscopy; however, the

median intubation time after one month was longer when using a video laryngoscope compared with Macintosh laryngoscope.[5] These studies examined endotracheal skill retention on a mannequin after simulation training.[5, 6] However, our study examined the endotracheal skill retention of novice residents who completed a 2-month anesthesiology department rotation in contrast to the previous studies. In addition, endotracheal skill retention was assessed on a mannequin over six months. Therefore, the more extended training period in an actual clinical setting rather than training on a mannequin possibly contributed to improved endotracheal skill acquisition and retention observed in our study.

Endotracheal intubation is an essential technique in life-threatening situations. Physicians are required to maintain this skill despite only performing it occasionally. We, therefore, aimed for novice first-year residents to master this skill using deliberate practice. The process of deliberate practice requires focused repetitive practice and receiving informative feedback.[10] A prior study in novice medical students demonstrated that the minimal number of encounters required to achieve a 90% success rate under the supervision of attending anesthesiologists was 17.[11] In our study, the residents performed an average of 75 endotracheal intubations during their anesthesiology department rotation. The number of repetitive practices was sufficient for novice residents[12]; however, this number alone may not explain the better skill retention observed in the MML group. In addition, the process of providing feedback during endotracheal intubation contributed to better skill retention. The residents in the MML group received precise feedback from anesthesiologists who constantly monitored the view of the larynx. Receiving feedback with the aid of the viewing monitor enabled residents to identify areas that required further improvement and set goals for improvement. In contrast, the residents in the ML group received feedback based on the view of the larynx envisioned by the anesthesiology faculty based on the residents' explanation, which may lead to residents receiving inadequate feedback and not having a well-defined goal for repetitive practice. We believe that the goal-orientated and informative feedback provided when using a video laryngoscopy resulted in superior skill retention in the MML group, even at six months after completing the rotation.

The extent of the laryngeal opening was also investigated using the POGO scale.[13] However, there was no significant difference in the POGO scale scores between the two groups in this study. Closer examination showed that variations in the POGO scores were lower and tended to be higher in the MML group. In contrast, the variation was considerable, and the score tended to be lower in the ML group. Thus, while a clear difference was not observed, the MML group may maintain a higher degree of laryngeal opening. It has been previously reported that the field of view during laryngeal opening is better in group training with a video laryngoscope.[14]

The endotracheal intubation skill was evaluated based on the intubation time and the POGO score. Even though endotracheal intubation was 10 seconds faster and glottis visualization was better in the MML group, this may not have a clinical impact during life-threatening situations. Evaluating the endotracheal intubation skill was because the skills of beginners may rapidly decline to novice levels based on the deliberate practice concept.[10, 15] We, therefore, believe that mastering and retaining good endotracheal intubation skills are clinically significant in the long run.

Another reason for better skill retention in the MML group may be technical difficulties with MML.[7] Even though the MML group had a monitor screen. The anesthesiology faculty encouraged the residents not to see the monitor but to visualize the larynx directly. Because video laryngoscopes are only used in the anesthesia department at our hospital, residents assigned to the MML group may eventually need to perform the intubation under direct vision with an ML. The shape of the MML blade was strongly bent compared with that of the ML and resulted in an imperfect view of the larynx, and thus increased in the Cormack-Lehane classification grade compared with the ML. Increased difficulty for the direct vision of the larynx with MML may have contributed to further improvement of intubation skills in the MML group.

This study has several limitations. The residents' group assignments were randomized but not blinded to the anesthesiology faculty members. A prior study investigated the residents' emergency endotracheal intubation skill retention, which indicated that residents needed to perform approximately three or supervise approximately five endotracheal intubations per year to maintain procedural proficiency and skill retention.[16] The opportunities for residents to intubate patients at our hospital are limited to anesthesia and emergency department rotations. In most cases, residents rotate to the emergency department immediately after completing their rotation in the anesthesiology department. The residents may have some opportunities for performing intubations after rotation at the anesthesiology department; however, the number of times residents perform endotracheal intubation may vary. The uneven intubation experience after the anesthesiology department rotation may have caused bias and affected endotracheal skill retention.

Conclusions

Intubation training with the McGRATH MAC video laryngoscope in first-year residents shortened the procedure and facilitated long-term skill retention compared with the traditional Macintosh laryngoscope.

Declarations

Ethics approval and consent to participate

This study was approved by the Jikei university ethics committee (approval number, 26-044 (7549)). Written informed consent was obtained from the first-year residents before enrolment in this study.

Consent of publication

Not applicable.

Availability of data and material

The data sets used during the current study are available from the corresponding author on reasonable request.

Competing interests

None.

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Authors' contributions

YY designed the study and wrote the initial draft of the manuscript. SK contributed to analysis and interpretation of data. TT contributed to analysis and interpretation of data. HK contributed to analysis and interpretation of data. TH contributed to the analysis of the results and the writing of the manuscript. YK contributed to data collection and interpretation, and critically reviewed and revised the manuscript. All authors have read and approved the manuscript.

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Abbreviations

ML

Macintosh laryngoscope

MML

McGRATH MAC video laryngoscope

POGO

Percentage of glottic opening

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Figures

Figure 1

Figure 2

Intubation time in ML and MML groups ML: Macintosh laryngoscope, MML: McGrath MAC video laryngoscope Vertical axis: Intubation time (sec) Horizontal axis: Months after completion of training Black line: ML group Dotted line: MML group Error bars: 95% confidence interval MANOVA showed that the intubation time was significantly shorter in the MML group than in the ML group ($p=0.0017$). The t-test also showed that intubation time was significantly shorter at three months and at six months in the MML group (immediately afterward, 6.0 sec ($p=0.0305$); three months later, 10.2 sec ($p=0.0014$); six months later, 10.2 sec ($p=0.0064$)).

Figure 3

POGO scales in ML and MML groups