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Assessment of proficiency in videolaryngoscopic orotracheal intubation with the xlearn® mobile application

AVALIAÇÃO DA PROFICIÊNCIA EM INTUBAÇÃO OROTRAQUEAL COM VIDEOLARINGOSCOPIA UTILIZANDO O APLICATIVO XLEARN®

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Abstract

Introduction. There is no precise definition of how many times a trainee specialist must perform orotracheal intubation via video laryngoscopy (VL) before they can be considered proficient in this procedure. Objective. To compare psychomotor learning curves for acquisition of proficiency in VL-assisted orotracheal intubation between medical students and two groups of physicians (with and without prior experience in conventional laryngoscopy). Materials and Methods. Orotracheal intubation was simulated using a manikin. The VL device consisted of a 3D-printed laryngoscope blade and an endoscope used to transmit the image captured at the blade to a monitor. Participants were divided into three groups according to their expertise: medical students (n=3), physicians with no prior experience of laryngoscopy (n=3), and physicians experienced in performing conventional laryngoscopy (n=3). A mobile application, XLEARN®, was developed and used to construct learning curves. Results. All participants crossed the 5% acceptable failure rate line (h0) before completing 200 intubations. The number of attempts required to achieve proficiency ranged from 43 to 85. Tukey’s test showed a statistically significant difference between medical students and physicians with prior experience. Conclusion. The XLEARN® application is a health education tool that allows continuous follow-up of acquisition and maintenance of the skills, such as orotracheal intubation.

Keywords: learning curve, laryngoscopy, intubation.

Resumo

Introdução. O especialista em formação deverá aprender inúmeras habilidades durante o seu período de profissionalizacão, não havendo a definição exata de quantas vezes ele deve executar uma intubação orotraqueal (IOT) por videolaringoscopia para que seja considerado proficiente quanto à execução da mesma. Objetivo. Analisar as curvas de aprendizagem psicomotora para aquisição de proficiência em IOT por videolaringoscopia entre alunos de graduação, profissionais com e sem experiência prévia em laringoscopia convencional. Material e métodos. O procedimento foi realizado com manequim Laerdel®, em posição olfatória utilizando tubo orotraqueal com diâmetro de 7,0 mm. Utilizou-se um videolaringoscópio que transmite a imagem captada na ponta da lâmina (produzida em impressora 3D) para um monitor. Foram formados, aleatoriamente, 3 grupos: alunos de graduação (n=3), profissionais sem experiência prévia com laringoscopia (n=3) e outro grupo de profissionais com experiência na realização de laringoscopia convencional (n=3). As construções das curvas de aprendizado foram feitas pelo aplicativo XLEARN®. Resultados. Todos voluntários cruzaram a linha de taxa de falha aceitável de 5% (h0) antes de completar as 200 IOT. O número de tentativas necessárias para atingir proficiência variou de 43 até 85. O teste de Tukey demonstrou que houve diferença estatística significativa entre os grupos formados por alunos de graduação e profissionais com experiência previa. Conclusão. O aplicativo XLEARN® é uma ferramenta de educação em saúde que permite realizar seguimento contínuo da aquisição e manutenção das habilidades necessárias a procedimentos importantes, tal como a intubação orotraqueal.

Palavras-chave: curva de aprendizado, laringoscopia e intubação.

1. Introduction

The ability to apply what is learned in school is a cornerstone of training for health professions. Nevertheless, many training programs are still content-based and rely on rote memorization of an ever-increasing volume of information which is ever less relevant to actual professional practice.[1]

To learn is to acquire knowledge, skills, and understanding; it also means to "grasp" intellectually. Until the 20th century, "to learn" meant to commit a fact or skill to memory or habit.[1]

Medical specialists in training are expected to acquire a number of technical and clinical decision-making skills during their period of transition from student to provider.

The learning curve for a given procedure can take a long period of time without achieving the required level of proficiency. But a new movement within health care education has placed increasing emphasis on safety and professional ethics.[2]

These new methodologies are based on practicing new skills and competences in a realistic simulated environment before actually performing them on patients, thus allowing the learner to receive feedback on what they did right and what they did wrong during the activity.[3]

In recent years, there has been a paradigm shift in the teaching of medicine and its specialties. Patients are more aware that medical students are "practicing" on them, while students, in turn, are more aware of their lack of training in certain clinical skills.[3]

Coupled with an increasingly powerful medicolegal system, this paradigm shift has increasingly undermined the acceptability of learning from real patients – which carries the risk of making mistakes that can cause significant harm or even death.[1]

To date, there is no exact definition of how many times a health care worker must perform a certain task to be considered proficient.[4] The number of attempts required to achieve proficiency is highly variable, as it depends on a wide range of conditions, such as anatomic variability, operator skills, patient positioning, and available supplies.

The various procedural skills developed during medical education include endotracheal intubation, fiberoptic bronchoscopy, venipuncture for peripheral venous access, and peripheral insertion of a central catheter (PICC), among others.[4]

There is a growing need to ensure quality in the performance of skills required for medical practice, as these skills have an impact on patient care and on the outcomes obtained by both patients and facilities.[3]

The use of simulators and manikins for medical training is based on the notion of developing a minimum skill level to facilitate care before the learner has actual contact with patients.

Learning curves have proved to be a valuable tool in assessing learning and improving techniques employed during professional training, allowing the process to be course-corrected or halted in case of unacceptable failure.[4] They also allow evaluation of the learner's performance over time, unlike tests and exams, which assess performance at a single time point.

1.1 The importance of orotracheal intubation

In critically ill patients, orotracheal intubation is considered one of the major potentially life-saving procedures. Its main indication is in any situation where the maintenance of airway patency is threatened or impaired.[5]

As in any other procedure, orotracheal intubation carries risks and potential for complications, which can be prevented if proper technique is employed. Possible complications include esophageal intubation, which can lead to hypoxemia, hypercapnia, and death; selective intubation, resulting in atelectasis of the nonventilated lung or barotrauma; trauma to the upper airways, cervical spine, or teeth; and cardiac arrhythmias, among others.[6]

In the emergency department, the most common indications for orotracheal intubation are acute respiratory failure, inadequate oxygenation or ventilation, and to secure the airway in patients with a decreased level of consciousness.[7]

In the trauma patient, intubation is indicated when airway patency cannot be maintained by other means and there is imminent or potential airway compromise (such as after inhalation injury, facial fractures, or retropharyngeal hematoma), inability to maintain adequate oxygenation with supplemental oxygen delivered through a face mask, or in the presence of apnea and a decreased level of consciousness.[7] Further situations necessitating intubation in the emergency setting include patients who are combative due to cerebral hypoperfusion, dependency on assisted ventilation (Glasgow Coma Score [GCS] 8 or lower), sustained seizure activity, and to protect the lower airways from aspiration of blood or vomitus.[7]

In perioperative medicine, intubation is universally required in patients who will undergo general anesthesia, surgery involving the airways or adjacent areas, unconscious patients that require airway protection, surgical procedures involving unusual patient positioning, and for short-term hyperventilation to reduce increased intracranial pressure, as well as to manage copious secretions or intercurrent events such as airway bleeding.[7] Finally, orotracheal intubation is also a routine procedure in the intensive care unit (ICU) and other critical care settings.

The need to perform intubation with the correct technique is evident. For this, it is important to know the intubation techniques, which must follow a rigid protocol and cover all stages5.

It is thus evident that intubation must be performed correctly. To do so, the operator must be familiar with the various intubation techniques, follow strict protocol, and cover all steps of the procedure.[5]

1.2 Simulation in healthcare and the cumulative sum control chart

The first uses of simulation were recorded in the military. With the advent of the aviation and nuclear industries, simulation was soon incorporated into these as well, as a way of developing high-fidelity models to replace real-world training, which in these fields is highly expensive and unsafe.[3]

In medicine, the first instances of simulation date back to the use of cadavers for the study and practice of dissection, with a focus on anatomy. Modern medical simulation can be traced to three major events. The first was when toymaker Åsmund Laerdal joined forces with physicians Peter Safar and Bjorn Lind in 1960 to create “Resusci-Anne”, a half-body manikin simulator that revolutionized cardiopulmonary resuscitation (CPR) training by its low cost and positive impact on training. The second was the development of sophisticated simulators capable of reproducing aspects of patient physiology with high fidelity.[3]

Abrahamson and Denson’s “Sim-One” was the first such simulator to be developed, in 1966. A whole-body manikin, Sim-One could breathe, open and close his mouth, had a synchronized heartbeat and pulse, simulated blood pressure, and responded to four intravenous drugs and two medicinal gases (oxygen and nitrous oxide), which could be administered through a mask.[3]

Advanced airway management techniques will continue to evolve, and video laryngoscopy is being used with increasing frequency in management of the difficult airways and as a rescue technique after unsuccessful intubation attempts.[8] The challenge is to effectively educate new generations in the safe and proper use of this technique. This should include competent trainers who have sufficient access to devices to maintain their skills and educate others.[8]

Training should be done in stages that progressively increase the level of difficulty, first encompassing basic skills so the learner can understand the tools used during the procedure and only later the procedure itself, according to its level of complexity. In this context, simulation is an educational tool with great potential, providing practice in a controlled environment free from the pressures of actual patient care, which improves the training of basic skills that can then be transferred to real-world practice.[2]

The cumulative sum (CUSUM) control chart is one of the statistical techniques known as sequential analysis (discussed further below) that allows one to ascertain whether the quality of a production process is "under control" (producing items within a defined quality limit) or "out of control" and, based on a predefined rule, take corrective action if needed.[4]

The advent of mathematical models for quality control in the biomedical field was driven by the successful application of these models in industrial manufacturing. In medicine, CUSUM analysis has proven to be an objective and effective adjunct to the learning process and tool to monitor operator performance in procedures such as endoscopy, colonoscopy, ultrasound-guided biopsy, surgical and anesthetic procedures, and laboratory testing, among others.[4]

2. Material and methods

2.1 Setting and timeframe

The present study was carried out at Hospital Federal Cardoso Fontes, Rio de Janeiro, Brazil, from August to October 2021. The study protocol was approved by the institutional research ethics committee (certificate of submission for ethical approval no. 45093121.2.0000.8066, opinion no. 4.763.179).

2.2 Preliminary considerations

Before starting the simulation scenario, each participant met with the principal investigator, was introduced to the proposed training and research activities, received a data collection form, and was briefed on the anonymous nature of study records.

The principal investigator also provided additional information, such as the defined failure and success criteria for the procedure; answered any questions; and provided common examples of hits and misses in orotracheal intubation, so that participants might have a clearer understanding of the significance of each criterion.

For the purposes of this study, orotracheal intubation in 45 seconds or less, confirmed by visualization of the endotracheal tube in the trachea of the manikin and inflation of the lungs through manual ventilation with a bag-valve apparatus, was considered a successful attempt (“hit”), while a time to intubation >45 seconds and/or inability to intubate was considered a failed attempt (“miss”).

2.3 Material used for the simulation

2.3.1 Video laryngoscope

A low-cost video laryngoscope (Figure 1) was manufactured in-house by 3D printing a freely available file (the AirAngel blade, <http://airangelblade.org>). The device is designed to transmit the image captured at the tip of the blade to an external display, which may be a mobile phone, tablet, or computer.

The design of the device provides a clear view of the larynx (Figure 1) and can thus be a useful alternative to conventional laryngoscopy when the operator is confronted with an anticipated or unanticipated difficult airway.

Figure 1. Video laryngoscope system used in the study and a representative image captured by the device.

Source: Own work.

2.3.2 Manikin

The manikin used in this study (Laerdel®) reproduces several body segments and organs (head, neck, larynx, trachea, lungs, and stomach). This model can be used to acquire technical and psychomotor skills for procedures including orotracheal and nasotracheal intubation, supraglottic airway placement, and noninvasive facemask ventilation. For the purposes of this study, the head of the manikin was placed in the sniffing position and a 7.0 orotracheal tube was used. Proper tube placement is signaled by a green light on the manikin control panel and confirmed visually by lung inflation once the bag-valve resuscitator has been coupled to the tube.

2.4 Study participants

The study sample comprised three first-year anesthesiology residents, three medical students, and three anesthesiologists with more than 2 years' experience in clinical practice but not yet proficient in video laryngoscopy. All participants were volunteers, selected from the house staff or residency program of Hospital Federal Cardoso Fontes. All were briefed on the purpose of the study and gave their informed consent to participate.

2.5 Simulation dynamics

The simulation was composed of three sections: prebriefing, scenario, and debriefing. Creating a positive space to encourage the active participation of all those involved is essential. It is also important to make clear that the purpose of the process is training, not evaluation.

Before the simulation, participants were sent information on the time, place, and duration of the planned activities, and were forwarded copies of relevant bibliographical references (2, 4, 6). Upon arrival, the participants were introduced to the materials and briefed on their roles; the limitations of the simulation were also explained.

The participants were then given time to present their expectations and ask any questions. Only then was written informed consent obtained, ensuring the voluntary nature of participation and making it clear that participants would be free to cease their involvement at any time.

All volunteers were told that, during the scenario itself, they would be allowed to call for help or use a provided bougie to assist in intubation.

2.5.1 Prebriefing

During this stage, the participants were briefed on the dynamics of the scenario to follow. They were shown how to interact with the Laerdel® manikin and instructed on the significance of the different alarms triggered by a correct (orotracheal) intubation and a failed (esophageal) intubation. Theoretical aspects of airway management and available algorithms were also discussed.

2.5.2 Debriefing

The post-simulation debriefing is the most crucial element of the learning process. It allows participants to reflect on the experience and, through this reflection, draw significant lessons from the scenario.

2.6 The XLEARN® application

The XLEARN® mobile application was developed to perform all data analysis and CUSUM curve construction for this study. It is based on a statistical method that considers the acceptable error rate and the unacceptable error rate to define the point at which each user acquired proficiency.

XLEARN® was designed using the model–view–viewmodel (MVVM) approach. It was written in C#, using the Xamarin open-source framework installed in Microsoft Visual Studio® 2019 on Windows 10. NHibernate® was used for data retrieval from an SQLite® database, while UI components were obtained from Syncfusion®. A beta version of the application was developed in 2021 and made available (for Android only) on the Google Play Store.

2.7 The CUSUM chart

As noted above, the CUSUM chart is one of several statistical techniques known as sequential analysis, a framework developed to evaluate whether the quality of a production process is "under control" (i.e., producing items within a defined quality limit) or "out of control" and allowing the process to be corrected, stopped, and restarted as needed.[4]

To construct a CUSUM chart, one must define four parameters: the type 1 (alpha) error rate, the type 2 (beta) error rate, and the acceptable and unacceptable failure rates for the procedure, usually defined according to whichever quality standard exists in the literature.

For the purposes of this study, the acceptable failure rate (p0) for orotracheal intubation was set at 5%, while the unacceptable failure rate (p1) was 10%. The type 1 (alpha) and 2 (beta) error probabilities were both defined as 0.1. Once set, these parameters yield three values: line *h0*, line *h1*, and number *s*.

A point above *h1* means that the failure rate was unacceptable, while a point below *h0* means that proficiency has been achieved; between the two horizontal lines lies the "gray area". The values calculated for *s* (each increment of success) and *1-s* (each increment of failure) determine the slope of the curve (downward and upward, respectively).

A participant whose curve crosses line *h1* is performing at an unacceptable failure rate and requires reevaluation. Conversely, once line *h0* is crossed, the participant has become proficient in the technique or procedure.

The results of the aforementioned calculations are displayed on a single screen of the mobile application.

2.8 Statistical analysis

Analysis of variance (ANOVA) with Tukey's post-test as needed was performed to compare the average number of successful and failed attempts between the participants. This analysis was performed in the PAST® software environment, version 4.03 (http://past.en.lo4d.com/download).

Analysis of variance is appropriated when Y is a numeric variable and X is a categorical variable. In the present study, Y is the number of attempts needed to achieve proficiency, while X corresponds to the group of participants (medical students, residents, or anesthesiologists).

PAST® detects if any significant difference exists between groups, but is unable to demonstrate between which groups this difference is significant; therefore, if PAST® analysis yields a statistically significant result, one must then apply Tukey's post-test to ascertain exactly between which groups this difference exists.

3. Results

Each volunteer performed 200 attempts at orotracheal intubation, for a total of 1800 trials on the Laerdal® manikin. CUSUM charts were then plotted for each of the participants using these data points. According to the literature,[4] the number of trials (sample size) needed to achieve an acceptable failure rate of 5% would be 105.

The data used to construct the CUSUM charts are shown in table 1.

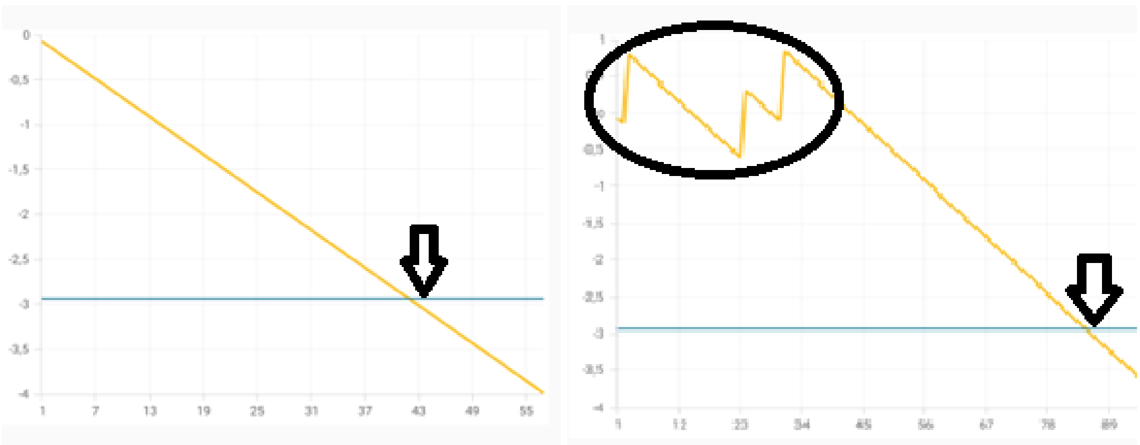
Table 1. Number of attempts needed to acquire proficiency and total number of failures (out of 200 attempts) by each participant.

	Number of attempts needed to acquire proficiency	**Number of failures (out of 200 attempts)**
Anesthesiologist 1 (A1)	43	0
Anesthesiologist 2 (A2)	57	1

Anesthesiologist 3 (A3)	43	0
Resident 1 (R1)	71	2
Resident 2 (R2)	43	0
Resident 3 (R3)	57	1
Student 1 (S1)	71	2
Student 2 (S2)	85	3
Student 3 (S3)	71	2

Most failures occurred on the first day of training. All nine volunteers crossed the 5% acceptable failure rate line (*h0*) before completing 200 intubations. Two anesthesiologists (A1 and A3) and one resident (R2) reached the proficiency range after 43 intubations; one anesthesiologist (A2) and one resident (R3), after 57 trials; one resident (R1) and two medical students (S1 and S3) after 71 attempts; and one student (S2) only achieved proficiency after 85 trials. All volunteers displayed constant performance after reaching proficiency (Figures 2, 3, and 4).

Figure 2. CUSUM charts for volunteers A1 and S2.



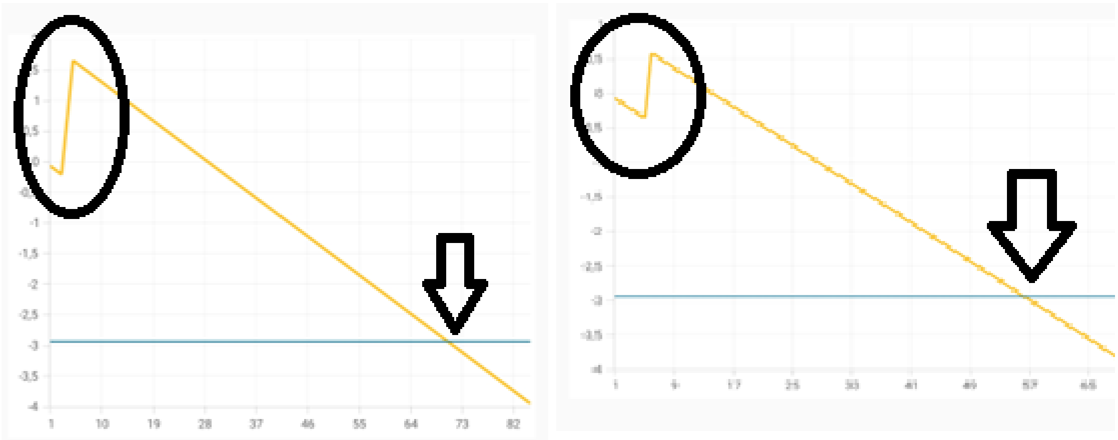
A1
Number of attempts: 200
Failures: 0
Proficiency achieved at: 43

S2
Number of attempts: 200
Failures: 3
Proficiency achieved at: 85

Source: XLEARN® application.

Note that volunteer A1 had no failed attempts and reached proficiency on trial 43. Volunteers R2 and A3 also had no failures; therefore, their curves were identical to those of volunteer A1. Meanwhile, volunteer S2 experienced three failures; accordingly, the curve shifted upwards with each failed trial. Proficiency was reached on attempt 85.

Figure 3. CUSUM charts for volunteers R1 and A2.

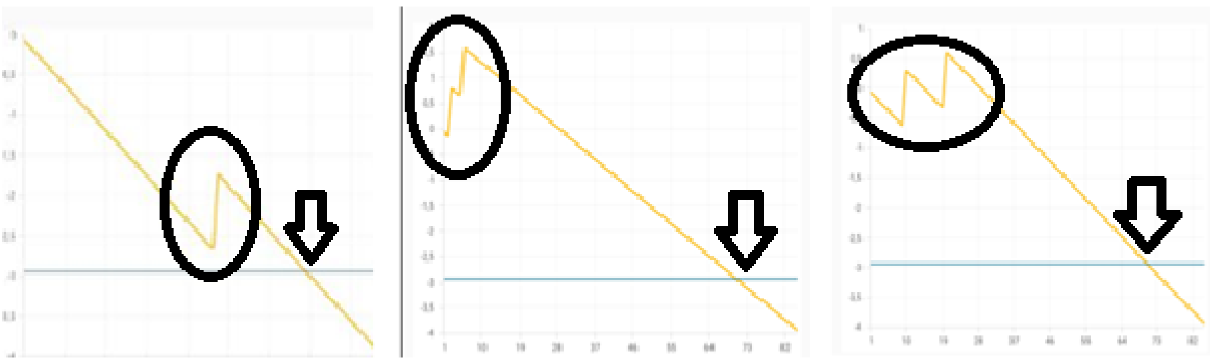


R1	A2
Number of attempts: 200	Number of attempts: 200
Failures: 2	Failures: 1
Proficiency achieved at: 71	Proficiency achieved at: 57

Source: XLEARN® application.

Volunteer R1 experienced two failures during training. Therefore, the curve was shifted “one step” up with each failure; however, as he failed on two consecutive attempts (trials 4 and 5), the curve shows only a single step with twice the amplitude. Proficiency was reached on trial 71. Meanwhile, volunteer A2 experienced only one failed attempt, so the curve was shifted only once, by a single increment. Proficiency was achieved on attempt 57.

Figure 4. CUSUM charts for volunteers R3, S1, and S3.



R3	S1	S3
Number of attempts: 200	Number of attempts: 200	Number of attempts: 200
Failures: 1	Failures: 2	Failures: 2
Proficiency achieved at: 57	Proficiency achieved at: 71	Proficiency achieved at: 71

Source: XLEARN® application.

Note that volunteer R3 experienced only one failure during training: on trial 39, the curve slopes one step upward, and then crosses the *h0* line on trial 57. Volunteer S1 experienced two failures during training and achieved proficiency on attempt 71. Volunteer S3 also had two failed attempts during training (trials 10 and 20), achieving proficiency on attempt 71.

There were few failures during the first 10 intubations, and no failures at all after the 39th attempt. This provides corroborating evidence of the ease of use of the video laryngoscope, as all volunteers achieved proficiency before the maximum number of attempts allowed.

The results of ANOVA showed no significant within-group differences, i.e., between members of the same group (Table 1).

Table 1. Analysis of variance.

One-way ANOVA | Residuals | Tukey's pairwise | Kruskal-Wallis | Mann-Whitney pairwise | Dunn's post hoc

Test for equal means

	Sum of sqrs	df	Mean square	*F*	*p* (same)
Between groups:	1376,89	2	688,444	7,307	0,02466
Within groups:	565,333	6	94,2222		**Permutation *p* (n=99999)**
Total:	1942,22	8			0,03252

Components of variance (only for random effects):

Var(group): 198,074 **Var(error):** 94,2222 **ICC:** 0,677648

***omega*2:** 0,5836

Levene´s test for homogeneity of variance, from means ***p* (same):** 0,4206

Levene´s test, from medians ***p* (same):** 0,5361

Welch *F* test in the case of unequal variances: *F*=13,15, df=3,457, *p*=0,02421

Source: PAST®.

The only significant difference observed was between the group of anesthesiologists and the group of medical students, as confirmed by Tukey's test (p=0.03833) (Table 2).

Table 2. Tukey's post-test.

	Anesthesiologists	Residents	Students
Anesthesiologists	X	0.5508	**0.03833**
Residents	1.549	X	0.1514
Students	4.648	3.098	X

4. Discussion

In 2017, Lewis et al. showed that difficult intubation occurs in 1% to 6% of cases, intubation failure rates range from 0.1% to 0.3%, and both difficult airways and intubation failures are more likely to be encountered in the ICU and emergency department.[7]

In the present study, there were 11 failed intubations out of 1800 attempts evaluated, representing 0.6% of cases. If we consider only the more experienced operators, this rate drops further to 0.16% (one failure out of 600 attempts). Among residents, the failure rate was 0.5% (three failures out of 600), while among medical students, it was 1.1% (seven out of 600).

In 2016, Pieters et al. found an incidence of difficult or unsuccessful orotracheal intubation of approximately 15% in emergency surgery cases, versus up to 9% for elective surgical procedures. In this study, all volunteers attempted intubation on a manikin, used a video laryngoscope, and were not exposed to the stress of a real-life scenario.[9]

According to Quintão et al., video laryngoscopy should preferably be performed with the display separate from the blade so that the operator's face need not be near the patient's airway. The AirAngel blade used in the present study allows the external display to be easily disconnected, making the procedure more ergonomic and safer for the operator.[10]

The INTUBE multicenter international trial found that, for beginners, video laryngoscopes are easier to handle than the standard Macintosh laryngoscope. During the scenario tested in this study, medical students did not experience many difficulties in handling the video laryngoscope, and most of the failures observed were attributable to a difficulty in inserting the tube into the manikin's airway rather than in obtaining a satisfactory view.[11]

Video laryngoscopes provide a wider view of the glottis without the need for "three-axis alignment", avoiding hyperextension of the head and, in practice, allowing more structures to be visualized during laryngoscopy. However, this does not ensure successful intubation; placement of the orotracheal tube may still require additional maneuvers. Nevertheless, as a simple, user-friendly, low-cost tool, the video laryngoscope is extremely useful when approaching the unexpectedly difficult airway.

The variety of circumstances faced in real-world practice make intubation a complex process and highlight some limitations of simulation scenarios. These limitations include variant airway anatomy, conditions which make mask ventilation difficult or impossible, urgent or emergent intubation, and the operator’s previous experience with critical situations while managing the difficult airway.

Coupled with the safety of a simulated environment, the XLEARN® application provides an exact definition of the number of repetitions needed to master this clinical skill. However, it bears stressing that, by changing the variables (type 1 and type 2 error rates, acceptable and unacceptable failure rates) in the application while keeping the same number of successful and failed attempts, the *h0* line will be crossed (denoting proficiency) at different time points.

5. Conclusion

The XLEARN® application was used to construct CUSUM learning curves for all participants, thus allowing us to determine the exact point in time at which they achieved proficiency in performing videolaryngoscopic orotracheal intubation. The ability to quantify failures or “misses” and visualize the exact moment when the operator reaches proficiency on the CUSUM chart significantly contributes to the learning process.

Analysis of variance, performed in the PAST® software environment, detected a significant between-group difference; Tukey’s post-test then identified that this significant difference was between the group of medical students and the group of anesthesiologists.

LEARN® is a valuable health education tool that allows continuous follow-up of the acquisition and maintenance of skills needed for major procedures, such as endotracheal intubation.

No issues or challenges that could disrupt the learning process of orotracheal intubation technique were observed during the course of this study.

6. Final considerations and limitations

Publications on videolaryngoscopy have demonstrated the effectiveness of these optical devices in management of the anticipated difficult airway and in morbidly obese patients, as demonstrated by Hurtado et al.[8]

Analysis of other outcomes has shown significant reductions in laryngeal trauma and lower incidence of postoperative hoarseness when a video laryngoscope was used.[6] Although video laryngoscopes are still often seen as rescue devices, indirect video laryngoscopy has shown these and other advantages over direct laryngoscopy.

The imaging technology of new video laryngoscopy devices offers instructor and learner a shared view of the airway, which should facilitate teaching of airway anatomy. Training and demonstrable acquisition of practical skills in the use of any new equipment or device are essential before starting studies to compare it to a now-standard technique.

The learning of psychomotor components of practical activities should be monitored with special tools that allow assessment of skill acquisition and adjustment to optimal quality standards and Xlearn® mobile is free, easy and must contribute to the assessment of proficiency acquisition.

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