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Respiration and the Airway

RESPIRATION AND THE AIRWAY

Assessment of competency during orotracheal intubation in medical simulation

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Abstract

Background: Clinicians performing orotracheal intubation need to be competent to perform this technical skill safely. It is recognized that aggressive force applied during direct laryngoscopy may damage the oropharyngeal soft tissue; however, force is seldom considered in assessment of competency. The objective of this study was to explore the force applied during orotracheal intubation as a method of further discriminating between levels of competence. We sought evidence of construct validity in the form of discriminant, criterion, and concurrent validity. We hypothesized that the force generated during simulated intubation could serve to discriminate skill level among clinicians.

Methods: A convenience sample of 35 health-care professionals filled a self-reported questionnaire and were then divided into the following three groups: Group 1, experts (n=16); Group 2, intermediates (n=7); and Group 3, novices (n=12). They then intubated a part-task trainer (Laerdal Airway Management Trainer) after reviewing a procedural video and engaging in one practice session. Intubations were recorded. Outcome measures were as follows: (i) force applied to the epiglottis, calculated (in newtons) using two superimposed pressure-sensitive films (Prescale; Fujifilm, Madison, WI, USA) on the laryngoscope blade; (ii) number of attempts required to achieve successful intubation; (iii) time to intubation; and (iv) hand position.

Results: Of the four outcome measures, only force applied during orotracheal intubation was able to discriminate between groups. All data are reported as the mean (SD). There was a significant difference in force between groups during orotracheal intubation [one-way ANOVA; experts, 102 (25) N; intermediates, 134 (28) N; and novices, 153 (43) N], with a significant difference (P<0.05) noted between novice and experts on *post hoc* analysis.

Conclusions: Force exerted during intubation provides meaningful information when attempting to discriminate intubation skill level. Force demonstrated criterion validity and could be used as a measure of competency during training.

Key words: airway; anaesthetic techniques, laryngoscopy; education; equipment, laryngoscope

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Editor's key points

- Pressure-sensitive films placed on the tip of a laryngoscope blade can be used to measure the force applied on a laryngoscope blade during tracheal intubation.
- The force exerted during intubation might serve as an objective and valid measure to discriminate skill level among a group of health-care professionals.

Competency-based education is dependent on assessment to monitor and support trainee progress. In the simulated and clinical environment, checklists are often used to determine whether a practitioner is competent and safe with a technique, such as intubation.[1] A measure is said to have criterion and construct validity if it can readily differentiate the expert from the intermediate and the novice. Measures such as success at intubation, time to intubation, and hand position on the laryngoscope are often included in checklists, but it is not clear if they are valid assessment tools.

It is recognized that aggressive force during successful intubation may cause oropharyngeal trauma and may lead to complications, such as lacerations, sore throat, laryngospasm, and perforation. Although using appropriate force during orotracheal intubation is a patient safety imperative, it is rarely measured and not used to determine competency.

The force applied during tracheal intubation can be measured using sensors, transducers, and special pressure-sensitive films secured to the laryngoscope. The force exerted varies depending on the type of blade,[2–5] patient characteristics,[2 6] and the experience of the operator,[5 7 8] with a tendency for experts to use less force than non-experts. We therefore hypothesized that the force exerted during intubation might serve as an objective and valid measure to discriminate skill level among a group of health-care professionals.

Methods

Volunteers and groups of experience

Over a 2 day period, health-care professionals who participated in a team training workshop at a local Simulation Centre were asked to participate in the present study. A self-report questionnaire (two dichotomous and two contingency questions) exploring profile and skill with orotracheal intubation was administered to participants. Based on these results, we categorized participants based on experience level with intubation, which we categorized as expert, intermediate, or novice. *A priori*, we labelled as 'experts' those who had performed more than 30 intubations on humans per year and had more than 3 years of experience with intubation. We labelled as novices those who had performed fewer than five intubations on humans or had less than 3 months of experience with tracheal intubation. Finally, we labelled as intermediates those excluded from expert and novice groups. All questionnaires were coded and reviewed only after the participants completed the study. One author (A.C.), who categorized the skill level of the participants, was blinded to the study scores. Finally, we asked if the participants had previous experience with intubation manikins, and all had had at least one previous practice session during the course of their training. Nonetheless, all volunteers were allowed to view a procedural training video and had at least one practice session on the Laerdal Airway Management Trainer manikin before data collection.

Experimental set-up

Our outcomes measure included the following: (i) time to intubation; (ii) intubation success; (iii) hand position; and (iv) force applied during intubation. After the practice session, participants were asked to intubate the manikin using direct laryngoscopy. They were allowed to move the bed up or down according to preference and to hyperextend the neck. 'Time to intubation' was recorded by noting the time the blade of the laryngoscope was inserted into the mouth for intubation and stopped once the tool was removed. All data are reported as the mean (SD). Intubation success was also captured by noting first lung inflation and by direct observation of the tube through the cords. Hand position was evaluated by video recording the placement of the hand on the laryngoscope from the right side at a 90° angle to the participant. Hand placement was determined as being primarily on one of three areas of the laryngoscope: the handle, the junction of the handle and the blade, or the blade. Time to intubation and success of intubation were determined by two individuals (A.C. and J.G.). Hand placement was determined by one individual (A.C.); when in doubt, a team of three individuals adjudicated (A.C., J.G., and K.L.).

Force measurement

The force applied by the participant during tracheal intubation was first calculated by measuring pressure with two superimposed pressure-sensitive films (Prescale; Fujifilm, Madison, WI, USA) fixed with adhesive tape on the under surface of a Macintosh no. 4 laryngoscope, as previously described.[2] Force (in newtons) was then calculated using the formula, where pressure is measured by the film and the pressurized area of the film calculated by software (see below). All data are reported as the mean (SD).

As opposed to electronic sensors, these films do not change the shape or the weight of the laryngoscope such that the movement and technique of the participant are not altered. More importantly, these films are commercially available and relatively easy to set up. The pressure-sensitive films had the same area (15 mm^2×40 mm^2), and care was taken to have the film surpass the tip of the blade by 2 mm so that pressure exerted on the very tip of the blade could be recorded at the blade tip.

In a pilot project,[9 10] we had limited our experimentation with one range by using only an ultra-super low-pressure film (known as LLLW). The film saturated at 0.6 MPa, and higher force magnitude could not be measured. In this study, therefore, we applied (by superimposing one over the other) two films with different sensitivity ranges; the ultra-super low-pressure (LLLW, 0.2–0.6 MPa) and the super low-pressure film (LLW, 0.5–2.5 MPa). This allowed us to increase the range of pressure and force measured during the intubation. In this manner, the pressure from 0.2 to 2.5 MPa could be measured and recorded. Each sensor consists of two layers secured together: a micro-encapsulated red colour-forming layer (A) and a colour-developing layer (C). The colour-developing layer shows red tint densities that were then analysed by a pressure distribution mapping system (FPD-8010E; Fujifilm), and forces were calculated by measuring the surface areas via the software. The forces determined from each sensor were averaged. To cut the film to the desired dimensions and to avoid broken microcapsules in manipulating (A), a laser (Samourai UV Laser Marking System; DPSS Laser Inc., Santa Clara, CA, USA) was used. The final assembly is shown in Figure 1.