Video-recorded Endotracheal Intubations

An Educational Tool in Airway Management Training for Pulmonary and Critical Care Fellows

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ABSTRACT

Background: Expert airway management is an essential skill for pulmonary and critical care fellows. Providing high-quality real-time feedback to trainees performing emergent intubations is often limited because of the acuity of the situation and the lack of full airway visualization by the supervising provider.

Objective: We sought to improve the quality of airway management education in a pulmonary and critical care fellowship training program by recording all emergent intubations and systematically reviewing select videos at a regularly scheduled airway management conference.

Methods: We introduced several modifications to our airway training curriculum, including the recording of all fellow-performed emergent tracheal intubations along with a regularly scheduled conference in which selected videos recordings were systematically reviewed. Surveys completed by trainees before and after the redesign of the curriculum were used to determine the efficacy of the individual curriculum modifications. Paired Student's t tests, χ^2 tests, and Kruskal-Wallis tests were used for statistical analysis. A P value lower than 0.05 was considered significant in all analyses.

Results: After completion of the redesigned curriculum, trainees (100% response rate) demonstrated improved technical knowledge ($P < 0.04$) and procedural confidence ($P < 0.04$) with regard to airway management. Of the modifications incorporated into

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The video can be viewed in the online version of this article.

This article has a related editorial.

This article has a data supplement, which is accessible at the Supplements tab.

the curriculum redesign, fellows ranked the video-recorded intubation review conference as the most beneficial ($P = 0.001$) of the educational interventions.

Conclusion: Recording of trainee-performed intubations and subsequent review of these videos using a standardized rubric was a highly valued modification to our fellowship airway training curriculum.

Keywords:
airway; critical care; education; laryngoscopy; video laryngoscopy

For pulmonary and critical care medicine (PCCM) fellowship trainees, competency in emergent airway management is a fundamental skill required by the Accreditation Council for Graduate Medical Education and future employers (1). Despite the importance of this skill, training methods employed by academic institutions are highly variable, with faculty members and fellows reporting numerous challenges to achieving procedural competency (2, 3). The low frequency and high-risk nature of emergent intubations may limit the number of opportunities a trainee has to perform this procedure. Indeed, most PCCM trainees report performing 20–50 endotracheal intubations during their fellowship, yet studies estimate the number of intubations needed to achieve laryngoscopy proficiency exceeds 50 (4, 5). Considering the limited and unpredictable number of emergent intubations available for fellows to perform, we sought to improve the quality of the learning experience associated with each intubation, specifically by providing enhanced feedback through review of automated video recordings. High-quality feedback is a well-established and integral part of the framework for medical procedural teaching (6). Unfortunately, providing real-time airway management commentary is difficult as a result of time constraints inherent to emergent procedures and the limited visualization available to the supervising physician when the trainee is performing direct laryngoscopy. Review of a recording of an airway after the procedure has been completed, on the contrary, allows for the trainer and trainee to have the same visual perspective uninhibited by time constraints.

In nonmedical settings, video feedback to improve performance has been well studied and implemented in a wide range of fields, most notably in amateur and professional sports (7–9). Recent medical education studies have indicated that video feedback improved procedural skill acquisition for laparoscopic procedures among surgical residents (10, 11). In this study, we describe our experience, the perceived learner benefit of a redesigned multimodal airway management curriculum, and a knowledge assessment featuring airway video review conferences in which automated video recordings of trainee-performed intubations were systematically reviewed. We describe automated video recording and review of trainee-performed intubations using a standardized rubric as an innovative and easily adaptable adjunct method for training PCCM fellows in airway management.

METHODS

Revised Airway Curriculum

In addition to the airway video review conference, our revised airway curriculum consisted of the establishment and review of a preintubation checklist, simulation

sessions including cricothyrotomy, and didactic conferences. All intubations were performed in the intensive care unit (ICU) setting using a GlideScope Core video laryngoscope or a Karl Storz C-MAC 8404ZXK system. Both systems accommodated the use of standard geometry or hyperangulated laryngoscope blades and have the capability to record videos automatically upon startup to an internal storage device. Every month, recorded videos were transferred to an encrypted USB drive and subsequently deleted from the video laryngoscopes. Deidentified video-recorded procedures were stored on a secure university Microsoft OneDrive account. The recorded procedures were reviewed by one of the investigators, and those videos that were deemed as having instructional value by all three of the investigators were then shown at regularly scheduled video review conferences. These videos were chosen with the purpose of highlighting the elements of the intubation rubric created by the investigators (Table 1). Examples include videos and still images showing intubations in which the rubric criteria were not met (Figure 1 and Videos 1 and 2) and intubations in which all the rubric criteria were met by the proceduralist (Video 3). We developed an intubation rubric (Table 1) with the goal of providing trainers and trainees with a tool to objectively evaluate the individual steps required to perform a successful intubation. Accordingly, we created this instrument based on expert opinions from the critical care medicine division and the emergency medicine department at our institution. This intubation rubric was used by faculty members and trainees to assess video-recorded intubations at a newly instituted and regularly scheduled airway video review conference. This conference experience largely consisted of the trainees and an investigator reviewing the preselected videos in a step-wise fashion, noting if each component of the rubric was adequately performed.

Surveys and Value Assessment of the New Curriculum

The survey to assess trainee airway management knowledge before and after the implementation of the revised curriculum was initially constructed by one of the investigators following evidence-based approaches (12). The survey was independently pretested by the other two investigators (both trained in critical care medicine, with one also trained in emergency medicine). Subsequently, the three authors convened and reviewed the survey to ensure that questions tested relative and important concepts in airway management and that the language was straightforward and clear. We followed the Checklist for Reporting Results of Internet E-Surveys guidelines for the construction and delivery of both survey tools (13). The survey was optional, restricted to PCCM fellows (years 1–3), and administered before (July 2022) and after (May 2023) the implementation and completion of the revised airway management curriculum. PCCM trainees also completed an optional survey in May 2023 to assess the perceived educational value of each for the elements of the airway management curriculum (rank-order question) and a Likert scale–based question created by the investigators to assess learner impressions of the various curriculum components.

Statistical Methods

Paired Student's t tests and χ^2 tests were used for statistical analysis to compare pre- and posttest knowledge and the procedural confidence survey questions. Comparisons among three or more groups of nonparametric data were performed with the Kruskal-Wallis test.

Table 1. Airway video review rubric

	Adequate	Inadequate
Mouth opening	Correct thumb/middle finger technique, adequate space for blade insertion	Did not use right thumb/middle finger technique, inadequate space for blade insertion
Blade insertion	No difficulty inserting blade, appropriate angle used	Difficulty inserting blade, did not enter from correct angle
Tongue control	Blade advanced easily, tongue kept out of way of view and ETT delivery	Blade catching on tongue, tongue impeding tube delivery
Secretion management	Suctioning adequate to clear secretions and prevent camera smudging	Inadequate suctioning, view impeded, requiring second pass
Anatomy recognition	Uvula, epiglottis, chords identified sequentially	Uvula, epiglottis, chords not identified sequentially
Blade placement/ epiglottic control	Blade in vallecula, engaging hyoepiglottic ligament with good exposure of chords	Blade not in vallecula with poor view or blade too close to chords
Tube delivery/ securement	ETT passed with ease, used ETT rotation/stylet withdrawal techniques	Unable to pass ETT, did not rotate ETT or withdraw rigid stylet, ETT not secured

Definition of abbreviation: ETT = endotracheal tube.

A *P* value lower than 0.05 was considered statistically significant in all analyses. In addition, the trainees were shown video-recorded intubations and were asked to identify specific deficiencies in procedural technique based on the intubation assessment rubric. Finally, trainees were asked a series of questions related to the various curriculum modifications and to ultimately rank the various modifications in order of most to least beneficial.

Ethical Considerations

All survey data were exempt from review by our institutional review board. We approached our risk management department before recording and reviewing tracheal intubations performed in our ICUs, and personnel from that department approved the deidentified storage and review of the videos.

RESULTS

Over an 8-month period (July 2022 through February 2023), 139 intubations were performed by trainees in their first ($n = 8$), second ($n = 7$), or third ($n = 6$) year of fellowship. Based on procedure log data, the fellows each performed an average of 22 tracheal intubation over the course of 12 months (July 2022 through June 2023). Intubations were recorded, and select examples were shown and systematically assessed at three 1-hour airway video review conferences dedicated to airway management education. After completion of the redesigned curriculum, trainees (100% response rate) demonstrated improved technical knowledge ($P < 0.04$) and procedural confidence ($P < 0.04$) with regard to airway management (Figure E1 in the data supplement). Fellows were also able to properly apply
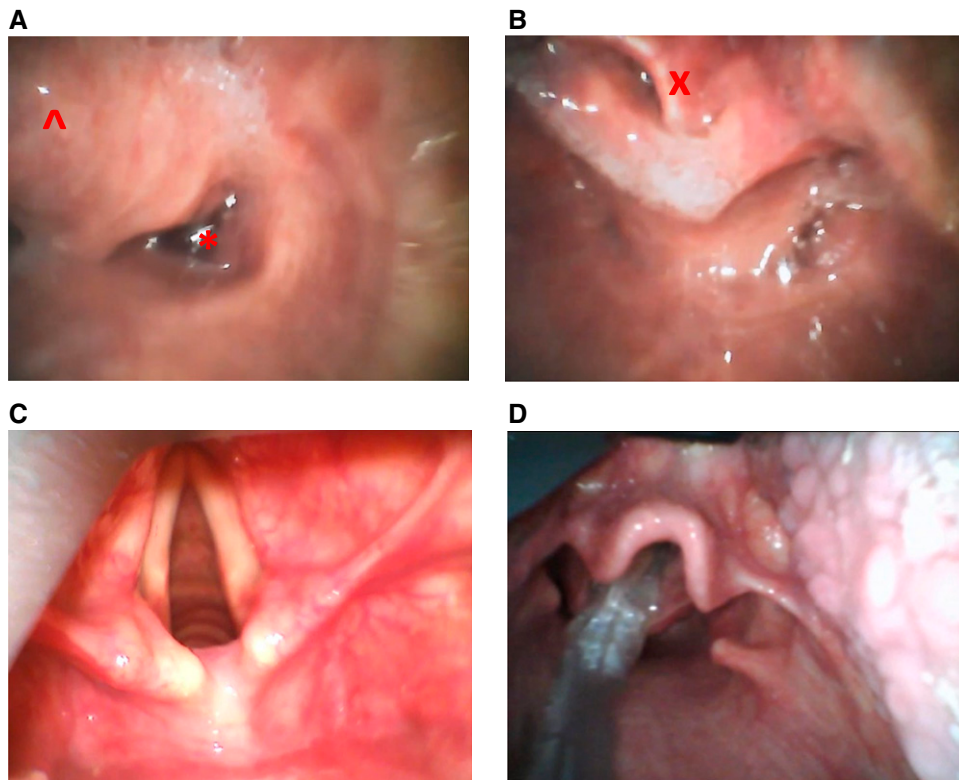
Figure 1. Still-frame images from video-recorded intubations showing inadequate steps per our video review rubric. (*A*) Error in laryngoscope blade insertion: blade insertion is too deep, with the esophagus (*) and right arytenoid visualized (ˆ). (*B*) Error in laryngoscope blade placement and epiglottic control: the blade is pushing the epiglottis (x) into the glottic opening and obstructing the view. (*C*) Error in laryngoscopy blade placement and epiglottic control: the blade tip is placed below the epiglottis, with lifting of the airway anterior, making tube placement more difficult. (*D*) Endotracheal tube delivery error: tube passage is meeting resistance most likely because the tube tip is against an endotracheal ring. Earlier removal of the rigid stylet and rotation of the tube with passage would correct this problem.

the intubation assessment rubric to identify inadequate intubation procedural steps in 74% of cases, compared with 56% before the updated curriculum was implemented ($P = 0.184$). Of the modifications made, trainees ranked the video feedback sessions highest among the components of the revised airway curriculum

Video 1. Video showing intubation not meeting all of the rubric criteria.
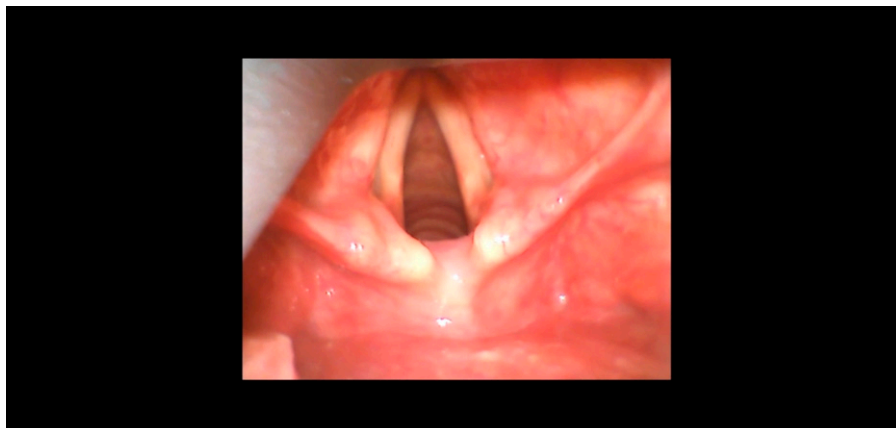
Video 2. A second video showing intubation not meeting all of the rubric criteria.

($P=0.001$; Figure 2). Of note, most trainees further reported that they would have preferred ("agree" or "strongly agree") to review intubations they personally performed rather than anonymized video-recorded intubations at the video review conference or immediately after performing the intubation (Table E1).

DISCUSSION

Here we provide a framework for how to establish an airway video review conference, including a rubric that can be used by the learners to systematically assess the steps required to perform a tracheal intubation. Our data indicate that the airway video review conference was rated by the trainees to be the most beneficial component of our revised airway curriculum. Endotracheal intubation remains one of the highest-risk procedures performed in the ICU, with reported complication rates of >40%, including cardiac arrest occurring during 2.7% of these procedures (14–16). Considering the obvious need for PCCM fellowship graduates to be proficient in performing endotracheal intubations, we believe training programs should adopt modern training methodologies, including recording trainee-performed procedures and providing expert and systematic review of these videos with the learners. Video laryngoscopy has become the
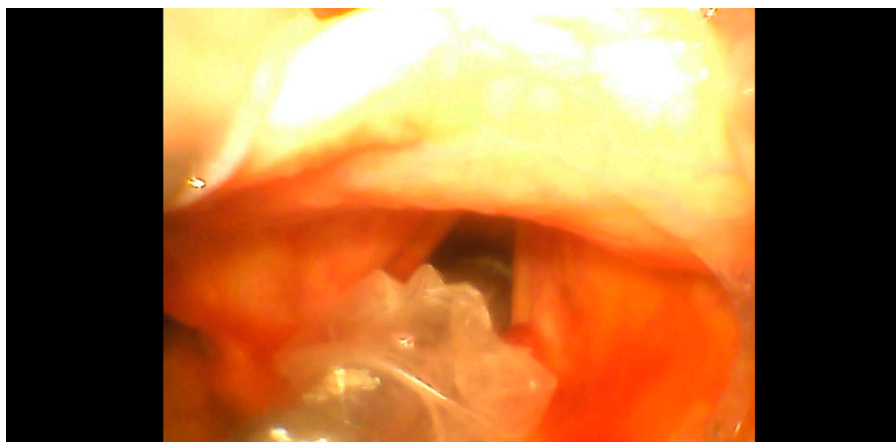
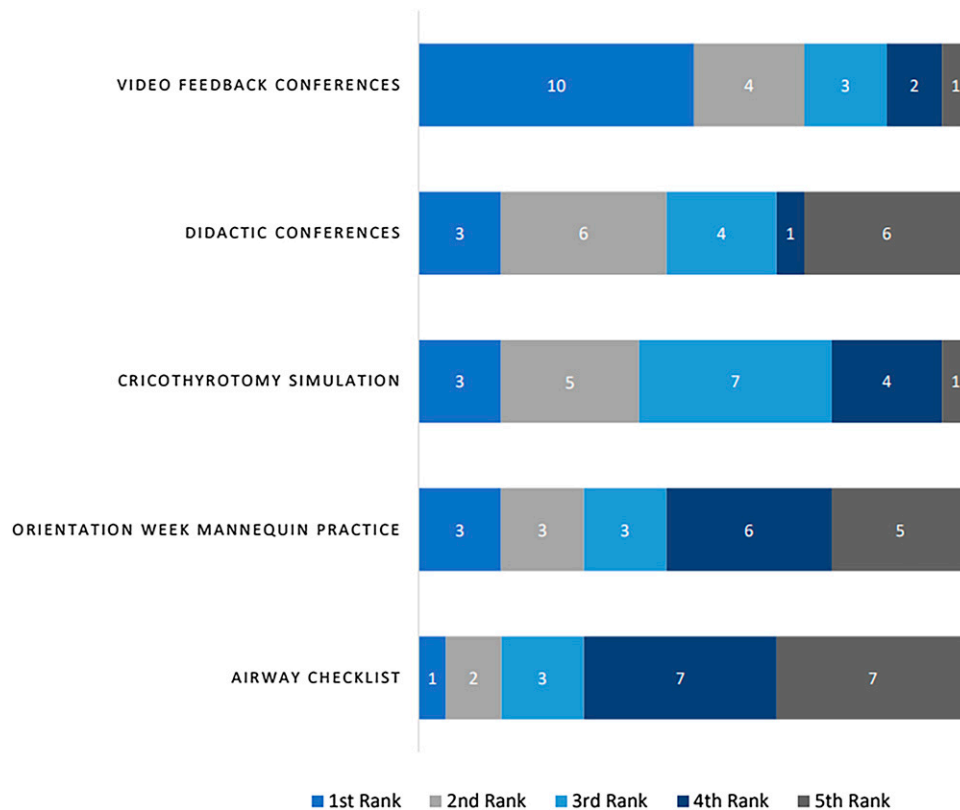**Video 3.** Video showing intubation meeting all of the rubric criteria.

Figure 2. Trainee ranking of the airway management curriculum elements from most to least valuable.

recommended standard for intubation in critically ill patients (17). An added benefit of video laryngoscopy is that most (if not all) systems allow for intubations to be automatically recorded and easily downloaded. Although video review of medical procedures has been adopted by multiple medical specialties, the specific use of videos obtained from video laryngoscopes to educate trainees has not been systematically adopted in the anesthesia, emergency medicine, or critical care medicine fields. Finally, it is important and feasible to obtain approval from risk-management personnel within an institution before instituting this type of initiative.

Although we chose to evaluate anonymous cases in a large group review session, the ideal approach to video review is uncertain. Seventy-five percent of respondents reported that they would rather review their own video-recorded intubations. Although it is possible to review the video recording immediately after a patient undergoes tracheal intubation, this can be challenging, particularly from a time standpoint, because patients often require significant resuscitation in the postintubation phase. Immediate video review also requires that all teaching attending physicians know how to access and replay these videos on the video laryngoscope and are familiar with the rubric to systematically assess video-recorded procedures. Future investigations into the ideal approach and timing of video review are thus indicated to optimize the trainees' educational experience and measure how this intervention affects competency in tracheal intubation.

In addition to reviewing videos of trainee-performed intubations, we created a

simple rubric to assess the series of steps required to successfully intubate a patient. Although this rubric has not been validated, it shares many of the same elements found in a recent publication aimed at defining the "taxonomy" of intubation errors (18). Interestingly, this retrospective study of 100 intubations failed to identify a correlation between the number of errors identified and intubation success, although it noted a trend between the number of performance errors and the total time needed for endotracheal tube placement. Undoubtedly, future studies evaluating the impact of video laryngoscopy review will also need to simultaneously assess the rubric employed to evaluate operator technique.

Surprisingly, we did not detect any differences between the trainees' stage of training and their ability to successfully identify procedural errors using the airway rubric. Admittedly, the small number of fellows we surveyed prevents any firm conclusions from being made; nonetheless, the fact that fellows were similarly adept at evaluating videos of intubations is likely a function of the fact that the fellows have probably performed similar numbers of intubations regardless of the stage of training.

We acknowledge several limitations. We describe a single-center, single–academic year experience with introducing intubation video review into an airway educational curriculum. The improvements in airway knowledge we described may be due in part to increased experience with airway management outside of this educational initiative or due to any of the various components of our revised airway curriculum. We also acknowledge that our study focused on the base of the Kirkpatrick model of training evaluation (i.e., reaction and learning) (19). Future studies should be designed to address the pinnacle of this model and measure how video-recorded airway review impacts fellow procedural competency and patient-centered outcomes. Despite these shortcomings, these preliminary data show that review of trainee-performed intubations in conjunction with a standardized rubric to assess these procedures has the potential to improve fellowship airway management training.

Conclusions

PCCM fellows rated video feedback sessions as being the most beneficial adaptation to our revised airway management curriculum. This educational tool is easily generalizable to other training programs because video laryngoscopy is readily available in nearly all ICUs and most, if not all, of these systems allow for intubations to be automatically recorded and easily downloaded. Whether it would be more educational for trainees to review videos of intubations they specifically performed (possibly immediately after the procedure) is not known. Future investigations should ultimately explore how video review relates to improvement in technical skill in performing tracheal intubation and patient-centered outcomes.

Author disclosures are available with the text of this article at www.atsjournals.org.

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