Training With Video Imaging Improves the Initial Intubation Success Rates of Paramedic Trainees in an Operating Room Setting

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Study objective: Video imaging of intubation as seen by the laryngoscopist has not been a part of traditional instruction methods, and its potential impact on novice intubation success rates has not been evaluated.

Methods: We prospectively tracked the success rates of novice intubators in paramedic classes who were required to watch a 26-minute instructional videotape made with a direct laryngoscopy imaging system (video group). We compared the prospectively obtained intubation success rate of the video group against retrospectively collected data from prior classes of paramedic students (traditional group) in the same training program. All classes received the same didactic airway instruction, same mannequin practice time, same paramedic textbook, and were trained in the same operating room with the same teaching staff.

Results: The traditional group (n=113, total attempts 783) had a mean individual intubation success rate of 46.7% (95% confidence interval 42.2% to 51.3%). The video group (n=36, total attempts 102) had a mean individual intubation success rate of 88.1% (95% confidence interval 79.6% to 96.5%). The difference in mean intubation success rates between the 2 groups was 41.4% (95% confidence interval 31.1% to 50.7%, $P<.0001$). The 2 groups did not differ in respect to age, male sex, or level of education.

Conclusion: An instructional videotape made with the direct laryngoscopy video system significantly improved the initial success rates of novice intubators in an operating room setting.

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INTRODUCTION

Traditional intubation training involves line drawings of anatomic structures and mannequin practice of laryngoscopy. Novice intubators who have received traditional training have low success rates during their initial intubation attempts, whether in the operating room or out-of-hospital setting. Intubation training for basic emergency medical technicians (EMT-Bs) has been criticized because of recent studies that showed EMT-Bs with mannequin-only training achieved out-of-hospital intubation in approximately 50% of laryngoscope insertions.[1-3] Success rates of novices in the operating room range from 35% to 69% in numerous studies that advocate the use of alternative devices, such as the intubating laryngeal mask airway (LMA) or esophageal-tracheal twin-lumen airway device (Combitube; Kendall-Sheridan Catheter Corp, Argyle, NY), over laryngoscopy.[4-7] Even anesthesia residents in the operating room have a mean intubation success rate below 50% with their first 10 patients.[8]

Emergency medical services (EMS) providers, like other nonanesthesia personnel, have been shown to be competent intubators after receiving sufficient experience.[9,10] The "problem" of intubation is not that skill competence cannot be achieved, but rather that the learning curve rises too slowly. In anesthesia trainees, the learning curve of laryngoscopy did not plateau above a 90% success rate until a mean of 57 attempts.[8] This degree of laryngoscopy practice is unavailable to EMS personnel and many other health care workers who are responsible for providing advanced cardiac life support and resuscitation. Skill retention, particularly among those who perform the procedure infrequently, is another educational challenge.

The US Department of Transportation paramedic curriculum requires observation and practice of actual intubations in the operating room.[11] Observation of intubation, before actual hands-on practice, is a standard part of operating room intubation training. During laryngoscopy, however, the larynx is sighted monocularly by both experienced and novice intubators.[12] This degree of visual restriction prevents effective observation over the laryngoscopist's shoulder.

Practicing intubation on the newly deceased, although commonly done in the past, is considered ethically unacceptable without consent.[13-16] Various animal models involving cats, ferrets, and pigs have also not become routine because of ethical and logistic concerns. The effectiveness of these animal models in improving success rates has never been validated.

The combination of inadequate models, the inability to effectively observe, and the lack of imaging makes laryngoscopy a challenging skill to master. In terms of skill acquisition and competence, laryngoscopy is learned through trial and failure. Low initial intubation success rates in operating room training or out-of-hospital settings are detrimental to patient care, trainee confidence, and relationships between trainee programs and physician supervisors.

A camera system that captures images of laryngoscopy as seen by the operator has been used to produce educational videotapes.[17-21] The hypothesis of this study was that training with this type of video imaging of the procedure, in addition to traditional didactic and mannequin instruction, would improve the success rates of paramedic trainees during their initial operating room intubations.

MATERIALS AND METHODS

Four years of intubation training data from the Star Technical Institute of Philadelphia, PA, were retrospectively reviewed. During this time, each paramedic trainee received traditional intubation instruction and subsequently had the opportunity to observe and practice intubation in the operating rooms at Temple University, Philadelphia, PA. Didactic instruction included 42 hours of classroom instruction, as specified by the national standard paramedic curriculum, as well as mannequin practice.[11] Throughout the study period, all classes used the same instructional textbook, *Paramedic Emergency Care* (classes from 1995 and 1996 used the second edition; classes from 1997 to 1999 used the third edition).[22,23] In the operating room, intubation attempts and successes were recorded with the signatures of the supervising anesthesiologists on every laryngoscope insertion.

In the intervention (video) group, data on intubation success were recorded in the same manner but prospectively collected. All intubation attempts occurred in the same operating rooms and were supervised by the same anesthesia department as with the prior 4 years of paramedic students. The intervention (video) group received traditional mannequin practice and didactic instruction but was also required to watch a 26-minute videotape showing 15 actual laryngoscopies as seen by the laryngoscopist (Airway Cam, Airway Cam Technologies, Wayne PA).[19-21] Each trainee watched the videotape a total of 3 times before starting the operating room rotation. Trainee signatures were obtained to verify compliance. The students viewed the videotape in their homes at times convenient for each student, and presumably shortly before the operating room rotations. The supervising anesthesiologists were not told in advance about the study design.

Demographic data on all trainees were collected including age, sex, and years of education.

The Temple University Hospital institutional review board approved paramedic intubation training and documentation of intubation success rates throughout the study period. The study itself, addressing the impact of video imaging on success rates of novice intubators, was approved by the institutional review board of the principal author (RML, Hospital of the University of Pennsylvania).

RESULTS

One hundred thirteen students, comprising 4 years of paramedic classes (1995-1998), received traditional mannequin training. Collectively, this group performed 783 laryngoscope insertions. The mean intubation success rate was 46.7% (95% confidence interval [CI] 42.2% to 51.3%, SD±0.247). The range of laryngoscope insertions per student was from 1 to 15 (mean 6.99, mode 6). In the video group (paramedic classes 1998-1999), 36 students performed 102 laryngoscopies, with a mean individual success rate of 88.1% (95% CI 79.6% to 96.5%, SD±0.259). The range of insertions was from 1 to 10 (mean 2.8, mode 3). Comparing the traditional group with the video group, the difference in success rates was statistically significant ($P \leq .0001$; 46.7% versus 88.1%, difference 41.4%, 95% CI 31.1% to 50.7%).

We also analyzed the performance of subgroups based on the total number of laryngoscopy attempts during their training (Figure). The specific percentages and the size of each subgroup are shown in the Table.

The video and traditional groups did not differ in terms of age (25.0 versus 26.1, P=.48), male sex (65.8% versus 52.6%, P=.147), or level of education (87.5% grade 12 versus 86.8% grade 12, P=.375).

Figure.
Sugroup analysis: intubation success rates categorized by number of intubation attempts per subgroup of trainees, all of whom had the same number of attempts. Video subgroups are marked in solid bars, traditional subgroups in open bars. Note that the number of intubation attempts (x axis, range 1 to 15) refers to total number of laryngoscopic insertions by a given subgroup of trainees, not the total number on any one patient or by one trainee. For example, the video subgroup of trainees who collectively had 3 intubation attempts during their training had a mean individual success rate of 86%. The subgroup of trainees in the traditional group who had 3 attempts had a mean individual success rate of 46%. See the Table for size of each subgroup and specific subgroup percentages.

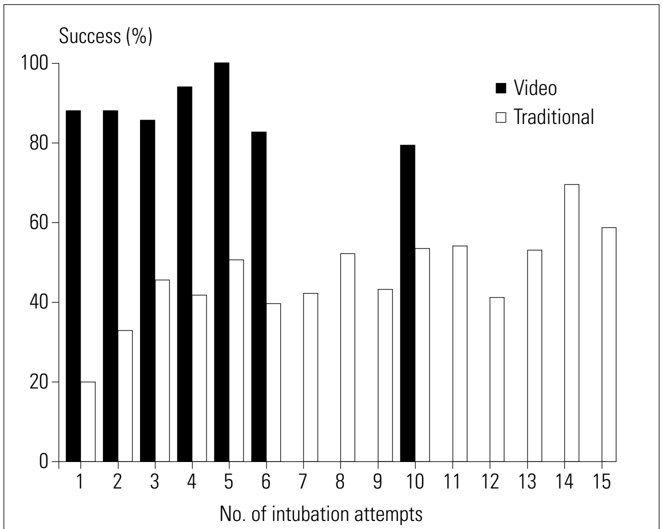

Table.
*Subgroup analysis: success rates in each subgroup, with subgroups listed by total number of intubation attempts.**

Group	No. of Attempts	No. of Trainees	Successful Intubation (%)
Traditional			
	1	5	20
	2	3	33
	3	8	46
	4	6	42
	5	16	51
	6	21	40
	7	2	43
	8	18	53
	9	2	44
	10	21	54
	11	1	55
	12	7	42
	13	1	54
	14	1	71
	15	1	60
Video			
	1	8	88
	2	8	88
	3	12	86
	4	4	94
	5	2	100
	6	1	83
	10	1	80

*The number of trainees within each subgroup is listed in the middle column.

DISCUSSION

Video imaging, unlike mannequins or line drawings, allows novices to observe the appearance of critical landmarks on real patients. Laryngeal anatomy is complex, and successful laryngoscopy depends on recognition of subtle visual cues. On real patients, minor variation in placement of the laryngoscope tip can result in marked differences in the appearance of structures. Repeat practice with an intubation mannequin yields the exact same view of a plastic, idealized larynx. Simple line drawings of anatomic structures also do not correlate with what is seen at laryngoscopy. The distinctness of structures is overemphasized, and a 2-dimensional representation of the larynx causes the structures to appear foreshortened and superimposed. Video imaging, as captured with the direct laryngoscopy video system, allows students to learn the subtleties of intubation before their first laryngoscope insertion.[17-21] The utility of video imaging has been demonstrated in learning other complex psychomotor tasks, including fiberoptic intubation and surgical endoscopy.[24,25]

Compared with actual operating room practice, video imaging for the purpose of learning laryngeal landmarks has distinct advantages. During an actual intubation, the opportunity to visualize the larynx is very limited (ie, 5 to 10 seconds with each intubation). There is no targeted feedback, and the supervisor cannot observe exactly what the trainee is seeing. The logistical issues of EMS personnel obtaining operating room intubation experience are formidable, and include issues with obtaining patient consent, trainee time and scheduling issues, and pressures related to patient care and patient flow. The increasing use of the LMA in the operating room also may be decreasing the total number of intubation training opportunities. The sheer numbers of people who are taught intubation and who could benefit from operating room practice is also logistically overwhelming. In 1998-1999, approximately 515,000 persons were taught how to intubate in advanced cardiac life support and pediatric advanced life support courses.[26]

Video imaging can easily be incorporated into traditional training routines, without the logistical issues of using fresh cadavers or animal models. In our study, the trainees took the tape home and watched it at their convenience. This did not add to didactic instruction time in the classroom, and the scheduling was customized to precede their operating room rotation. We believe that the additional time commitment is not significant given that paramedics rank intubation as among the most important skills in their initial and continuing education.[27]

Our study has several limitations. We used a historical control group, instead of prospectively studying success rates with and without the video training. Numerous other studies, however, have reported similar initial success rates with traditional training.[1,3-8] The groups differed in the mean number of laryngoscope insertions per trainee: 6.99 in the traditional group and 2.8 in the video group. Previous studies have shown increased success rates with increasing experience.[8] Theoretically, the smaller number of intubation attempts per trainee in the video group could have led to a lower success rate, but the video group had a higher success rate despite the lower number of attempts. The difference in the number of laryngoscopy insertions between the 2 groups may be related to several factors: larger class sizes, increased competition for practice cases (with medical students), and decreasing intubation opportunities because of the increased frequency of LMA cases in the last 2 years of the study.

A further limitation of the study could have been biased patient selection by the anesthesiologists. It might be presumed they deliberately selected patients whom the trainees could easily intubate. This selection bias would be expected throughout the study, in both groups, however. The trainees and anesthesiologists throughout the study period, not just in the video group, were aware that trainee performance was being monitored. Patients in the 2 groups were not compared for predictors of difficult laryngoscopy (ie, Mallampati scores, dentition, neck mobility), and it is possible that the 2 groups differed in these variables. We did not compare the involvement of specific faculty members, and it is possible that better supervision or feedback by specific anesthesia faculty contributed to the difference. Although the supervising anesthesiologists were not specifically informed of the study design, they were also not deliberately blinded to the design. Awareness of the study design may have affected patient selection or supervision by the anesthesiologists.

This study did not identify specifically the temporal relationship between watching the videotape and subsequent performance of the procedure. It also does not address issues of skill retention, or longitudinally compare the effect of video imaging against traditional training.

In summary, video imaging markedly increased the initial intubation success rate of paramedic trainees in our operating room setting. It appears to easily complement mannequin training and accelerate the learning curve of intubation. Laryngoscopy is a complicated psychomotor task with inherent visual restrictions and complex anatomy.

Video imaging improves the visual identification of critical structures and permits detailed instruction in the subtleties of the procedure. Further studies are needed to determine whether video imaging will improve the success rates of novice intubators in emergency settings. The utility of video imaging for continuing medical education and skill retention also warrants investigation.

REFERENCES

1. Sayre MR, Sakles JC, Mistler AF, et al. Field trial of endotracheal intubation by basic-EMTs. *Ann Emerg Med.* 1998;31:228-233.

2. Spaite D. Intubation by basic EMTs: lifesaving advance or catastrophic complication? *Ann Emerg Med.* 1998:31:276-277.

3. Bradley JS, Billows GL, Olinger ML, et al. Prehospital oral endotracheal intubation by rural basic emergency medical technicians. *Ann Emerg Med.* 1998;32:26-32.

4. Pennant JH, Walker MB. Comparison of the endotracheal tube and laryngeal mask in airway management by paramedical personnel. *Anesth Analg.* 1992;74:531-534.

5. Bryden DC, Gwinnutt CL. Tracheal intubation via the laryngeal mask airway: a viable alternative to direct laryngoscopy for nursing staff during cardiopulmonary resuscitation. *Resuscitation.* 1998;36:19-22.

6. Davies PR, Tighe SQ, Greenslade GL, et al. Laryngeal mask airway and tracheal tube insertion by unskilled personnel. *Lancet.* 1990;336:977-979.

7. Avidan MS, Harvey A, Chitkara N, et al. The intubating laryngeal mask airway compared with direct laryngoscopy. *Br J Anaesth.* 1999;83:615-617.

8. Konrad C, Schupfer G, Witlisbach M, et al. Learning manual skills in anesthesiology: is there a recommended number of cases for anesthetic procedures? *Anesth Analg.* 1998;86:635-639.

9. Jacobs LM, Berrizbetia LD, Bennet B, et al. Endotracheal intubation in the prehospital phase of emergency medical care. *JAMA.* 1983;250:2175-2177.

10. Stewart RD, Paris PM, Pelton GH, et al. Effect of varied training techniques on field endotracheal intubation success rates. *Ann Emerg Med.* 1984;13:1032-1036.

11. Department of Transportation, National Highway Traffice Safety Administration. *EMT-Paramedic National Standard Curriculum, 1998.* Available at: http://www.nhtsa.dot.gov/people/injury/ems/EMT-P/index.html.

12. Levitan RM, Ochroch AE, Higgins MS. Contrary to popular belief and traditional instruction, the larynx is sighted one eye at a time during direct laryngoscopy [letter]. *Acad Emerg Med.* 1998;5:844-846.

13. Morhaim DK, Heller MB. The practice of teaching endotracheal intubation on recently deceased patients. *J Emerg Med.* 1991;515-518.

14. Orlowski JP. The ethics of using newly dead patients for teaching and practicing intubation techniques. *N Engl J Med.* 1988;319:439-441.

15. Kerns AF. Better to lay it out on the table than to do it behind the curtain: hospitals need to obtain consent before using newly deceased patients to teach resuscitation skills. *J Contemp Health Law Policy.* 1997;13:581-612.

16. Manifold CA, Storrow A, Rodgers K. Patient and family attitudes regarding the practice of procedures on the newly deceased. *Acad Emerg Med.* 1999;6:110-115.

17. Levitan RM. A new tool for teaching and supervising direct laryngoscopy. *Acad Emerg Med.* 1996;3:79-81.

18. Levitan RM. Direct laryngoscopy imaging: teaching and research applications. Educational Synopses in Anesthesiology and Critical Care Medicine (June 1998): *The On-line Anesthesia Journal.* Available at: http://gasnet.med.yale.edu/esia/1998/june/samart.html. [Reprinted in *Am J Anesthesiol,* 1999;26:39-42].

19. Flamik DE. Airway Cam direct laryngoscopic video system, vol. 1 and 2 [media review]. *Ann Emerg Med.* 1999;34:418-419.

20. Bryan JH. Airway Cam video series, vol 1: orotracheal intubation [media review]. *Acad Emerg Med.* 1997;4:130.

21. Doyle J. Video review—orotracheal intubation [Airway Cam Video Series, volume 1]. *Can J Anesth.* 1998;45:288.

22. Bledsoe BE, Porter RB, Shade BR, eds. *Paramedic Emergency Care.* 3rd ed. Upper Saddle River, NJ: Brady; 1999.

23. Bledsoe BE, Porter RB, Shade BR, eds. *Paramedic Emergency Care.* 2nd ed. Upper Saddle River, NJ: Brady; 1994.

24. Smith JE, Fenner SG, King MJ. Teaching fiberoptic nasotracheal intubation with and without closed circuit television. *Br J Anesth.* 1993;71:206-211.

25. Satava RM, Gooden SM. The impact of video endoscopy on surgical training. *Am Surg.* 1989;55:263-266.

26. American Heart Association. Available at: http://www.americanheart.org/Heart_and_Stroke_A_Z_Guide/hpro.html. Accessed November 16, 2000.

27. Pollock MJ, Brown LH, Dunn KA. The perceived importance of paramedic skills and the emphasis they receive during EMS education programs. *Prehosp Emerg Care.* 1997;1:263-268.