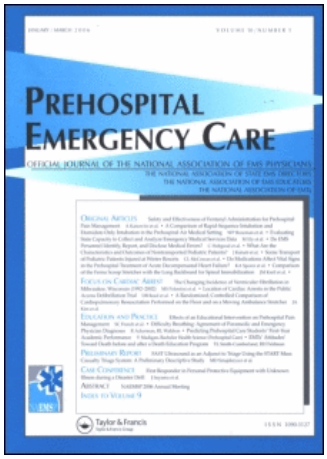
This article was downloaded by:[Canyon County Ambulance Dstr]
[Canyon County Ambulance Dstr]
On: 4 April 2007
Access Details: [subscription number 775648637]
Publisher: Informa Healthcare
Informa Ltd Registered in England and Wales Registered Number: 1072954
Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Prehospital Emergency Care
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713698281

The Effectiveness of a Novel, Algorithm-Based Difficult Airway Curriculum for Air Medical Crews Using Human Patient Simulators

Daniel P. Davis [ab]; Colleen Buono [a]; Janie Ford [b]; Lorien Paulson [c]; William Koenig [b]; Dale Carrison [bd]
[a] UC San Diego, Department of Emergency Medicine.
[b] Mercy Air Medical Services.
[c] UC San Diego School of Medicine.
[d] University Medical Center. Las Vegas, Nevada

To cite this Article: Daniel P. Davis, Colleen Buono, Janie Ford, Lorien Paulson, William Koenig and Dale Carrison , 'The Effectiveness of a Novel, Algorithm-Based Difficult Airway Curriculum for Air Medical Crews Using Human Patient Simulators', Prehospital Emergency Care, 11:1, 72 - 79
To link to this article: DOI: 10.1080/10903120601023370
URL: http://dx.doi.org/10.1080/10903120601023370

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article maybe used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

© Taylor and Francis 2007

Downloaded By: [Canyon County Ambulance Dstr] At: 20:16 4 April 2007

The Effectiveness of a Novel, Algorithm-Based Difficult Airway Curriculum for Air Medical Crews Using Human Patient Simulators

Daniel P. Davis, MD, Colleen Buono, MD, Janie Ford, RN, CFRN, Lorien Paulson, BS, William Koenig, MD, Dale Carrison, MD

Abstract

Introduction. Airway management is one of the most important skills possessed by flight crews. However, few data exist about the efficacy of various educational approaches. Traditional models for airway training, including cadaver labs, operating room exposure, and clinical apprenticeships, are scarce and offer variable educational quality. The objective of this analysis was to evaluate the effectiveness of a simulator-based difficult airway curriculum in a large, aeromedical company. **Methods.** Simulation training was integrated into existing airway training for all crew members; an original difficult airway algorithm was used to guide scenarios. To evaluate its effectiveness, rapid sequence intubation (RSI) success before and after curriculum implementation was determined. In addition, crew members rated their confidence with various aspects of airway management before and after exposure to the airway workshops. **Results.** First attempt and overall ETI success improved from 71.3% and 89.3% before ($n = 261$) to 87.5% and 94.6% after ($n = 504$) implementation of the algorithm and simulation training, whereas the incidence of hypoxic arrests during RSI decreased from 2.7% to 0.2% ($p < 0.01$ for all comparisons). Crew members reported improvements in confidence with regard to all aspects of airway management following participation in the simulation workshops. **Conclusions.** A novel, integrated airway management curriculum using treatment algorithms and simulation appeared to be effective for improving RSI success among air medical crews in this program. **Key words:** airmedical; airway management; difficult airway; rapid sequence intubation; simulation; succinylcholine; training.

PREHOSPITAL EMERGENCY CARE 2007;11:72–79

Introduction

Endotracheal intubation (ETI) has become standard of care in the prehospital environment to provide airway protection, oxygenation, and ventilatory support to critically ill and injured patients.[1,2] Many patients cannot be intubated without the use of neuromuscular blocking agents, leading to the development of rapid sequence intubation (RSI) protocols for air medical crews and select paramedic agencies.[3–7] Reports from various emergency medical service (EMS) systems incorporating RSI into the prehospital scope of practice have documented improvements in ETI success.[6–12] However, recent data suggest that desaturations, hyperventilation, and ETI failure occur with alarming frequency among both paramedics and air medical crews.[13–15] Furthermore, these airway management difficulties appear to adversely affect outcome.[16,17]

Training of prehospital providers appears to be an important factor for successful performance of ETI, with or without the use of neuromuscular blocking agents.[18] Wayne and Friedland document 97% intubation success among a small group of paramedics who undergo intensive initial and ongoing training.[6] This success rate is comparable to that reported for most emergency physicians and is substantially higher than reported by other paramedic agencies.[3,19,20] Unfortunately, training opportunities using human cadavers, large animals, and surgical patients may not be universally available and may be cost prohibitive.[21] In addition, none of these affords optimal training opportunities for difficult airway scenarios.[22,23] This creates a dilemma to provide adequate training for prehospital personnel expected to perform RSI in the prehospital environment.

Human patient simulators have emerged as a potential solution to this problem.[24–27] The current generation can simulate physiological data, including respirations and vital signs, and combine cognitive and technical training.[22,23,27–33] The ability to manipulate anatomic structures and vital signs can force the student to address specific therapeutic decisions. This lends itself well to the instruction and reinforcement of clinical guidelines or critical care algorithms.[30,32,34–36] The anesthesia literature suggests that residents can achieve competency in performing intubation and managing complex operating room cases in a shorter amount of time with fewer actual patient encounters.[23,37–43] However, the optimal design of simulator-based EMS curricula has not been studied, and the experience using simulators to train prehospital crews is limited. We designed a novel, simulator-based curriculum to teach a difficult airway algorithm to air medical crews. Furthermore, the simulation curriculum was integrated with existing educational platforms and quality assurance using an original difficulty airway algorithm. The

Received April 16, 2006, from the UC San Diego, Department of Emergency Medicine (DPD, CB), Mercy Air Medical Services (DPD, JF, WK, DC), UC San Diego School of Medicine (LP), and University Medical Center, Las Vegas, Nevada (DC). Revision received August 21, 2006; accepted for publication August 25, 2006.

Address correspondence to: Daniel Davis, MD, UCSD Emergency Medicine, 200 West Arbor Drive, #8676, San Diego, CA 92103-8676. e-mail: <davismd@cox.net>.

doi: 10.1080/10903120601023370

Downloaded By: [Canyon County Ambulance Dstr] At: 20:16 4 April 2007

objective of this analysis was to evaluate the effectiveness of this curriculum, focusing on before and after airway management success and the subjective experience of air medical crews.

METHODS

Design

The primary analysis was a comparison of airway management success before and after implementation of the novel difficult airway curriculum. In addition, a self-assessment by air medical crews before and after participation in the simulation sessions was performed. Approval for this project was granted by our institutional review board.

Setting

Mercy Air Medical Services includes 12 bases in Southern California and Nevada, with approximately 120 flight nurses and paramedics. Helicopter-based crews respond to scene calls when requested by ground providers. Interfacility transports are performed at the request of the sending facility. Air medical crews can perform ETI, and flight nurses carry neuromuscular blocking agents to facilitate laryngoscopy for patients with intact airway reflexes or clenched jaws or if ETI without paralysis is unsuccessful. The RSI protocols during the study period included the use of either etomidate or midazolam with succinylcholine, with additional midazolam and vecuronium administered for long-term sedation and paralysis following confirmation of tube position. Combitube insertion (CTI), use of a gum elastic bougie, and performance of cricothyrotomy were the salvage airway management techniques available throughout the primary study period.

Airway Training

Historically, airway training has consisted of an annual 1- to 2-hour lecture and two 3- to 4-hour cadaver-based skills laboratories. Some crew members perform ETI in the operating room as part of their initial training, depending on access and availability. In addition, newly hired crew members undergo a 2- to 3-month period of ride alongs with a clinical mentor prior to practicing independently; airway management is typically incorporated into this mentorship period. Online tutorials are used for some topics, although not specifically for airway management.

At the end of 2003, simulation training airway management was implemented across the entire company and integrated with existing educational platforms and quality assurance. We used a SimMan® (Laerdal Corporation, Gatesville, TX) human patient simulator. An original difficult airway algorithm was distributed to all crew members and served as a treatment guideline, platform for quality assurance, and template for lectures and simulation scenarios (Figure 1). All crew members, including both flight nurses and paramedics, were exposed to the curriculum at the beginning of the interventional period through the distribution of the algorithm to all employees and a series of difficult airway workshops. These began with a 1-hour lecture on difficult airway management explaining each of the decisions involved in the algorithm. This was followed by a 3-hour simulation workshop, using original scenarios that are each designed to emphasize a specific pathway through the algorithm. After each scenario, a debriefing session was performed to reinforce critical components of the algorithm and discuss optimal and suboptimal performance during the simulation. Crew members not directly involved in the scenario remain in the room as observers and participate in the debriefing sessions. The same individual (DD) ran the simulator and performed debriefings during the study period. The scenarios were not preprogrammed but were instead run manually to allow real-time manipulation of the simulator to emphasize the specific clinical dilemma or algorithm pathway emphasized by that particular scenario.

For recurrency training, crews attend an annual 1-hour airway lecture and 3-hour simulation session. In addition, one of the two cadaver skill laboratories has been replaced by a 3-hour simulator-based skills session. Crew members identified as having clinical difficulties attend additional simulator-based mediation. In addition, quality assurance personnel are encouraged to perform chart audits and conduct case conferences using the difficult airway algorithm as a template. New hires undergo more extensive lectures on airway management as well as participate in both initial and 6-month simulation and technical training workshops.

Data Collection and Analysis

The effectiveness of this curriculum was evaluated in two ways. The primary objective was to compare airway management success before and after implementation of this curriculum. The advanced skill form, which is a quality assurance document completed following all intubation attempts, was modified to include data regarding the number of ETI attempts and ultimate airway management strategy. The following data were abstracted from these forms for this analysis: vital signs, pulse oximetry (SpO2) values, procedure success, number of intubation attempts, and clinical course. Web-based entry of advanced skill form data was made available in January 2003. Nine bases began entering data immediately, with all bases entering data electronically by the end of 2003. This was not thought to introduce any significant degree of selection bias, because crew members staff multiple bases with no measurable

Downloaded By: [Canyon County Ambulance Dstr] At: 20:16 4 April 2007

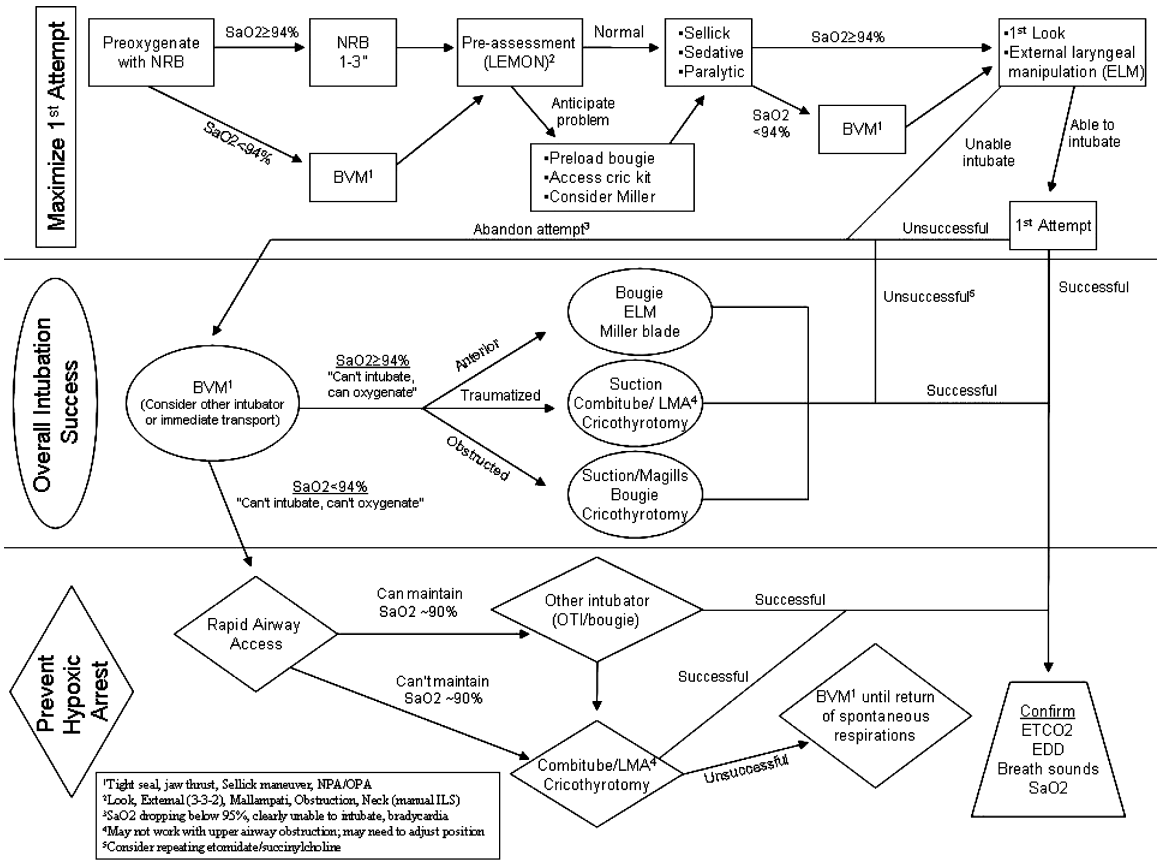


FIGURE 1. Difficult airway algorithm.

difference in crew experience levels across bases. Historical data regarding airway management were also available for the years 1997–1999 to confirm airway success in the presimulator time period. A single individual reviewed all charts and abstracted data for this analysis.

The primary analysis compared airway management success in patients undergoing RSI prior to implementation of the difficult airway curriculum (from January to December 2003) to those undergoing RSI following implementation (from January 2004 to May 2005). Comparisons were made on the basis of first attempt ETI success, overall ETI success, invasive airway management success (ETI, CTI, and cricothyrotomy), and the incidence of arrests related to difficulties with the RSI procedure. An arrest was defined as the loss of a measurable blood pressure or palpable pulse and was deemed related to difficulties with the RSI procedure if desaturation occurred during intubation attempts and prior to arrest, or if multiple unsuccessful attempts at intubation were made prior to arrest and SpO2 values were not recorded in the quality assurance documents. In addition, charts for patients who deteriorate prior to hospital delivery undergo quality assurance review by the county EMS oversight committee to determine potential etiologies for this deterioration. These assessments were included to help determine whether an arrest was related to difficulties with the RSI procedure. Odds ratios with 95% confidence intervals were used to quantify all comparisons. To account for possible changes in the experience level of air medical crew members during the study period, the percentage of new hires was calculated for each year, with comparisons across years made by using χ^2.

Historical data regarding airway management success from 1997 to 1999 were presented descriptively to serve as a reference for presimulator airway management. In addition, these data were used for a power calculation regarding the primary comparison between pre- and postsimulator RSI patients. With the historical intubation success rate of 89% and a target postintervention ETI success rate of 95%, we determined that 503 postintervention subjects would be required (80% power, alpha 0.05).

The second objective was to measure confidence with airway management and the subjective experience of crew members exposed to the simulation training. At the beginning of the simulation workshop, each participant completed a self-assessment of their confidence with airway management in general as well as each specific component and salvage technique. A 100-mm visual analog scale (VAS) was used to quantify their responses. Following the simulation session, crew members completed another self-assessment identical to the

Downloaded By: [Canyon County Ambulance Dstr] At: 20:16 4 April 2007

TABLE 1. Airway Management Success Before and After Implementation of a Novel Difficult Airway Curriculum

Variable	Precurriculum (n = 261)	Postcurriculum (n = 504)	Odds ratio (95% CI)
First attempt ETI success	186 (71.3)	441 (87.5)	2.8 (1.9–4.1)**
Overall ETI success	233 (89.3)	477 (94.6)	2.1 (1.2–3.7)*
Any invasive airway	8 (3.1)	11 (2.2)	1.4 (0.6–3.6)
Hypoxic arrest	7 (2.7)	2 (0.4)	6.9 (1.4–33.5)*

*$p < 0.01$.
**$p < 0.001$.

first; in addition, questions were completed for their overall opinion as to the utility of simulation compared with other training platforms and the optimal role for simulation training. Descriptive analysis of data from these surveys was performed, with mean and 95% confidence intervals reported for each. In addition, confidence assessment values before and after the workshop were compared by calculating the mean difference in scores, with statistical significance achieved if the confidence intervals did not cross zero. This allowed each patient to serve as his or her own control. Multiple linear regression was used to explore the relationship between the number of years working in the field and the change in confidence for each component of airway management. A power calculation was performed to determine the target sample size. By assuming a mean pre- and postworkshop difference in confidence with airway management of 10 mm on the VAS (SD 25 mm), a total of approximately 51 subjects would be required (80% power, alpha 0.05). Statistical calculations were performed by using StatsDirect™ (StatsDirect Software Inc., Ashwell, UK).

RESULTS

A total of 504 RSI patients were enrolled over 17 months following implementation of the difficult airway curriculum, for a total of 2.47 intubations/base/month. This included all 12 bases entering data into the electronic data base. These were compared to 261 patients undergoing RSI in the 12 months preceding implementation. This resulted in a total of 2.42 intubations/base/month because only 9 bases were entering data into the electronic database during 2003. The rate of first attempt and any attempt ETI success was significantly higher and the rate of hypoxic arrests lower following implementation of the difficult airway curriculum (Table 1). The first attempt (74.0) and overall ETI (90.9) success rates for the 870 RSI patients in the historical database (1997–1999) were similar to those for the precurriculum time period. There were no differences for the new-hire rate over the study period ($p = 0.421$).

The first 50 participants in the difficulty airway workshop completed self-assessment surveys, with these data reported here. Improvements in all aspects of airway management were observed (Figure 2). The regression model indicated an association between fewer years of prehospital experience and an increased improvement in general ETI confidence and between more years of prehospital experience and confidence with use of the bougie and cricothyrotomy ($p < 0.05$

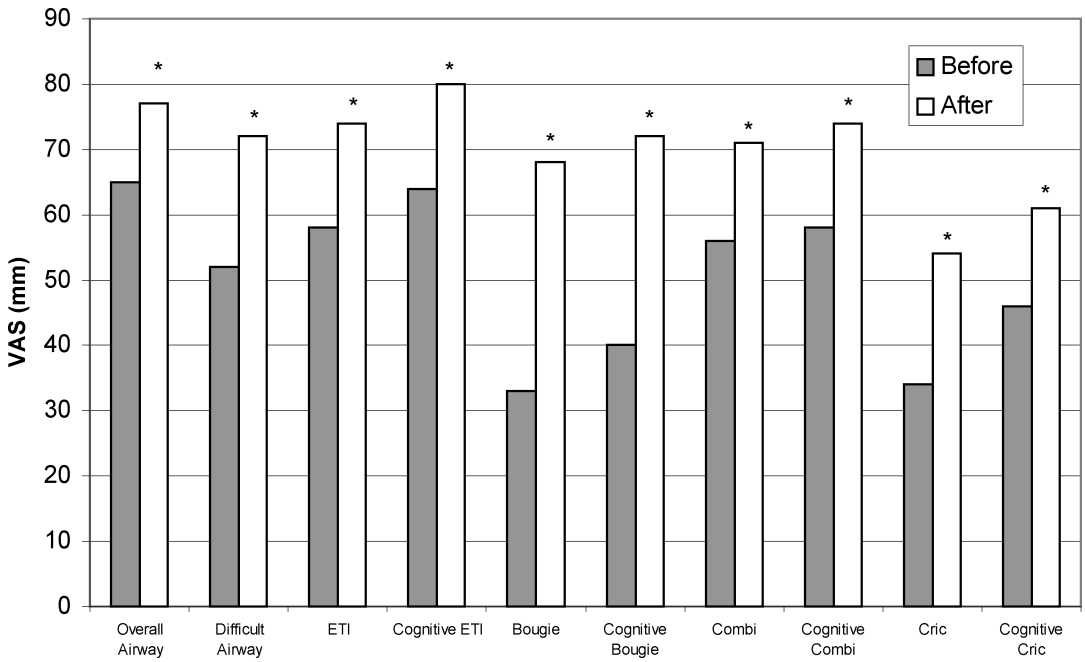


FIGURE 2. Self-reported confidence levels for various aspects of airway management by before and after participation in the airway workshop. *$p < 0.05$ for all comparisons.

Downloaded By: [Canyon County Ambulance Dstr] At: 20:16 4 April 2007

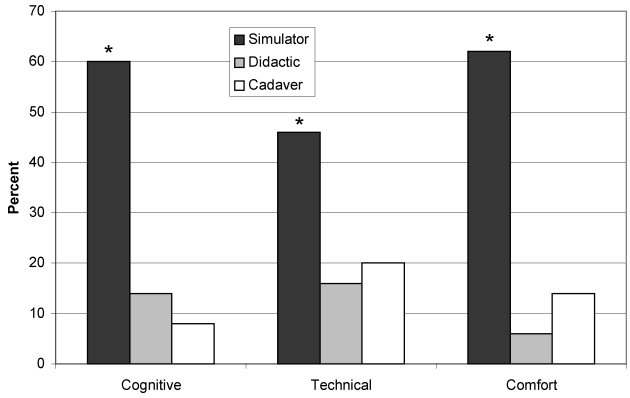


FIGURE 3. Assessment by airway workshop participants as to the most effective platform for learning the cognitive aspects, technical components, and overall comfort with airway management. *$p < 0.001$ for each comparison.

for both). Participants in the difficult airway workshop regarded each component as valuable: didactic session (92 mm out of 100 mm), cadaver-based technical training (88 mm), simulator scenarios (94 mm), and overall airway training curriculum (94 mm). Simulators were felt to be more effective than either didactics or cadaver training for the cognitive and technical components as well as the overall comfort will airway management (Figure 3). Most participants felt that simulation training should be used regularly (84%) and for new hires (68%); none felt that simulators should not be used at all.

DISCUSSION

Early intubation has been advocated with inadequate ventilation, decreased level of consciousness, and hypoxia.[1,2] This philosophy has led to aggressive prehospital airway management protocols, including the use of neuromuscular blocking agents by prehospital personnel to facilitate laryngoscopy and increase ETI success.[3,6–12] Thus, it has been somewhat surprising that a growing number of studies have failed to show benefit with early intubation.[44–49] One potential explanation involves suboptimal performance of ETI and subsequent ventilation, possibly reflecting inadequate training.[13–16] This has led to recommendations that training receive substantial focus for EMS agencies performing RSI.[18]

The optimal approach to airway management training remains to be elucidated. Traditional approaches include lecture-based didactic sessions, technical training using static manikins or cadavers, and clinical experience in the operating room or prehospital environment.[22,25,26,50,51] None of these provide the essential combination of cognitive and technical training required to develop critical thinking skills. In addition, access may be limited in many EMS systems because of scarce resources or liability issues.[52] Human patient simulators have recently emerged as a potential solution, allowing technical and cognitive training to be combined.[24,27,29,30,32,35,53] The effectiveness of simulator-based training and the optimal approach to curriculum development have not been defined.

Here we demonstrate the effectiveness of this novel difficult airway curriculum in several ways. Improvement in confidence with various aspects of airway management measured with a VAS was notable. In addition, participants of various experience levels benefited differently from the workshop. Although the survey tool was not previously validated, the observed improvements in overall airway management confidence for novice crew members and in specific skills, such as the bougie and cricothyrotomy, for experienced crew members seems to validate both the training and the measurement tool. Participants rated each component of the workshop as valuable and suggested that simulation be used routinely and for new hires.

It is notable that crew members assessed the simulator as being the most valuable tool for technical and cognitive training as well as overall airway management comfort. Simulator technology has certainly advanced in recent years, with more realistic anatomic features and clinical examination findings. In addition, this likely reflects the limitations of more traditional platforms, such as cadaver laboratories and formal didactics. This also underscores the importance of the debriefing session following each simulation scenario. This gives the instructor the opportunity to highlight good and bad decision making, reinforce the airway algorithm, and make suggestions for subsequent scenarios and clinical practice.

The primary analysis indicated improvements in airway management success following implementation of the difficult airway simulation training and treatment algorithm. Both first attempt and overall ETI success increased and the rate of hypoxic arrests associated with RSI difficulty decreased. These differences did not seem to result from differences in the experience level of crews, because there was no difference in the rate of new hires during the study period. It is notable that historical airway management success rates were similar to those in the immediate presimulator period, suggesting that the relatively modest intubation success observed in 2003 was not an anomaly.

Our approach to airway management training is unique for several reasons. First, the curriculum was based on a clinical treatment guideline or algorithm. Although this may limit flexibility and creative thinking, a standardized approach may be desirable for critical resuscitations, with Advanced Cardiac Life Support and Advanced Trauma Life Support as models.[30,32,52,54] The algorithm was used to construct simulator scenarios, with an optimal path through the algorithm identified for each. In addition, we integrated the algorithm into clinical practice and quality assurance as well. Finally,

Downloaded By: [Canyon County Ambulance Dstr] At: 20:16 4 April 2007

the concepts are reinforced through formal didactics and validated through formal research methodologies.

We specifically avoided programming the simulators to run a standardized scenario and instead asked the instructor to operate the simulation "on the fly." This is somewhat unique, creating several distinct advantages and disadvantages over more traditional uses of the simulator. Operating in a manual mode allows the operator to make immediate adjustments to force the student into a particular decision or pathway. This prevents the skilled participant from avoiding critical decisions by rapidly assessing and stabilizing the "patient"; in addition, this approach gives the operator freedom to deemphasize mistakes made by novice participants if these do not occur in relation to the specific objectives of a given scenario. For example, if the goal is to emphasize a "cannot intubate but can ventilate" pathway, then failure to appropriately preoxygenate can be noted for debriefing but does not produce immediate decompensation and prevent the true objectives from being met.

Most of our knowledge about the value of simulation training for airway management comes from the anesthesia literature.[28,50,55–59] The use of human patient simulators to train anesthesia residents decreases the number of actual cases required to achieve proficiency, both with regard to the initial intubation and the management of the case itself.[23,37–43] Hall et al. document the use of simulators to train paramedic students and observed equivalent ETI success in surgical patients between a group of students undergoing 10 hours of simulation training versus another group performing 15 ETI attempts in the operating room with an instructor.[60] Their experience is consistent with our own, although it is not clear that the ideal conditions present with elective surgical patients is equivalent to the performance of emergent airway management in the prehospital environment. Clearly, additional experience to document the utility of simulation training and the optimal curriculum configuration are needed.

There are several limitations to both phases of this study that must be considered. First, it is unlikely that the simulation sessions alone explain the improvements in airway management success following the novel airway curriculum. The algorithm, an emphasis on difficult airway management, the modified quality assurance program, and an enthusiastic instructor likely all play a role. Alternatively, this can be regarded as a strength of the study, because integration of the simulation program with other educational platforms as well as the clinical and quality assurance missions is critical. In addition, a single instructor did all of the teaching, and the results may be different with other instructors. The annual intubation rate appeared to be lower in 2003; however, this likely reflects the phasing in of online data entry for several bases. As stated above, flight crews routinely staff multiple bases, and there are no differences between bases for experience levels, so this was not thought to be a significant source of bias. In addition, historical intubation success rates were identical to those observed in 2003.

An additional limitation is the absence of individual provider data. It would be preferable to document airway management improvements for individuals exposed to the curriculum compared with those trained with more traditional techniques. This would be difficult, given the mobility of crews and the team approach to RSI, making it likely that a mixture of exposure levels would exist for any given patient encounter. Ultimately, the benefits for airway management success must be weighed against the cost of setting up such a program, which we do not address here. Finally, we did not attempt to correlate the improvements in airway management success to outcome, although the decrease in arrests related to difficulty with the RSI procedure certainly affected outcome in these patients.

For the self-assessment survey, participants may have been influenced by their knowledge that the survey results may affect access to simulation in the future or a desire to manifest an expected benefit from the training. Participants did not have access to the initial survey when filling out the postworkshop assessment but may have been able to recall approximately where they placed the VAS mark. In addition, the minimal clinically significant difference in confidence values is unclear. Finally, air medical providers were exposed to the curriculum in stages, making it difficult to determine exactly when complete penetration of the airway curriculum occurred; however, this would be expected to decrease the apparent impact of the curriculum, because the first several months would represent only partial implementation.

CONCLUSIONS

The integration of simulator training and an original algorithm into the existing air medical airway training curriculum appeared to result in improvements in airway management success in this program. Increases in first attempt and overall ETI success as well as decreases in hypoxic arrests related to RSI were observed following the curriculum change. Improvements in airway management confidence levels were reported by simulator session participants, and all thought it should be a routine part of initial and ongoing training.

References

1. Wall RL. Rapid-sequence intubation in head trauma. Ann Emerg Med. 1993;22(6):1008–13.
2. Chesnut RM, Marshall LF, Klauber MR, et al. The role of secondary brain injury in determining outcome from severe head injury. Journal of Trauma. 1993;34(2):216–22.

Downloaded By: [Canyon County Ambulance Dstr] At: 20:16 4 April 2007

3. Ochs M, Davis D, Hoyt D, Bailey D, Marshall L, Rosen P. Paramedic-performed rapid sequence intubation of patients with severe head injuries. Annals of Emergency Medicine. 2002;40(2):159–67.
4. Winchell RJ, Hoyt DB. Endotracheal intubation in the field improves survival in patients with severe head injury. Trauma Research and Education Foundation of San Diego. Archives of Surgery. 1997;132(6):592–7.
5. Ma OJ, Atchley RB, Hatley T, Green M, Young J, Brady W. Intubation success rates improve for an air medical program after implementing the use of neuromuscular blocking agents. American Journal of Emergency Medicine. 1998;16(2):125–7.
6. Wayne MA, Friedland E. Prehospital use of succinylcholine: a 20-year review. Prehospital Emergency Care. 1999;3(2):107–9.
7. Vilke GM, Hoyt DB, Epperson M, Fortlage D, Hutton KC, Rosen P. Intubation techniques in the helicopter. Journal of Emergency Medicine. 1994;12(2):217–24.
8. Sing RF, Rotondo MF, Zonies DH, et al. Rapid sequence induction for intubation by an aeromedical transport team: a critical analysis. American Journal of Emergency Medicine. 1998;16(6):598–602.
9. Syverud SA, Borron SW, Storer DL, et al. Prehospital use of neuromuscular blocking agents in a helicopter ambulance program. Annals of Emergency Medicine. 1988;17(3):236–42.
10. Pace SA, Fuller FP. Out-of-hospital succinylcholine-assisted endotracheal intubation by paramedics. Annals of Emergency Medicine. 2000;35(6):568–72.
11. Hedges JR, Dronen SC, Feero S, Hawkins S, Syverud SA, Shultz B. Succinylcholine-assisted intubations in prehospital care. Annals of Emergency Medicine. 1988;17(5):469–72.
12. Falcone RE, Herron H, Dean B, Werman H. Emergency scene endotracheal intubation before and after the introduction of a rapid sequence induction protocol. Air Medical Journal. 1996;15(4):163–7.
13. Davis DP, Douglas DJ, Buono C, Dunford JV. The incidence of desaturations and hyperventilation associated with air medical rapid sequence intubation [submitted]. Prehosp Emerg Care. 2005.
14. Davis DP, Dunford JV, Ochs M, Heister R, Hoyt DB. Ventilation patterns following paramedic rapid sequence intubation of patients with severe traumatic brain injury. Neurocritical Care. 2005;2(2).
15. Dunford JV, Davis DP, Ochs M, Doney M, Hoyt DB. Incidence of transient hypoxia and pulse rate reactivity during paramedic rapid sequence intubation. Annals of Emergency Medicine. 2003;42(6):721–8.
16. Davis DP, Dunford JV, Hoyt DB, Ochs M, Holbrook T, Fortlage D. The impact of hypoxia and hyperventilation on outcome following paramedic rapid sequence intubation of patients with severe traumatic brain injury. Journal of Trauma. 2004;[submitted].
17. Davis DP, Idris AH, Sise MJ, et al. Ventilation and outcome in patients with moderate-to-severe traumatic brain injury [submitted]. Crit Care Med. 2005.
18. Wang HE, Davis DP, Wayne MA, Delbridge T. Prehospital rapid sequence intubation: what does the evidence show? Prehosp Emerg Care. 2004;8(4):366–77.
19. Sivilotti MLA, Filbin MR, Murray HE, Slasor P, Walls RM. Does the sedative agent facilitate emergency rapid sequence intubation? Acad Emerg Med. 2003;10:612–20.
20. Sakles JC, G. LE, Rantapaa AA, Panacek EA. Airway management in the emergency department: a one-year study of 610 tracheal intubations. Ann Emerg Med. 1998;31:325–32.
21. Issenberg SB, McGaghie WC, Hart IR, et al. Simulation technology for health care professional skills training and assessment. Jama. 1999;282(9):861–6.
22. Kesavadas T, Joshi D, Mayrose J, Chugh K. A virtual environment for esophageal intubation training. Stud Health Technol Inform. 2002;85:221–7.
23. Delson NJ, Koussa N, Hastings RH, Weinger MB. Quantifying expert vs. novice skill in vivo for development of a laryngoscopy simulator. Stud Health Technol Inform. 2003;94: 45–51.
24. Good ML. Patient simulation for training basic and advanced clinical skills. Med Educ. 2003;1:14–21.
25. Cooper JB, Taqueti VR. A brief history of the development of mannequin simulators for clinical education and training. Qual Saf Health Care. 2004;13(1):i11–8.
26. Buck GH. Development of simulators in medical education. Gesnerus. 1991;1:7–28.
27. Euliano TY. Teaching respiratory physiology: clinical correlation with a human patient simulator. J Clin Monit Comput. 2000;16(5–6):465–70.
28. Christensen UJ, Andersen SF, Jacobsen J, Jensen PF, Ording H. The Sophus anaesthesia simulator v. 2.0. A Windows 95 control-center of a full-scale simulator. Int J Clin Monit Comput. 1997;14(1):11–6.
29. Euliano TY. Small group teaching: clinical correlation with a human patient simulator. Adv Physiol Educ. 2001;25(1–4):36–43.
30. Block EF, Lottenberg L, Flint L, Jakobsen J, Liebnitzky D. Use of a human patient simulator for the advanced trauma life support course. Am Surg. 2002;68(7):648–51.
31. Marshall WJ. Comparative hazard evaluation of near-infrared diode lasers. Health Phys. 1994;66(5):532–9.
32. Holcomb JB, Dumire RD, Crommett JW, et al. Evaluation of trauma team performance using an advanced human patient simulator for resuscitation training. J Trauma. 2002;52(6): 1078–85.
33. Blike G, Cravero J, Nelson E. Same patients, same critical events–different systems of care, different outcomes: description of a human factors approach aimed at improving the efficacy and safety of sedation/analgesia care. Qual Manag Health Care. 2001;10(1):17–36.
34. Nackman GB, Bermann M, Hammond J. Effective use of human simulators in surgical education. J Surg Res. 2003;115(2):214–8.
35. Takashina T, Shimizu M, Katayama H. A new cardiology patient simulator. Cardiology. 1997;88(5):408–13.
36. Hammond J. Simulation in critical care and trauma education and training. Curr Opin Crit Care. 2004;10(5):325–9.
37. Naik VN, Matsumoto ED, Houston PL, et al. Fiberoptic orotracheal intubation on anesthetized patients: Do manipulation skills learned on a simple model transfer into the operating room? Anesthesiology. 2001;95:343–8.
38. Weller JM, Robinson BJ, Jolly B, et al. Psychometric characteristics of simulation-based assessment in anaesthesia and accuracy of self-assessed scores. Anaesthesia. 2005;60(3):245–50.
39. Abrahamson S, Denson JS, Wolf RM. Effectiveness of a simulator in training anesthesiology residents. Qual Saf Health Care. 2004;13(5):395–7.
40. Schwid HA, O'Donnell D. Anesthesiologists' management of simulated critical incidents. Anesthesiology. 1992;76(4):495–501.
41. Schwid HA, Rooke GA, Ross BK, Sivarajan M. Use of a computerized advanced cardiac life support simulator improves retention of advanced cardiac life support guidelines better than a textbook review. Crit Care Med. 1999;27(4):821–4.
42. Gurushanthaiah K, Weinger MB, Englund CE. Visual display format affects the ability of anesthesiologists to detect acute physiologic changes. A laboratory study employing a clinical display simulator. Anesthesiology. 1995;83(6):1184–93.
43. Sica GT, Barron DM, Blum R, Frenna TH, Raemer DB. Computerized realistic simulation: a teaching module for crisis management in radiology. AJR Am J Roentgenol. 1999;172(2):301–4.
44. Bochicchio GV, Ilahi O, Joshi M, Bochicchio K, Scalea TM. Endotracheal intubation in the field does not improve outcome in trauma patients who present without lethal traumatic brain injury. J Trauma. 2003;54(2):307–11.

Downloaded By: [Canyon County Ambulance Dstr] At: 20:16 4 April 2007

45. Davis DP, Peay J, Sise MJ, et al. The impact of prehospital endotracheal intubation on outcome in moderate-to-severe traumatic brain injury. J Trauma. 2005.
46. Wang HE, Peitzman AD, Cassidy LD, Adelson PD, Yealy DM. Out-of-hospital endotracheal intubation and outcome after traumatic brain injury. Ann Emerg Med. 2004;44(5):439–50.
47. Gausche M, Lewis RJ, Stratton SJ, et al. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial [see comments]. Jama. 2000;283(6):783–90.
48. Eckstein M, Chan L, Schneir A, Palmer R. Effect of prehospital advanced life support on outcomes of major trauma patients. Journal of Trauma. 2000;48(4):643–8.
49. Murray JA, Demetriades D, Berne TV, et al. Prehospital intubation in patients with severe head injury. Journal of Trauma. 2000;49(6):1065–70.
50. Nargozian C. Teaching consultants airway management skills. Paediatr Anaesth. 2004;14(1):24–7.
51. Arne R, Stale F, Ragna K, Petter L. PatSim—simulator for practising anaesthesia and intensive care. Development and observations. Int J Clin Monit Comput. 1996;13(3):147–52.
52. Treloar D, Hawayek J, Montgomery JR, Russell W. On-site and distance education of emergency medicine personnel with a human patient simulator. Mil Med. 2001;166(11): 1003–6.
53. Grenvik A, Schaefer JJ, 3rd, DeVita MA, Rogers P. New aspects on critical care medicine training. Curr Opin Crit Care. 2004;10(4):233–7.
54. Schlindwein M, von Wagner G, Kirst M, et al. Mobile patient simulator for resuscitation training with automatic external defibrillators. Biomed Tech. 2002;2:559–60.
55. Aydeniz B, Meyer A, Posten J, Konig M, Wallwiener D, Kurek R. The 'HysteroTrainer'—an in vitro simulator for hysteroscopy and falloposcopy. Experimental and clinical background and technical realisation including the development of organ modules for electrothermal treatment. Contrib Gynecol Obstet. 2000;20:171–81.
56. Norman J, Wilkins D. Simulators for anesthesia. J Clin Monit. 1996;12(1):91–9.
57. Schaefer JJ, 3rd. Simulators and difficult airway management skills. Paediatr Anaesth. 2004;14(1):28–37.
58. Schaefer JJ, 3rd, Grenvik A. Simulation-based training at the University of Pittsburgh. Ann Acad Med Singapore. 2001;30(3):274–80.
59. Parry K, Owen H. Small simulators for teaching procedural skills in a difficult airway algorithm. Anaesth Intensive Care. 2004;32(3):401–9.
60. Hall RE, Plant JR, Bands CJ, Wall AR, Kang J, Hall CA. Human patient simulation is effective for teaching paramedic students endotracheal intubation. Acad Emerg Med. 2005;12(9):850–5.