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Original Research

SIMULATION TRAINING

Initial Airway Management Skills of Senior Residents*

Simulation Training Compared With Traditional Training

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Background: **Scenario-based training (SBT) with a computerized patient simulator (CPS) is effective in teaching physicians to manage high-risk, low-frequency events that are typical of critical care medicine. This study compares the initial airway management skills of a group of senior internal medicine residents trained using SBT with CPS during their first year of postgraduate training (PGY) with a group of senior internal medicine residents trained using the traditional experiential method.**

Methods: **This was a prospective, controlled trial that compared two groups of PGY3 internal medicine residents at an urban teaching hospital. One group (n = 32) received training in initial airway management skills using SBT with CPS in their PGY1 (*ie*, the simulation-trained [ST] group). The second group (n = 30) received traditional residency training (*ie*, the traditionally trained [TT] group). Each group was then tested during PGY3 in initial airway management skills using a standardized respiratory arrest scenario.**

Results: **The ST group performed significantly better than the TT group in 8 of the 11 steps of the respiratory arrest scenario. Notable differences were found in the ability to attach a bag-valve mask (BVM) to high-flow oxygen (ST group, 69%; TT group, 17%; $p < 0.001$), correct insertion of oral airway (ST group, 88%; TT group, 20%; $p < 0.001$), and achieving an effective BVM seal (ST group, 97%; TT group, 20%; $p < 0.001$).**

Conclusions: **Traditional training consisting of 2 years of clinical experience was not sufficient to achieve proficiency in initial airway management skills, mostly due to inadequate equipment usage. This suggests that SBT with CPS is more effective in training medical residents than the traditional experiential method.** ***(CHEST 2007; 132:1927–1931)***

Key words: medical simulation; residency education; resuscitation skills; scenario-based training

Abbreviations: ACLS = advanced cardiac life support; BVM = bag-valve mask; CPS = computerized patient simulator; PGY = postgraduate year; SBT = scenario-based training; ST = simulation trained; TT = traditionally trained; UT = untrained

Residency training has traditionally relied on the apprenticeship model for training physicians. This experiential learning, or "learning by doing" dominates the culture of residency training.[1] The "see one, do one, teach one" method of training is not appropriate in high-risk, low-frequency events such as cardiac arrest or respiratory arrest.

Simulation training offers a controlled, safe, and reproducible environment in which to practice clinical interventions during high-risk events.[2] It has also been shown to be effective in acquiring clinical skill proficiency[3–7] and improving performance in actual clinical situations.[5]

Although residency training programs are increasingly offering training of critical skills using simulation technology, the use of simulators is not yet a standard component of residency training.[8] A likely reason for this has been the belief that traditional educational approaches have been successful. For example, resuscitation skills, including initial airway

management, are assumed to be acquired from advanced cardiac life support (ACLS) courses and enhanced during traditional experiential training. Some studies[9–16] have questioned this belief. The present study compares the skills of simulation-trained (ST) residents with residents trained by the traditional experiential method using a validated model of initial airway management training.

Materials and Methods

Subjects and Study Design

This study was approved by the Committee on Scientific Activities of Beth Israel Medical Center (New York, NY); all subjects gave informed consent before participating in the study. The study took place at Beth Israel Medical Center, an urban teaching hospital and the Manhattan campus for Albert Einstein College of Medicine. All third-year residents had received ACLS certification before beginning residency and had renewed their ACLS certification at the end of their second year.

We studied two separate groups of internal medicine residents at the beginning of their third year of postgraduate training (PGY). Data were collected in July of 2 consecutive years, enabling comparison of these groups. In July 2003, we tested all PGY3 residents (n = 32) for skill in initial airway management using scenario-based training (SBT) with a computerized patient simulator (CPS). This resident group had never received formal SBT with a CPS at any time during their residency. This group was designated as the traditionally trained (TT) group. In July 2004, we tested all PGY3 residents (n = 30) for skill in initial airway management using identical testing methods. This resident group had undergone SBT with a CPS in initial airway management in July 2002 as part of a mandatory training program that began that year and only targeted PGY1 residents. This group was designated as the ST group. Group assignment is summarized in Figure 1.

In order to compare the performance of TT residents with residents who had no experience in initial airway management, in July 2003 we tested all PGY1 internal medicine residents (n = 49) who had just started postgraduate training. These residents were designated as the untrained (UT) group.

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Description of SBT With CPS

We used the identical setup, testing, scoring, and training as in our previous studies.[4,5] We briefly describe the procedures as follows.

Simulation Setup

The testing of residents was standardized and performed in a hospital room that was dedicated to simulation training. The CPS control computer was concealed behind a curtain. The testing team consisted of a computer operator and two researchers who played the roles of floor nurses. These nurses acted consistent with standard nursing practice but could not lead the study subject with suggestions. The CPS unit (SimMan; Laerdal Medical Corporation; Wappingers Falls, NY) was a human-sized mannequin lying supine on a hospital bed. The CPS had realistic features, such as a palpable pulse, chest wall excursion, and audible breath sounds. Vital signs were displayed on a bedside monitor and could be assessed by physical examination. The adequacy of ventilation with a bag-valve mask (BVM) was sensed and was graphically represented on the concealed computer screen. The computer operator programmed clinical scenarios and recorded the response of the subject for later analysis.

Testing Procedure

All residents were individually escorted to the training room by a trained simulation instructor. During a standardized introduction, the trainer demonstrated the capability of the mannequin and informed the resident that all of the equipment on a typical hospital floor as well as two nurses were available for assistance. The resident exited the room and was then called in to the bedside of the simulated patient as the first responder in an emergency situation.

The CPS was set to apnea with an oxygen saturation of 80%, a BP of 80/60 mm Hg, and a heart rate of 80 beats/min in sinus rhythm. This scenario simulated a respiratory arrest that had not yet progressed to cardiac arrest. If the actions of the resident did not result in successful BVM ventilation, the oxygen saturation declined followed by bradycardia and progressive hypotension. Full cardiac arrest then occurred in 3 min. Unsuccessful BVM ventilation was defined as the omission of any of the seven essential tasks of initial airway management (Table 1). Four nonessential tasks were also measured; however, omission of any of these items still permitted successful resuscitation.

Scoring

Immediately after testing, the two researchers portraying nurses independently completed a standardized scoring sheet based on their observations and the data recorded by the computer operator. The scoring sheet is based on Table 1; each task was scored as either completed or not completed. Discrepancies were resolved by consensus. In a previous study,[4] blinded video-based scoring of resident performance produced identical results as consensus observational scores. In the present study, we did not use video-based scoring or examine interrater variability.

Teaching and Debriefing Protocol

Training consisted of a 30-min session that began with testing the resident during the standardized CPS scenario of respiratory arrest in which they were expected to perform seven essential tasks and four nonessential tasks of initial airway management.

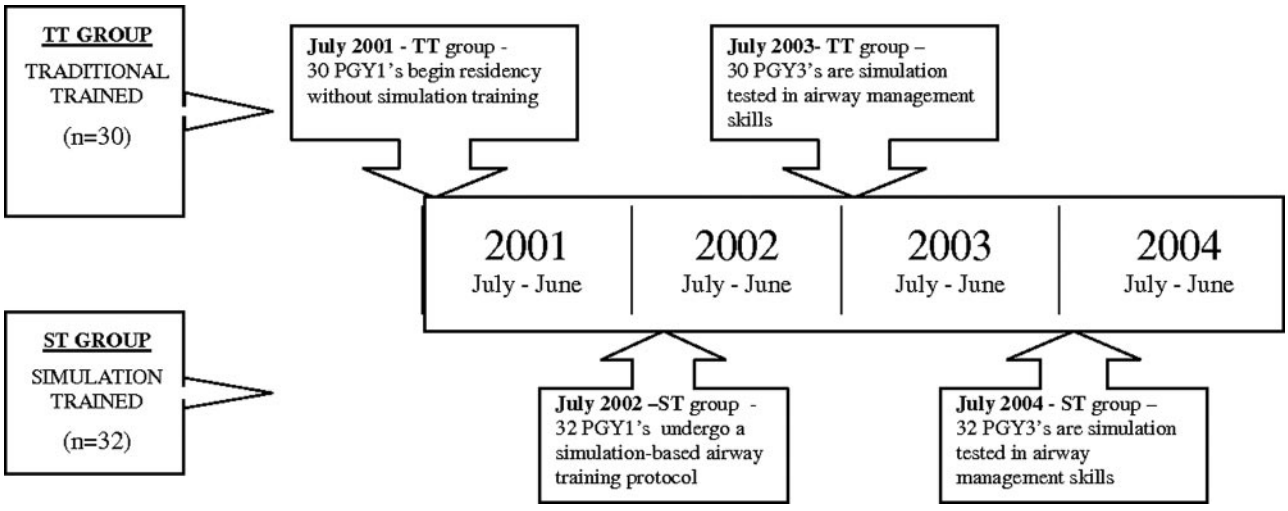

FIGURE 1. Assignment and testing of study groups.

Following testing, the resident was trained using the same simulator and scenario. This session began with a step-wise review of test performance that included a discussion of the physiology of apnea and the consequences of respiratory arrest. The resident was specifically trained in the 11 steps of initial airway management using a hands-on approach emphasizing specific task training. This was followed by a second run of the scenario. The resident was then again intensively debriefed in this manner, followed by another full run of the scenario with a final, comprehensive debriefing. The training session lasted 30 min and emphasized team communication skills and active task repetition. No resident was dismissed from training unless they demonstrated perfect initial airway management skills.

Statistical Analysis

The data were analyzed with the χ^2 test or Fisher exact test applied to 2×2 contingency tables as appropriate. A p value of 0.05 was considered to be statistically significant. All data were analyzed using a statistical software package (SAS, version 8.0; SAS Institute; Cary, NC).

RESULTS

All residents consented to participate in the study, and all were tested per the protocol. There were 30 PGY3 internal medicine residents in the TT group, 32 PGY3 internal medicine residents in the ST group, and 49 PGY1 internal medicine residents in the UT group. Table 2 presents the residents' scores on the 11 individual tasks of initial airway management for the ST group compared with the TT group. There were no significant differences in identifying apnea (ST group, 97%; TT group, 87%; $p = 0.14$), calling for a code team (ST group, 72% ; TT group, 50%; $p = 0.08$), or in attaching a pulse oximeter (ST group, 88%; TT group, 77%; $p = 0.26$). There were significant differences in the performance of the remaining eight tasks, most notably in attaching the BVM to O_2 (ST group, 69%; TT group, 17%; $p < 0.001$), inserting an oral airway correctly (ST group, 88%; TT group, 20%; $p < 0.001$), and achieving an effective BVM seal (ST group, 97%; TT group, 20%; $p < 0.001$).

None of the TT residents achieved a perfect score on the seven essential tasks of initial airway manage-

Table 1—*Essential and Nonessential Steps of Initial Airway Management

Steps	Description
1	Identifies apnea
2	Calls for code team
3	Takes position at head of bed
4	Attaches oxygen to BVM and turns on full
5	Inserts oral airway correctly
6	Initiates two-person BVM ventilation
7	Achieves effective BVM seal
8	Requests pulse oximetry
9	Places towel under head of patient
10	Requests suction setup
11	Requests intubation tray be placed next to patient head

*Steps 1 through 7 are essential.

Table 2—*Performance of Individual Steps of Airway Management Among TT PGY3 Residents and ST PGY3 Residents

Airway Management Step	TT Group (n = 30)	ST Group (n = 32)	p Value
1	26 (87)	31 (97)	0.141
2	15 (50)	23 (72)	0.077
3	8 (27)	30 (94)	0.031
4	5 (17)	22 (69)	< 0.001
5	6 (20)	26 (88)	< 0.001
6	12 (40)	28 (88)	< 0.001
7	6 (20)	31 (97)	< 0.001
8	23 (77)	28 (88)	0.264
9	2 (7)	20 (63)	< 0.001
10	2 (7)	14 (44)	< 0.001
11	4 (13)	22 (76)	< 0.001

*Values are given as No. (%), unless otherwise indicated.

Table 3—*Performance of Individual Steps of Airway Management Comparing UT PGY1 Interns and TT PGY3 Residents

Airway Management Step	UT Group (n = 49)	TT Group (n = 30)	p Value
1	42 (86)	26 (87)	0.907
2	18 (37)	15 (50)	0.253
3	3 (6)	8 (27)	0.011
4	0 (0)	5 (17)	0.003
5	3 (6)	6 (20)	0.059
6	12 (24)	12 (40)	0.145
7	1 (2)	6 (20)	0.006
8	34 (69)	23 (77)	0.483
9	0 (0)	2 (7)	0.067
10	1 (2)	2 (7)	0.296
11	13 (27)	4 (13)	0.165

*Values are given as No. (%), unless otherwise indicated.

ment, while 38% of the ST group achieved perfect scores on these tasks ($p < 0.001$). Table 3 presents the 11 individual task scores for the UT group compared with the TT group. The senior residents performed significantly better in three of the seven essential tasks and zero of the four nonessential tasks. However, no resident in the TT or UT group was able to successfully complete all seven essential tasks of initial airway management, so no resident in either group was considered to have successfully resuscitated the patient.

Discussion

Our study suggests that SBT with a CPS is superior to a traditional experiential approach for training internal medicine residents in initial airway management skills. Using a simple and validated training model,[4,5] we have shown that a group of PGY3 internal medicine residents (ST group), who underwent SBT with a CPS as PGY1 residents, had superior performance compared to residents at the same level of training who had not received SBT with a CPS (TT group). Our results also show that, while SBT with a CPS is more effective than experiential training, the latter may be more effective than no training at all. Senior residents without simulation training (TT group) performed better than PGY1 residents who had not yet received any type of training in initial airway management (UT group).

This study has methodological limitations that reflect the intrinsic difficulty of studying the effectiveness of this form of simulation training. The comparison groups (*ie*, ST and TT groups) were from two different calendar years so that contemporaneous skill testing was not possible. A stronger study design would have split a same-year resident group into an intervention group and a control group. We did not do this, as we considered it unethical to deny part of a resident group training that we knew to be highly effective from our previous studies.[4,5] In addition, we were concerned that a single-year approach would result in "cross-contamination" of the two groups because they worked closely together throughout the year.

This study was not double-blinded. Although the participants had no knowledge of study group assignment or purpose, the scorers were not blinded to group assignment. This could have led to bias in scoring. However, our experience from prior studies is that two on-site independent scorers give concordant and accurate results and that the addition of blinded video-based scoring did not alter those results.

Another limitation is that it is not possible to determine exactly the respective contributions of simulation training and clinical experience to performance on repeat testing. The results of the comparison between the TT group and the UT group show that clinical experience alone results in improved performance. We believe that the powerful results of simulation training derive from its synergistic relationship with subsequent clinical activity. A related concern is that the testing performance on a CPS may not reflect skill in actual clinical events. We have shown in two prior studies[4,5] that SBT with a CPS was strongly associated with clinical proficiency in initial airway management. In these two studies,[4,5] we measured excellent clinical performance of residents during emergency endotracheal intubation events over a 10-month period following completion of the SBT program in initial airway management skills.

It is a well-established fact that physicians' skills in resuscitation are poor overall and deteriorate quickly over time.[10,13,15,17–20] Even senior anesthesiology residents make numerous management errors in simulation-based critical event scenarios.[3,21] In keeping with these results, none of the 30 TT group residents performed all seven essential tasks for successful resuscitation. This lack of skill occurred despite the fact that they trained alongside the ST residents who had excellent clinical performance due to simulation training in initial airway management.[5] Surrounded by competence, the TT group residents did not themselves become competent.

Initial airway management is a critical element of ACLS training. However, ACLS certification does not establish competence in resuscitation.[10,11] Standard ACLS training results in high levels of cognitive knowledge but poor performance in the physical aspects of resuscitation.[19] However, focusing on practical skills, equipment usage, and deliberate practice leads to excellent results when resuscitation skills are taught

using a simulator.[6,7,22,23] Our approach combined these learning components. We feel that the combined impact of an effective role-playing team, a realistic replicated work environment, and a believable clinical scenario with trainee "buy-in" resulted in a highly effective learning environment. If the trainee is then engaged in deliberate practice with actual equipment and a defined set of learning objectives, the result is successful training in initial airway management. This process of simulation training could be applied to many other aspects of resuscitation skills.

Our study raises some questions for future investigation. While the ST group performed better than the TT group, only 38% of the ST group completed all seven essential tasks of initial airway management. This suggests that they had a decrement in skill level compared to their perfect performance at the end of the training session in their PGY1. How often should physicians be trained in this important skill given that we have shown decrement over a 2-year period? There is a core group of critical psychomotor skills that is implicit to critical care training. Traditional board certification examinations only test cognitive knowledge, while simulation allows the assessment of complex psychomotor skills. The simulation environment also allows for accurate assessment of skill level. Should the simulator be used to test competency and if so, how often and with what consequence?

In conclusion, traditional experiential training during residency was inferior to training that included SBT with a CPS in managing a scenario of respiratory arrest. Residency program directors may wish to consider using SBT with a CPS to train their incoming residents in this critical resuscitation skill.

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