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Residents as teachers: optimizing the benefit of a difficult airway management simulation session

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Abstract

Background: Simulation is widely used in airway management training.

Objectives: To show that assigning anesthesia residents' simulation educator roles improved cognitive learning outcomes.

Methods: Postgraduate second- and third-year (PGY-2 and PGY-3) anesthesia residents were randomly assigned to three groups: a teacher group (T), a hot-seat (active participant) group (H), and an observer group (O). After a train-the-trainer session, the T group prepared simulation scenarios for difficult airway management and then conducted the simulation sessions and post-session debriefing. The H group participated in the scenarios, and the O group observed the sessions. All participants attended the post-session debriefing. Evaluation was conducted at pretest, immediate posttest, and 3 months (retention test). Score differentiation and average normalized gain were calculated. Participants completed a post-simulation class survey.

Results: Participants were 49 residents (PGY-2 = 24, PGY-3 = 25). The T group had the highest posttest score (17.06 ± 1.23); this score significantly differed from the O group (14.75 ± 2.57, P = 0.003) but not the H group (15.64 ± 1.54, P = 0.103). The average normalized gain was significantly higher in the T group than in the H and O groups (0.51 ± 0.22, 0.18 ± 0.32, and 0.17 ± 0.47, respectively; P = 0.012). Participants retained knowledge at 3 months after the session, with no significant differences among the groups. Most participants (45%) preferred to be active scenario participants, and 20% preferred to teach. Overall satisfaction was high in all groups.

Conclusion: This study showed that a teaching role can be effectively applied for residents in simulation-based education on difficult airway management to support better learning outcomes.

Keywords: anesthesia resident training; difficult airway; peer teaching; retention knowledge; role in simulation

Difficult airway management is a crucial issue for anesthesiologists. It requires an ability to manage the airway with appropriate decision-making within a limited time. This competency has to be trained and practiced extensively during residency training and throughout professional life. Given limitations in trainees' clinical exposure and concerns regarding patient safety, simulation-based training is widely used as an effective teaching method to improve learner performance and patient outcomes [1]. However, evaluation of the effectiveness of simulation in airway management training has been shown in satisfaction and behavior performance, but not in time management skills and cognitive knowledge [2].

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The instructional design of simulation practice is a key element in improving outcomes rather than the simulation itself [3]. Many factors influence the benefits of simulation-based education, including curriculum integration, deliberate practice, mastery learning, effective debriefing, clear outcomes, a controlled learning environment, simulator validity, and the learner's engagement [1, 3, 4]. These factors present challenges for effective education practice.

Simulation in anesthesia resident training involves various aspects such as regional anesthesia technique, cardiac anesthesia practice, anesthesia for obstetrics emergency, and difficult airway management. In addition, factors that may interfere with simulation training opportunities include increasing numbers of trainees, scarcity of simulation resources (including educators), and the limited training period. Not all learners can participate in a simulation session as active or "hot-seat" participants; therefore, an observer role was proposed. A systematic review provided evidence that combining with strategies such as structured observation tools and active involvement during the debriefing session, the observer role provided knowledge gain and satisfaction comparable with that of active participants [5]. However, the role in simulation-based education that may gain the greatest benefit in terms of learning outcomes is that of educator.

"Resident-as-teacher" is an active learning strategy that requires transformation of knowledge through developing a teaching action plan [6]. Benefits of the teaching role in peer teaching include relieving pressure on faculty, building confidence, preparing residents for educator roles, and gaining knowledge [7, 8]. The educator role in simulation teaching demands a lot of work. It requires expertise on the topic and the ability to set objectives in a limited time frame, create the scenario, conduct the session, and conduct the post-session debriefing. For effective teaching curricula, simulation educators have to be trained and verified. The literature highlights the effort required for peer teaching in simulation training, and confirms the effectiveness and feasibility of this application [8, 9].

In an effort to optimize the benefit of airway simulation teaching, we proposed that assigning residents a teaching role in a difficult airway simulation session would offer advantages compared with hot-seat participants and observers. This study evaluated educational benefits in terms of immediate knowledge gain and knowledge retention at 3 months in teacher, hot-seat, and observer roles in a difficult airway management simulation session. We also assessed participant satisfaction with the training session in all three groups.

Materials and methods

The study protocol was approved by the Siriraj Hospital Institutional Review Board (certificate of approval No. SI242/2016). A nurse who was not involved in the training program obtained informed consent from postgraduate second- and third-year (PGY-2 and PGY-3) residents in the anesthesia residency program at Siriraj Hospital, Mahidol University, Bangkok. In our curriculum, all residents take a difficult airway session in PGY-1 which comprises a difficult airway management lecture and hands-on skill training in difficult airway equipment. The difficult airway management simulation session was introduced in PGY-3 by faculty simulation educators during a team training session, which was set up after this study had finished. At the time of this study, there was no airway rotation in our curriculum. Exclusion criteria were residents who had participated in other airway simulation workshops or who declined to join the study.

Participants were randomly assigned to 3 groups: a teacher group (T group), a hot-seat group (H group), and an observer group (O group). Group assignment was based on stratified randomization of participants' last examination scores. In that examination, PGY-2 and PGY-3 residents completed the same multiple choice questions (MCQ) assessing cognitive anesthesia clinical knowledge. These examination scores were categorized into high, intermediate, and low score groups. Each score group was randomized into T, H, and O groups equally. The three study groups were then rearranged into smaller simulation groups of about six or seven participants (comprising two or three participants from each group). The airway management guideline from the Difficult Airway Society [10] was used as the standard reference for the session, and was assigned to all participants as pre-course reading. Session objectives, which focused on preoperative airway assessment and planning, and the difficult airway management guideline algorithm were also provided.

T group

All T-group participants received a train-the-trainer class. Four simulation educators in the anesthesia department, who were experts in airway management and regularly taught difficult airway management with simulation, were assigned as mentors and randomly delegated to each simulation group. The mentors acted as consultants for the T group during simulation session preparation which took about 2 weeks. T-group participants were asked to prepare two scenarios that covered "cannot intubate, can oxygenate" and "cannot intubate, cannot oxygenate" situations in the operating room, and to prepare for the post-simulation debriefing.

H group

H-group participants were asked to take active roles in the simulation sessions. As there were two or three H-group participants in each group, all participants who joined in the session at the same time, their role as the key persons were switched between the two scenarios. H-group participants joined the debriefing after each scenario was completed.

O group

The role of the O group was to observe the session and participate in the debriefing after the scenario was completed. Observation was conducted in a room next to the simulation room, with a one-way mirror and live video screen. This room was also used for the debriefing session. O-group participants were instructed to follow the difficult airway management guideline algorithm during the observation.

Train-the-trainer session

A 1-day train-the-trainer session was conducted for T-group participants. This training included lectures about how to teach with simulation, how to write a scenario, and how to conduct debriefing. A scenario example and template were provided to facilitate the session planning. The created scenarios were critiqued by the assigned mentor. Alpha testing was performed during the 2-week preparation period at the simulation lab.

Simulation session

The simulation session took place in the simulation lab at the Siriraj Medical Simulation Center for Education and Training 2 weeks after study recruitment. The operating theater was set up with a full-body mannequin patient simulator (Laerdal Simman^{TM}) and a patient monitor. Essential equipment, such as an anesthetic machine, intravenous line, and medication for resuscitation and anesthesia, were provided. Airway equipment, such as different sizes of endotracheal tubes, different kinds of laryngoscope blades, laryngeal mask airway, video laryngoscope, intubating laryngeal mask airway, gum-elastic bougie, and scalpels for cricothyroidotomy, were requested by the T group according to the prepared scenarios. Each scenario took about 10 minutes, and was conducted by the T group with a simulation specialist to assist in controlling the simulator.

Debriefing session

The T group facilitated the debriefing sessions which took about 40 minutes for each scenario. According to the difficult airway guideline, the focus of the debriefing sessions was knowledge and technical skills. All three groups actively participated the session. The assigned mentor was available to assist in the debriefing.

Evaluation

Twenty MCQs based on the difficult airway management guideline were created by two anesthesiologists with expertise in airway management. The stem of the questions included airway evaluation, preparation for difficult airway situation, and strategies for intubation and emergency surgical airway. The MCQ test was first completed by 10 nurse anesthetists to evaluate reliability. The internal consistency was more than 0.70 and considered acceptable [11], and the test was used to evaluate the learning outcomes in this study.

All participants completed the MCQ test three times: pretest, posttest, and a retention test. The pretest was administered on the day of study recruitment, which was about 2 weeks before the simulation class. The posttest was performed immediately after the simulation class was completed. Three months after the simulation class, the test was administered again for the retention test. There was no difficult airway management class or workshop during this 3-month period. Participants' scores were evaluated for differences among the three groups and improvement within each group. Participants also completed a post-simulation class survey, which evaluated their satisfaction with the session and opinions of the knowledge gained during this training. Responses were on a 1–5 scale (strongly disagree to strongly agree).

Statistical analysis

Statistical analyses were conducted with PASW Statistics version 18 (SPSS Inc., Chicago, IL, USA). Demographic data were presented as frequencies. Cronbach's alpha was used to calculate the internal consistency of the MCQ test and post-simulation class survey. Categorical data were evaluated with chi-square tests. Pretest, posttest, and retention test scores, and the average normalized gain and post-simulation class survey were analyzed for all three groups using analysis of variance (ANOVA), analysis of covariance, and Bonferroni multiple comparisons. Within group comparisons of the pretest, posttest, and retention test, scores were calculated with the repeated ANOVA measures. $P < 0.05$ was considered statistically significant.

Average normalized gain (g) was used to evaluate score improvement, which was defined as a ratio of the actual average gain and the maximum possible average gain [12].

$$g_1 = (\%\text{ posttest score} - \%\text{ pretest score}) / (100 - \%\text{ pretest score})$$

$$g_2 = (\%\text{ retention score} - \%\text{ pretest score}) / (100 - \%\text{ pretest score})$$

where g_1 = average normalized gain of posttest and g_2 = average normalized gain of retention test.

Results

There were 49 participants in this study: 24 PGY-2 and 25 PGY-3. There were no statistically significant differences in age, sex, grade point average, or simulation session experience (**Table 1**). Eight simulation classes that included 16 sessions were conducted by 16 T-group participants. Seventeen H-group members participated in the sessions, and there were 16 observers. The 20 MCQs were tested for internal consistency and had a Cronbach's alpha of 0.73. All participants completed the pretest, posttest, and retention test.

T group versus H group versus O group

There were no differences in pretest scores among the three groups: T group, 13.93 ± 1.48; H group, 14.41 ± 1.94; and O group, 13.37 ± 2.39. However, the T group had the highest immediate posttest scores. When compared using the Bonferroni post-hoc test, the mean score of the T group (17.06 ± 1.23) was statistically significantly different from that of the O group (14.75 ± 2.57, $P = 0.003$), but not from that of the H group (15.64 ± 1.54, $P = 0.103$). The H and O groups showed no difference in posttest scores. There were no significant differences in the scores for the three groups in the retention test. The highest average normalized gain was in the T-group posttest scores compared with the H and O groups ($g_1 = 0.51 \pm 0.22$ vs 0.18 ± 0.32 and 0.17 ± 0.47, $P = 0.012$) (**Table 2** and **Figure 1**).

Pretest versus posttest versus retention test

All three groups had higher posttest and retention test scores than pretest scores. There was a significant improvement in pretest scores in the T group (3.12 ± 0.39 for the posttest,

Table 1. Participants' demographic data

	Teacher group (n = 16)	Hot-seat group (n = 17)	Observer group (n = 16)	*P*
Age (years)				
25–30	15	17	16	0.35
>30	1			
Sex				
Male	2	2	2	0.99
Female	14	15	14	
Grade point average				
2.5–3.0	1	3	2	0.86
3.0–3.5	12	11	10	
>3.5	3	3	4	
Postgraduate year				
2	9	6	9	0.38
3	7	11	7	
Simulation experience				
1–2 times	1	2	0	0.52
3–5 times	12	11	10	
>5 times	3	4	6	

Table 2. Mean knowledge score comparison among the teaching, hot-seat, and observer groups: pretest, immediate posttest, and retention test

	Teacher group (n = 16)	Hot-seat group (n = 17)	Observer group (n = 16)	*P*
Pretest score[a]	13.93 ± 1.48	14.41 ± 1.94	13.37 ± 2.39	0.338
Posttest score[a]	17.06 ± 1.23	15.64 ± 1.54	14.75 ± 2.57	0.004*
Retention test score[a]	16.00 ± 2.00	15.47 ± 1.87	14.56 ± 2.16	0.135
g_1[a]	0.51 ± 0.22	0.18 ± 0.32	0.17 ± 0.47	0.012*,**
g_2[a]	0.28 ± 0.44	0.12 ± 0.43	0.10 ± 0.57	0.529

[a]Data are presented as mean ± standard deviation.
*Statistically significant difference between teacher and observer groups.
**Statistically significant difference between teacher and hot-seat groups.
g_1 = average normalized gain of posttest.
g_2 = average normalized gain of retention test.

$P < 0.001$; 2.06 ± 0.73 for the retention test, $P = 0.039$) and in the H group (1.23 ± 0.39 for the posttest, $P = 0.02$). The retention test scores were lower than the immediate posttest scores in all groups, but this was not statistically significant as shown in **Table 3**.

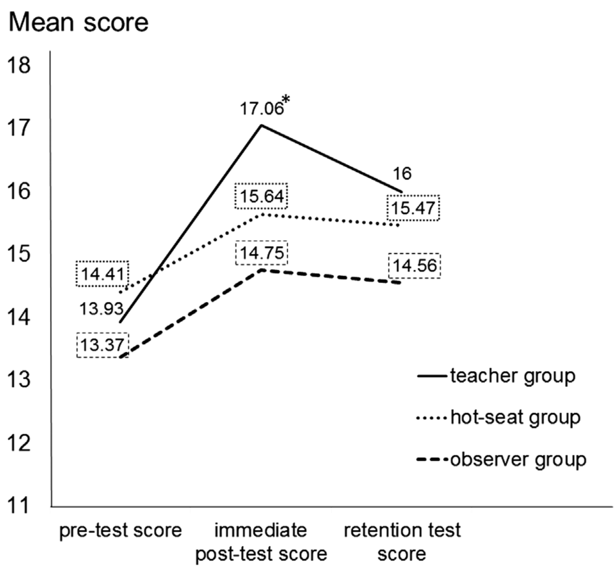

Figure 1. Score improvement from pretest to immediate posttest and retention test for the teacher, hot-seat, and observer groups. Data are represented as means. *Statistically significant difference between the teacher and observer groups.

Post-simulation session survey

The survey was administered after the simulation class. One participant was excluded because of incomplete responses. In total, 45% wanted to be active hot-seat participants, 20% wanted to be teachers, and 35% wanted to be observers (**Table 4**). Overall, participants reported satisfaction with the class, and that the knowledge gain was adequate. The Cronbach's alpha for the survey was 0.71.

Discussion

This study evaluated the learning outcomes for anesthesia residents in the roles of teachers, hot-seat participants, and observers in simulation-based difficult airway management training. Residents in teaching roles had the highest scores immediately after the difficult airway management simulation class compared with hot-seat and observer participants. The benefit of the teaching role was demonstrated by this group having the greatest improvement in knowledge scores immediately after training.

The average normalized gain (g) was used to evaluate score improvement regardless of pretest score. A g value of ≥0.7 was considered a high gain, <0.7 to ≥0.3 a medium gain, and 0.0 to <0.3 a low gain [12]. Only the T group showed a medium gain during the training. This result supports the evidence

Table 3. Within group score comparison between pretest, posttest, and retention test for the teacher, hot-seat, and observer groups

Group	Within group comparison		
	Pretest vs posttest score	**Pretest vs retention test score**	**Posttest vs retention test score**
Teacher group[a]	3.12 ± 0.39, $P < 0.001$	2.06 ± 0.73, $P = 0.039$	1.06 ± 0.62, $P = 0.325$
Hot-seat group[a]	1.23 ± 0.39, $P = 0.02$	1.06 ± 0.49, $P = 0.146$	0.18 ± 0.51, $P = 1$
Observer group[a]	1.37 ± 0.65, $P = 0.156$	1.19 ± 0.61, $P = 0.208$	0.19 ± 0.52, $P = 1$

[a]Data are presented as mean ± standard deviation.

Table 4. Post-simulation session survey results

	Teacher group (n = 16)	**Hot-seat group (n = 16)**	**Observer group (n = 16)**	***P***
The reality of the simulation session[a]	4.25 ± 0.58	4.37 ± 0.62	4.12 ± 0.50	0.466
Knowledge gain during preparation period[a]	4.50 ± 0.63	3.87 ± 0.88	4.19 ± 0.65	0.065
Knowledge gain during simulation session[a]	4.00 ± 0.63	4.31 ± 0.47	4.19 ± 0.54	0.287
Knowledge gain during debriefing[a]	4.31 ± 0.70	4.37 ± 0.50	4.31 ± 0.70	0.951
Overall adequate knowledge gain[a]	4.18 ± 0.54	4.12 ± 0.62	4.06 ± 0.44	0.808
Overall satisfaction[a]	4.37 ± 0.50	4.31 ± 0.47	4.18 ± 0.46	0.511

[a]Data are presented as mean ± standard deviation.

that traditional simulation training for airway management improves learners' knowledge and skills; however, knowledge acquisition may not be better than that from non-simulation training. There are several approaches, such as using cadaveric and animal models, highly sophisticated synthetic simulators, or hybrid simulation with standardized patients, for improving teaching airway management in simulation. The results for these methods were still inconclusive [2, 13]. Attention should be directed to improving simulation training sessions (e.g., implementing a teaching role) to improve learning outcomes.

This study highlighted the benefit and potential of the teaching role for anesthesia residents in simulation training. The value of peer learning has been widely recognized in medical education. Engaging in a teacher role provides intrinsic motivation to study more than just as a student. In addition, the peer teachers develop a deeper understanding of the content being taught. During the preparation period, the goal of the peer teachers was changed from reading to memorizing as learners to reading for the purpose of explaining to others. This difference in goal setting is reported to have an impact on learning outcomes [14].

Being a competent simulation educator requires training and practice. However, simulation can be effectively conducted by peer teaching. Providing a train-the-trainer program for peer teachers, along with instructions, objectives, and debriefing questions, is required to improve teaching skills [7] and effective outcomes [8, 9]. In this study, a 1-day train-the-trainer class was provided, but this could not guarantee the ability to teach with simulation. Therefore, a mentor system was introduced throughout the preparation period and during the sessions to ensure the standard of the sessions for other learners. Even though the teaching quality of T-group participants was not evaluated, the post-session survey indicated that participants were satisfied with the class and reported adequate knowledge gained from the session in all role assignments. Interestingly, relatively few residents wanted to be teachers (20%). This could be explained by the increased workload and time commitment required during the preparation period. To improve the methodology used in this study, comparison of satisfaction with peer teaching and satisfaction with faculty teaching should be investigated.

Simulation training improves the knowledge, skills, and performance of active participants. However, the benefits for the observer role are questionable. In this study, observer participants had lower scores at the immediate posttest compared with teaching participants, but not compared with active hot-seat participants. This implies that participating in a simulation session as an observer may have benefits comparable with hot-seat participation. A key area of focus is how to make the observer an active rather than a passive learner. Many factors influence observers' learning outcomes. Social learning theory describes four processes through which people learn from observation: attention, retention, motivation, and motor reproduction [15]. These processes should be recognized and applied to ensure effective learning during observation.

"Attention process" refers to the learners' ability to focus on the behaviors in the simulation session. Providing observation tools or guidelines may help learners to follow the scenarios. In this study, the difficult airway management guideline was assigned as a pre-course reading requirement. The guideline was also available for the O group during the observation period. In the "retention process," learners imprint the observation to their memory, which may be facilitated by engaging in the debriefing session. The debriefing session in this study was conducted immediately after each scenario. All participants were encouraged to discuss the scenario during this phase. The mentors were also available during debriefing to ensure that the debriefing session was effective. "Motivation" is an important consideration in adult learning. Learners may learn more if they have clear goal before the session starts. The well-prepared briefing session, the clear course objective, and the pre- and post-session assessments were considered extrinsic motivation for all participants in this study. The present study did not demonstrate the "motor reproduction process," which refers to observers being able to act as hot-seat participants and reproduce the behavior in the scenario after the debriefing. An opportunity for observers to rehearse the behavior from the organized mental model may contribute benefits for future application of this method.

Knowledge decreases over time. The frequency of knowledge and skill use and characteristics of the task play important roles in maintaining competence [16]. A difficult airway situation is uncommon in daily practice. Anesthesia residents in this study had experience in basic airway management almost every day in their clinical program, which enabled them to develop automaticity in airway skills; however, they might not be able to apply this expertise in advanced airway management [17]. Furthermore, cognitive knowledge (e.g., the difficult airway management guideline) is more susceptible to decay than physical skills. Attention should be directed to this issue in developing training strategies. Benefits of simulation-type learning in difficult airway management have been shown in terms of adherence to guidelines and skill retention [18, 19]. This study provides support for that evidence by demonstrating knowledge retention in all groups at 3 months after the training. The retention score of the T group was higher than the other groups, but this difference was not statistically significant. Therefore, the advantage of peer teaching in terms of knowledge retention compared with other roles remains unclear. Subsequent interventions after training should be considered in curriculum design, such as independent practice with effective feedback.

This study had some limitations. A difficult airway management situation requires knowledge, technical skills, and non-technical skills, all of which should be assessed with behavioral observation [17]. We used MCQs to evaluate participants' cognitive knowledge instead of simulation because of the different exposures to difficult airway scenarios in the three groups. Furthermore, the mentor system was involved in every process. This study demonstrated the ability of residents to teach with significant assistance. The four different mentors in this study might have created variability in the coaching system. Two T groups to one mentor were established to ensure the effectiveness of mentorship. As a result, the mentor system was also considered as a co-intervention in T-group higher score. A validated train-the-trainer session, simulation-based assessment, and role switching should be included to improve the design of future studies.

Conclusion

The benefit of simulation-based difficult airway management training could be improved by teaching role assignment. Peer teachers showed the greatest benefit in terms of knowledge gain. The application of peer teaching in simulation should be considered, with a pre-simulation train-the-trainer class and coaching during the simulation session.

Author contributions. TJ and KR contributed substantially to the conception and design of this study. PW and PA contributed substantially to the acquisition of data. SP and AS analyzed and interpreted the data. TJ drafted the manuscript. SP, PW, AS, PA, and KR contributed substantially to its critical revision. All the authors approved the final version submitted for publication and take responsibility for the statements made in the published article.

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Conflict of interest statement. The authors have completed and submitted the International Committee of Medical Journal Editors Uniform Disclosure Form for Potential Conflicts of Interest. None of the authors disclose any conflict of interest.

References

[1] McGaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB. Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. Acad Med. 2011; 86:706–11.

[2] Sun Y, Pan C, Li T, Gan TJ. Airway management education: simulation based training versus non-simulation based training - a systematic review and meta-analyses. BMC Anesthesiol. 2017; 17:17.

[3] Yang D, Wei YK, Xue FS, Deng XM, Zhi J. Simulation-based airway management training: application and looking forward. J Anesth. 2016; 30:284–9.

[4] McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation-based medical education research: 2003–2009. Med Educ. 2010; 44:50–63.

[5] O'Regan S, Molloy E, Watterson L, Nestel D. Observer roles that optimise learning in healthcare simulation education: a systematic review. Adv Simul (Lond). 2016; 1:4.

[6] Irby DM. Excellence in clinical teaching: knowledge transformation and development required. Med Educ. 2014; 48:776–84.

[7] Hill AG, Yu TC, Barrow M, Hattie J. A systematic review of resident-as-teacher programmes. Med Educ. 2009; 43:1129–40.

[8] Wagner M, Mileder LP, Goeral K, Klebermass-Schrehof K, Cardona FS, Berger A, et al. Student peer teaching in paediatric simulation training is a feasible low-cost alternative for education. Acta Paediatr. 2017; 106:995–1000.

[9] House JB, Choe CH, Wourman HL, Berg KM, Fischer JP, Santen SA. Efficient and effective use of peer teaching for medical student simulation. West J Emerg Med. 2017; 18:137–41.

[10] Frerk C, Mitchell VS, McNarry AF, Mendonca C, Bhagrath R, Patel A, Difficult airway society intubation guidelines working group. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. Br J Anaesth. 2015; 115:827–48.

[11] Tavakol M, Dennick R. Making sense of Cronbach's alpha. Int J Med Educ. 2011; 2:53–5.

[12] Hake RR. Interactive-engagement versus traditional methods: a six-thousand-student survey of mechanics test data for introductory physics courses. Am J Phys. 1998; 66:64.

[13] Kennedy CC, Cannon EK, Warner DO, Cook DA. Advanced airway management simulation training in medical education: a systematic review and meta-analysis. Crit Care Med. 2014; 42:169–78.

[14] Ten Cate O, Durning S. Dimensions and psychology of peer teaching in medical education. Med Teach. 2007; 29:546–52.

[15] Bethards ML. Applying social learning theory to the observer role in simulation. Clin Simul Nurs. 2014; 10:e65–9.

[16] Arthur W Jr, Bennett W Jr, Stanush PL, McNelly TL. Factors that influence skill decay and retention: a quantitative review and analysis. Hum Perform. 1998; 11:57–101.

[17] Baker PA, Weller JM, Greenland KB, Riley RH, Merry AF. Education in airway management. Anaesthesia. 2011; 66(Suppl 2):101–11.

[18] Kuduvalli PM, Jervis A, Tighe SQ, Robin NM. Unanticipated difficult airway management in anaesthetised patients: a prospective study of the effect of mannequin training on management strategies and skill retention. Anaesthesia. 2008; 63:364–9.

[19] Hubert V, Duwat A, Deransy R, Mahjoub Y, Dupont H. Effect of simulation training on compliance with difficult airway management algorithms, technical ability, and skills retention for emergency cricothyrotomy. Anesthesiology. 2014; 120:999–1008.