Original Article

Do Different Roles of Anesthesia Residents Improve Knowledge Retention after Non-Technical Skills Workshop?

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Objective: The authors assessed whether anesthesia residents who acted as a scenario creators would have better knowledge retention than their juniors 90 days after participating in a simulation-based anesthetists' non-technical skills (ANTS) workshop.

Materials and Methods: A prospective observational study via simulation ANTS workshop was conducted at a university hospital in southern Thailand in November 2017. Seven third-year post-graduate (PGY-3) residents volunteered as scenario creators, while the remaining anesthesia residents were randomly selected to participate in or observe three case scenarios, which were cardiac arrest, hypotension, and difficult ventilation. Resident's knowledge was assessed before, immediately after, and 90 days after the workshop using a 20-item multiple-choice questionnaire. Predictors of change in knowledge scores were analyzed using multivariate linear regression analysis and presented as beta coefficient (β) and 95% confidence limits (CL).

Results: Twenty-four anesthesia residents were recruited in the present study and included eight PGY-1, seven PGY-2, and nine PGY-3. The roles consisted of seven scenario creators, seven participants, and 10 observers. The overall immediate post-test and 90-day post-test scores increased significantly compared to the pre-test scores with a mean of 15.5 and 13.2 versus 11.7 ($p<0.001$ and $p=0.007$, respectively). The predictors of change in 90-day scores were PGY-3 versus PGY-1 (β 95% CL 4.0 [0.5 to 7.6], $p=0.039$), and role of participants and observers versus scenario creator (β 95% CL 5.5 [2.2 to 8.8] and 6.7 [2.8 to 10.6], $p=0.004$, respectively).

Conclusion: Anesthesia residents who were participants or observers could improve their knowledge 90 days after a simulation-based ANTS workshop without necessarily being a scenario creator.

Keywords: Anesthetists' non-technical skill; Knowledge retention; Scenario creator; Simulation workshop

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Anesthetists' non-technical skills (ANTS) are crucial in clinical anesthesia training. Although it is used worldwide, in Thailand, it has only just recently been introduced. ANTS is a behavioral marker tool that emphasizes communication skills as well as the ability to work in a multidisciplinary team to promote patient safety[1,2]. ANTS consists of four categories, namely task management, teamwork and communication, situation awareness, and decision making[1,2]. Mete and Brannick (2017) reported that the number of evaluators, skill level range of trainees, and the process of learning were predictors of the reliability of the assessments[3]. Al-Elq (2010) reported that learning ANTS by simulation promoted clinical competency in medical students and postgraduate trainees, as well as enhancing patient safety and reducing hospitalization costs[4]. For this reason, resident ANTS training using simulation has been implemented in the authors' institute since 2017. Moreover, ANTS simulation has been reported to assist in knowledge retention among medical students and critical care physicians[5,6]. Therefore, first, the authors would like to determine if post-graduate (PGY) anesthesia residents acting as scenario creator have better knowledge retention after a simulation-based ANTS training compared to first- or second-year residents acting as participant or observer. Second, to determine whether the training can improve knowledge among all participants.

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Materials and Methods

The present study was a prospective observational study conducted after the approval was granted by the Ethics Committee, Faculty of Medicine, Prince

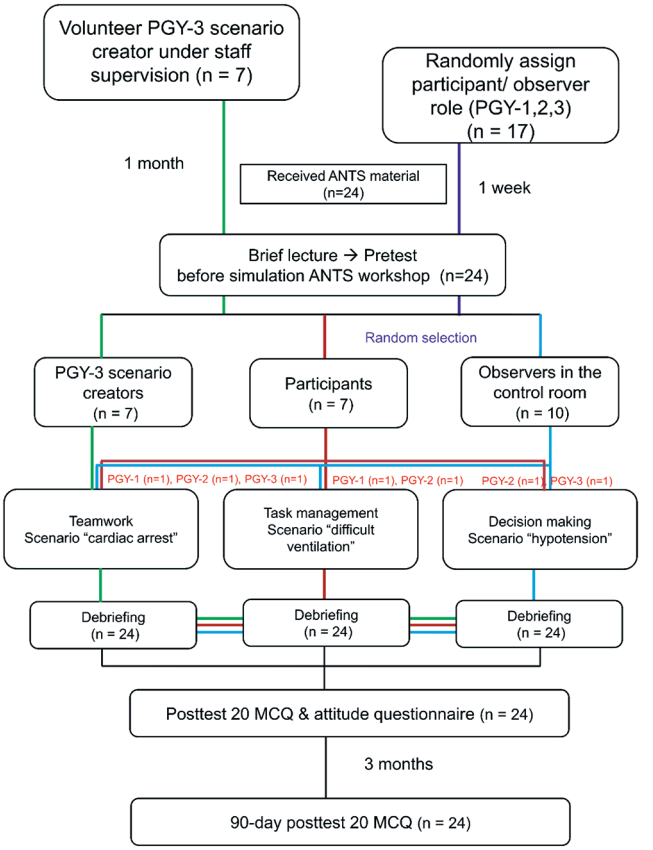

Figure 1. Step of Anesthetists' non-technical skill simulation-based training.

PGY: postgraduate year; ANTS: anesthetists' Non-Technical Skills; MCQ: multiple choices questions.

of Songkla University on August 26, 2017 (REC 60-366-08-1). The authors recruited all anesthesia residents consisting of PGY-1, PGY-2, and PGY-3 who attended a simulation-based ANTS training workshop at the Simulation center, Faculty of Medicine, Prince of Songkla University in November 2017. Written informed consent was waived by the Ethics Committee since it was a part of the anesthesia training program.

Step of simulation-based training (Figure 1)

All participants were informed of the schedule of the workshop one month in advance. Seven PGY-3 residents volunteered to act as scenario instructors and role creators. They developed one scenario under the supervision of the anesthesia staff (Oofuvong M), which was a "cardiac arrest" scenario under the theme "teamwork & communication". Two other scenarios were developed, which were "hypotension" and "difficult ventilation" scenarios under the theme "decision making" and "task management". They were developed by two other anesthesia staff (Pattaravit N and Kanjanawanichkul O, respectively). All residents of PGY-1, PGY-2, and PGY-3 received the ANTS material one week before the workshop. Three days before the workshop, the alpha test and beta test to simulate the three scenarios were conducted for three hours to ensure the readiness of the manikins and workstation. On the day of the workshop, the residents received a 10-minute briefing of overall concepts of the ANTS by Oofuvong M and a pretest consisting of 20 multiple choices questions (MCQ) . Each scenario consisted of a 30-minute simulation workshop and a 30-minute debriefing session.

One third-year resident, one second-year resident, and one first-year resident were randomly selected to participate in the scenario theme "teamwork & communication", while the remaining residents observed via a monitor in the observer room. The first case scenario was run by seven third-year residents and Oofuvong M for 30 minutes. The next 30 minutes was used for debriefing. One third-year

and one second-year resident were randomly selected to participate in the theme "decision making" ran by anesthesiologist staff (Pattaravit N) in the control room. One second-year resident and one first-year resident were randomly selected to participate in the theme "task management" ran by anesthesiologist staff (Kanjanawanichkul O) in the control room. The remaining anesthesia residents were observers. Each debriefing period was attended by all anesthesia residents.

After finishing the workshop, all residents completed the posttest and a 10-item attitude questionnaire each consisting of a visual analogue scale (VAS) ranging from 0 as strongly disagree to 10 as strongly agree. An anesthesia staff (Oofuvong M) explained all the answers from the MCQ after the immediate posttest. During the midterm examination, which was 90 days after the ANTS workshop, the residents were required to complete the posttest.

Operational definition

Knowledge retention was defined as knowledge or memory that is retained for 90 days after the simulation-based ANTS training workshop. The scenario creator was defined as a PGY-3 resident who created the scenario under supervision of anesthesia staff and ran the scenario throughout the simulation period. A participant was defined as a first-, second- or third-year resident who participated as a team leader or team member in the scenario. An observer was defined as a first- or second-year resident who was an observer in the observation room.

Outcome of the study and outcome measurement

The primary outcome of the study was the 90-day posttest knowledge score, which was calculated from the 20-item MCQ performed 90 days after the ANTS workshop. The secondary outcome was the difference in knowledge scores between immediate posttest and pretest.

Development and validation of questionnaires: The reliability of the pretest and posttest MCQ items were 0.90 and 0.95, respectively, assessed by two anesthesiologist staff (Pattaravit N and Siripruekpong S). The pretest and immediate posttest questionnaires were the same whereas the 90-day posttest questionnaire differed from the pretest questionnaire by three items. The authors modified three items from the pre-test to have more application taxonomy. Therefore, 80% of the 90-day posttest consisted of application of skills with 16 out of 20 items, and 20% was recall with four out of 20 items. The content of the questionnaire consisted of 25% situation awareness with five out of 20 items, 25% task management with five out of 20 items, 30% teamwork & communication with six out of 20 items, and 20% decision making with four out of 20 items.

Predictors and potential confounders

The main exposure variable was the resident's role in the scenario as creator, participant, or observer. Potential predictors were gender, PGY-1 to 3, percentage of self-study prior to attending the workshop, whether the participant attended a preworkshop lecture, and the number of times the participant attended previous ANTS lectures and workshops.

Sample size calculation

A pool of 24 residents were available throughout the three years of training. For the primary objective, the authors hypothesized that the 90-day posttest score would be five points out of 20 higher than the pretest score with a standard deviation of three points under a level of significance of 0.05 and 80% power to detect this increase. Therefore, the required sample size, again assuming a 10% drop out rate at 90 days, was 21 residents with seven residents per group. For the secondary objective, the authors used the overall score to calculate the sample size. The authors hypothesized that all residents would have 80% knowledge retention after 90 days with a precision of 20% under a level of significance of 0.05. Therefore, the sample size would be 15, but this was increased to 18 residents under the assumption that 10% would drop out after 90 days.

Data analysis

Continuous variables were presented using the median and interquartile range for non-normally distributed data or mean and standard deviation (SD) for normally distributed data. Categorical variables were presented using frequency and percentage and compared using Fisher's exact test or Pearson's chi-square test. Continuous variables were compared using Kruskal-Wallis tests and analysis of variance as appropriate. Predictors associated with pretest score, immediate posttest score and 90-days posttest score were compared using a multivariate linear regression model using a stepwise backward elimination method to select the best model. The authors included all exploratory variables to the initial multivariate linear regression model even though their p-value from the univariate analysis was greater than 0.2, since

Table 1. Comparison of characteristics of anesthesia residents between 3 roles

Characteristic	Role; n (%)			p-value
	Scenario creator (n=7)	Participant (n=7)	Observer (n=10)	
Sex (male/female)	2/5	1/6	3/7	0.85
Post-graduate year				<0.001*
1	0 (0.0)	2 (28.6)	6 (60.0)	
2	0 (0.0)	3 (42.9)	4 (40.0)	
3	7 (100)	2 (28.6)	0 (0.0)	
Percentage of self-study				0.168
0 to 25	3 (42.9)	3 (42.9)	5 (50.0)	
>25 to 50	0 (0.0)	3 (42.9)	4 (40.0)	
>50	4 (57.1)	1 (14.3)	1 (10.0)	
Lecture participant	6 (85.7)	7 (100)	7 (100)	0.58
Number of times attended previous lecture; median (IQR)	2 (1.5, 3.0)	0 (0, 0.5)	0 (0, 0)	<0.001**
Number of times attended previous workshop; median (IQR)	2 (1.0, 2.5)	0 (0, 0.5)	0 (0, 0)	<0.001**

IQR=interquartile range

* Fisher's exact test, ** Kruskal-Wallis test

Table 2. Comparison of pretest and posttest scores, and change from baseline, between anesthesia residents acting in 3 roles

Test	Overall (n=24); mean±SD	Role; mean±SD			p-value
		Scenario creator (n=7)	Participant (n=7)	Observer (n=10)	
Pre-test	11.7±2.4	12.3±2.4	10.7±3.0	12.0±1.9	0.44
Immediate post-test	15.5±2.5	15.4±3.3	15.4±3.0	15.5±1.6	0.99
90-day post-test	13.2±2.6	12.6±2.5	12.4±3.0	14.1±2.2	0.34
Immediate post-test to pre-test; median (IQR)	4.0 (1.8, 5.0)*	2.0 (1.0, 5.0)	4.0 (2.0, 7.0)	4.0 (2.3, 4.0)	0.50
90-day post-test to pre-test; median (IQR)	2.0 (0.0, 3.0)*	0.0 (–1.0, 1.5)	2.0 (0.5, 3.0)	2.5 (1.3, 3.0)	0.31

SD=standard deviation; IQR=interquartile range

p-value by Kruskal-Wallis test, * Significant at p<0.01

they were all related to internal validity threat. The strengths of the associations were presented as beta coefficients with 95% confidence limits.

Results

Twenty-four anesthesia residents were recruited, including eight PGY-1, seven PGY-2, and nine PGY-3 residents. The roles consisted of seven scenario creators, seven participants, and 10 observers. Table 1 compares their characteristics. All creators were third year residents, while a higher proportion of observers were first-year residents. Scenario creators had more experience in terms of attendance at previous ANTS lectures and workshops compared to participants and observers. Table 2 compares the pretest scores, immediate posttest scores and 90-day posttest scores among the three groups. The histogram of pretest scores showed normal distribution (Figure 2). The overall immediate and 90-day post-test scores increased significantly compared to the pre-test score at 15.5 versus 11.7 (p<0.001) and 13.2 versus 11.7 (p=0.007, respectively). However, the differences in pretest and two posttest scores between the three roles were not statistically significant nor the change in scores from the baseline.

In univariate analysis of potential predictors for pre-test score, differences between immediate post-test compared to pre-test score and difference between 90-day post-test compared to pre-test score among anesthesia residents. The histogram of immediate posttest score and 90-day posttest score also showed a normal distribution (Figure 3, 4). Predictors of higher pretest score were gender (p=0.025), the year of study (p=0.009), the role of the resident (p=0.0004), and participation in a previous ANTS workshop (p=0.008).

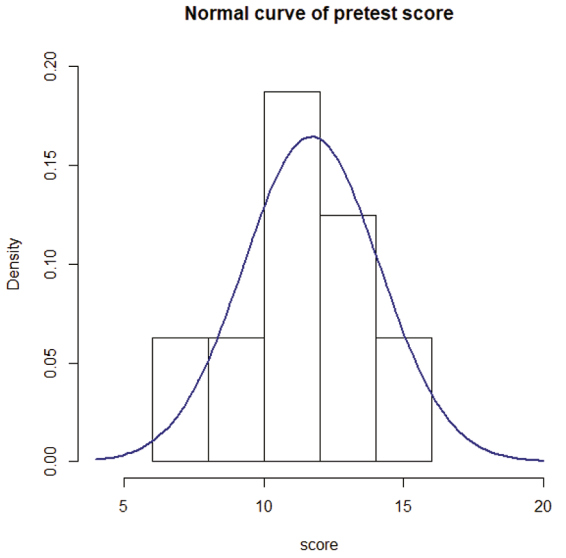

Figure 2. Histogram of pretest score.

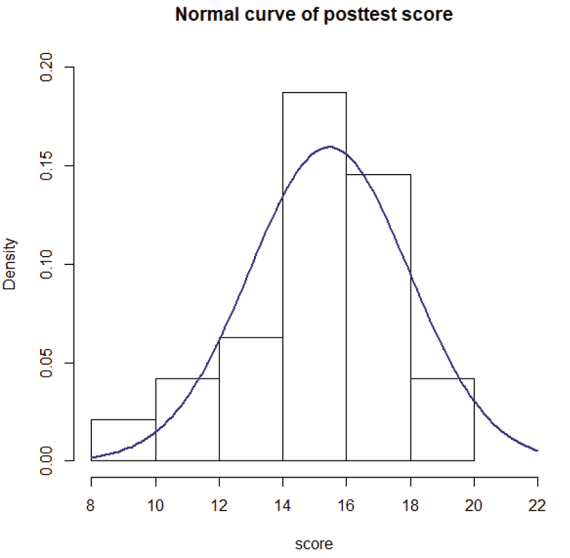

Figure 3. Histogram of immediate posttest score.

Table 3 shows results of the multivariate analysis to identify associated factors for the change in knowledge scores immediately and 90 days after the training workshop. Predictors of change in knowledge score immediately after the training were the graduate year, the role of the resident, and being participant of an ANTS lecture prior to the workshop. Third-year residents had significantly higher increase in knowledge score compared to first year residents (p=0.0003). Furthermore, scenario creators had a significantly lower increase in knowledge score compared to participants and observers (p=0.0005), and those who participated in an ANTS lecture prior to the workshop had a significantly lower increase in knowledge score compared to those who did not.

Predictors for change in knowledge score at 90-days were similar to those for the change in scores immediately after the training.

Table 4 shows a summary of the attitude items among resident in the three roles. The overall Cronbach´s alpha coefficient was 0.946. Cronbach's alpha for each item ranged from 0.936 to 0.947. The overall attitude score (mean±SD) after attending the workshop was 8.91±0.80. The two highest scoring items were "the facilitators showed good intention to teach" (9.52±0.71) and "the simulation workshop was applicable to normal practice" (9.12±0.91). Two items, "the atmosphere supported me to learn" and "the facilitators showed good intention to teach", scored significantly lower by scenario creators compared to the other groups.

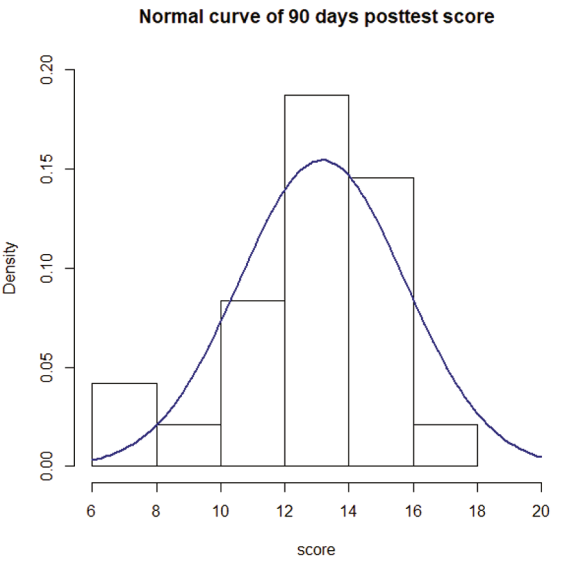

Figure 4. Histogram of 90-day posttest score.

Discussion

Since ANTS was introduced to anesthesia training in Thailand in 2016, the authors realize that non-technical skills are just as important as technical skills in anesthesia, especially situation awareness. The authors recently published a report suggesting that anesthesia staff may sometimes lack situation awareness by allowing trainees to manage difficult airways in children[7]. The present study found that the overall immediate post-test scores increased significantly compared to the pre-test scores at 15.5

Table 3. Predictors for pre-test score, differences between immediate post-test compared to pre-test score and difference between 90-day post-test compared to pre-test score among anesthesia residents

Predictors	Pretest		Immediate post-test to pre-test		90-day post-test to pre-test	
	β (95% CL)	p-value*	β (95% CL)	p-value*	β (95% CL)	p-value*
Sex (ref=female): male	2.98 (0.68 to 5.27)	0.025	-		1.96 (-0.06 to 3.98)	0.075
PGY (ref=1)		0.009		0.0003		0.039
2	3.69 (1.33 to 6.04)		1.00 (–0.82 to 2.82)		–0.43 (–2.62 to 1.76)	
3	–4.12 (–9.51 to 1.27)		7.30 (4.22 to 10.38)		4.03 (0.50 to 7.56)	
Role (ref=Scenario creator)		0.0004		0.0005		0.004
Participant	–6.96 (–4.10 to –9.83)		7.00 (4.19 to 9.81)		5.49 (2.20 to 8.78)	
Observer	–6.27 (–2.79 to –9.76)		7.90 (4.49 to 11.31)		6.70 (2.78 to 10.62)	
Percentage of self-study (ref=<25)		0.005	-		-	
25 to 50	1.15 (–1.06 to 3.36)					
>50	–4.44 (–1.94 to –6.93)					
Lecture participant	3.46 (–0.15 to 7.08)	0.083	–4.50 (–8.22 to –0.78)	0.029	–4.99 (–9.30 to –0.68)	0.037
Previous lecture participant	–6.89 (–11.85 to –1.94)	0.017	-		-	
Previous workshop participant	9.13 (3.44 to 14.81)	0.008	-		-	

β=beta coefficient; CL=confidence limit; PGY=post-graduate year

* F-statistic

Table 4. Comparison of attitudes toward non-technical skills simulation- based training of anesthesia residents among 3 roles

Item	Overall; mean±SD	Role; mean±SD			p-value†
		Creator	Participant	Observer	
A1	8.96±1.00	8.6±1.1	9.3±0.8	9.0±1.1	0.421
A2	9.02±0.96	8.6±1.1	9.3±0.5	9.2±1.1	0.340
A3	9.12±0.91	9.0±1.0	9.5±0.5	8.9±1.1	0.450
A4	8.88±0.90	8.3±0.8	9.3±0.5	9.0±1.1	0.093
A5	8.17±0.82	8.1±0.7	8.7±0.8	7.8±0.8	0.069
A6	8.83±1.01	8.3±1.3	9.4±0.5	8.8±0.9	0.100
A7	8.88±0.94	8.1±0.7	9.6±0.4	8.9±1.0	0.010
A8	8.83±1.10	8.1±1.1	9.5±0.5	8.8±1.2	0.063
A9; median (IQR)	10.0 (9.0, 10)	9.0 (8.0, 9.2)	10 (9.5, 10)	10 (10, 10)	0.005*
A10; median (IQR)	9.0 (8.0, 10)	8.0 (8.0, 9.2)	10 (9.0, 10)	9.0 (9.0, 9.8)	0.207*
Overall	8.91±0.80	8.4±0.8	9.4±0.4	8.9±0.8	0.081

SD=standard deviation; IQR=interquartile range

† ANOVA F test, * Kruskal-Wallis test

versus 11.7, and the increase in knowledge was maintained at 90 days at 13.2 versus 11.7. However, this finding might lack internal validity since it was a one group pretest posttest design. The threat of internal validity from a pretest posttest design might arise from confounding by participant characteristics such as gender and PGY, maturation such as experience of previous ANTS workshop and experience of ANTS in normal practice during training, and testing due to pretest practicing before the ANTS workshop[8,9]. Therefore, the authors attempted to minimize those threats by using a multivariate model and including potential confounders such as gender, PGY, and previous ANTS experiences, with the main exposure variable as participant role into the model. Even though the authors performed a multivariate analysis, the testing threat due to pretest practicing may not have been eliminated since using the same 20-item MCQ questionnaire for the immediate posttest and 17 MCQ questionnaire for the 90-day posttest.

Overall, residents improved in immediate and 90-day posttest scores. Scenario creators did not retain as much knowledge after the workshop compared to participants and observers. The reasons for this are two-fold. First, residents who were scenario creators were confined to the scenario they attended as they did not participate in all scenarios, and their role was changed to observers in the other two scenarios. Being an observer helps the resident to perform critical thinking in how to manage the situation in the scene with no added pressure. Second, the debriefing session after each scenario aided the residents to comprehend the core theme of each scenario and how each element of ANTS was applied in the scene as well as the participant's performance. Moreover, the authors did not invite the scenario creators to facilitate the residents in the "teamwork & communication" theme during the debriefing session. They might have retained more knowledge if they were encouraged to perform a facilitator role similar as scenario creators. A systemic review reported that the learner's performance can be improved after a self-led debriefing or standardized multimedia debriefing or even with no debriefing with experienced practitioners after ANTS simulation training with a box-trainer, mannikin, or virtual reality, or non-simulator training using a video or an instructor[10,11]. Boet et al (2011) also reported that both self-debriefing and instructor debriefing could improve ANTS performance in the pretest and posttest[12].

There were no differences in the immediate and 90-day posttest and pretest knowledge scores among scenario creators, participants, and observers (p=0.50 and 0.31, respectively) (Table 2). However, in the multivariate analysis, participants and observers had significantly higher improvement in immediate posttest knowledge compared to scenario creators, (p=0.0005) (Table 3). The reasons for this were three-fold. First, after adjusting for other factors, scenario creators had a significantly higher pretest score compared to the other roles (p=0.0004) (Table 3). This may be because scenario creators were PGY-3 and had some past experiences of ANTS in their residency training as well as being scenario creators in this workshop. Therefore, their knowledge did not improve as much after the workshop. Second, the 20 MCQ questionnaire contained 80% of application skills, which might be a challenging task for the residents, especially those who were scenario creators, to apply those scenarios to each ANTS category since they focused only on the "teamwork & communication" theme. Third, the 20-item MCQ questionnaire might not be an appropriate tool to measure knowledge, although it may have represented overall non-technical knowledge, it may not have represented clinical skills. Raksamani et al (2020) reported a moderate correlation between resident's knowledge scores and non-technical skills assessments using the ANTS scoring system by two independent raters[13]. The ANTS is a tool of evaluation of a behavioral marker system[1,14]. Using the ANTS system by two independent raters to evaluate the video of participants' performance is the appropriate measurement after ANTS simulation workshop[13,15]. However, the authors did not intend for all residents to participate in the workshop. The authors categorized residents into three roles, therefore, the ANTS system by two independent raters was not performed in the present study. Matos et al (2020) reported a positive evolution of the resident self-assessment of safety culture and communication skills over their simulation workshop[16]. Therefore, the self-evaluation of all 15 elements of ANTS after a 90-day workshop might be a better tool to represent the outcome measurement.

Regarding the attitude questionnaire, since the subjects were anesthesia residents who were well educated, the VAS was a reasonable tool to use in the present study. The attitude questionnaire had high internal validity with a Cronbach's alpha coefficient of 0.95. The overall attitude score after attending the simulation workshop was quite high at 8.9 over 10. However, the scenario creators gave significantly lower scores in some of the items of the "the atmosphere supported me to learn" and "the facilitators showed good intention to teach" compared to participants and observers. This may be because the scenario creators had to control the scene to make participants achieve the scenario objective while the participants and observers just participated and observed the scenario.

The ANTS simulation workshop was an essential course that all anesthesia residents were required to do to complete their training. Although the authors can ensure all residents attend the course to gain some basic knowledge in ANTS, they cannot truly evaluate their performance in clinical practice. The knowledge they had gained from the training course will be transferred to clinical practice to ensure patient safety in anesthesia.

Strengths and limitation

The authors performed a multivariate analysis, controlling for possible confounders, to examine if

the role of the resident was an independent predictor of the outcomes. The authors did not directly evaluate the non-technical skills of each resident because of the study design. Self-evaluation of four ANTS categories with 15 elements after the 90-day workshop could be applied to evaluate such non-technical skills in normal practice. Since the authors minimized the internal validity threat, the generalizability of the present study findings could be applicable.

Conclusion

A simulation-based ANTS training workshop using third-year postgraduate residents as scenario creators could help residents retain knowledge at 90-days.

What is already known in this topic?

ANTS is a behavioral marker tool that emphasizes communication skills as well as the ability to work in a multidisciplinary team. Therefore, it is crucial in clinical anesthesia training. ANTS simulation has been reported to assist in knowledge retention among medical students and critical care physicians. However, reports on knowledge retention among anesthesia residents after a simulation-based ANTS training are limited.

What this study adds?

In the present study, the authors determined if post-graduate third year anesthesia residents acting as a scenario creator have better knowledge retention 90 days after a simulation-based ANTS training compared to first- or second-year residents acting as a participant or observer by using a 20-item multiple-choice questionnaire. The study results indicated that anesthesia residents who were a participant or observer could improve their knowledge 90 days after a simulation-based ANTS workshop without necessarily being a scenario creator, which was confirmed by a multivariate linear regression analysis.

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Ethical approval

The study (Protocol # 60-366-08-1) was approved by the Human Research Ethics Committee, Faculty of Medicine, Prince of Songkla University (Chairperson Assoc. Prof. Boonsin Tangtrakulwanich) on 16 November 2017.

Funding disclosure

Faculty of Medicine, Prince of Songkla University, Hat Yai, Thailand.

Conflicts of interest

The authors have no conflicts of interest.

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