

ORIGINAL ARTICLE

Can NOTSS methodology improve ACGME competencies when combined with simulation-based education?

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Abstract

Background: An expanding neck hematoma after thyroidectomy is a rare complication requiring urgent airway management and potential bedside evacuation before definitive surgical management. During our review of the literature, no evidence of an adequate teaching method for the management of post-thyroidectomy hematoma for novice learners was found. This study aimed to determine if Non-Technical Skills for Surgeons (NOTSS) methodology can improve Accreditation Council for Graduate Medical Education (ACGME) competencies when combined with simulation-based education. **Methods:** This study used a randomized controlled study design to evaluate the performance of ACGME competencies among two study groups. The intervention group participated in a 30-min NOTSS lecture and a 25-min simulation scenario, and the control group participated in a 25-min simulation scenario only. A follow-up scenario was conducted to evaluate residents' performance in neck hematoma management. The study's primary outcome was participants' total performance scores on the six ACGME competencies (patient care, medical knowledge, interprofessional and communication skills, professionalism, practice-based learning and improvement, and system-based practice). **Results:** This study did not show a statistically significant difference in the total performance scores on the six ACGME competencies among the two study groups (35.2 ± 3.62 versus 31.7 ± 3.75 ; $P=0.077$). In addition, there were no statistically significant differences in the performance scores for any of the six ACGME competencies. **Conclusions:** This study failed to confirm our hypothesis that NOTSS methodology can improve ACGME competencies when combined with simulation-based education. A study with a bigger sample size and a higher number of observable events may be necessary to have the power to detect a statistically significant difference. In addition, there was a long delay in the study due to the Coronavirus-19 pandemic. Less retention of skills in the intervention group may have changed the results of the study. Some of the later evaluation scenarios were done under the rules of social distancing which could alter the efficacy of the teaching.

Keywords: neck hematoma; non-technical skills; simulation-based education

Introduction

Non-technical skills (NTS), such as communication, team working, and task coordination, have been shown to improve patient safety.¹ Up to 70%–80% of adverse events in health care are associated with errors in NTS.² The Non-Technical Skills for Surgeons (NOTSS) framework describes behavior markers for NTS in surgery, which allow surgeons to practice safely and minimize errors.^{3,4} This NOTSS framework focuses on four key essential NTS: situation awareness, decision-making, teamwork and communication, and leadership.³ In addition, the NOTSS framework has been validated for teaching and evaluating essential NTS for

practicing safe surgery to a multidisciplinary team of novice learners including surgery residents and nurses.^{3–8} Furthermore, the NOTSS framework has been shown to improve team performance in the operating room especially during a crisis.⁹

Neck hematoma is a rare postoperative event with an incidence between 0.53% and 1.43%.^{11–13} A review of 150,012 patients found a post-thyroidectomy hemorrhage incidence of 1.25% with higher mortality in this group (1.34% versus 0.32%).¹¹ General surgery residents may finish a residency without being exposed to this event clinically. Simulation-based education can be an adequate solution to ensure that

residents are exposed to this situation. A simulated case of post-thyroidectomy hematoma was used in this study to teach management of neck hematoma.

The ideal treatment plan for postoperative neck hematoma consists of quick recognition, adequate evaluation of airway compromise, release of sutures, evacuation of hematoma, and reoperation.¹⁸ Cervical hematoma presents as a large, dense, firm, immobile anterior or lateral cervical swelling under the incision. It may quickly lead to airway compromise with signs of upper airway obstruction such as dyspnea, stridor, and hoarseness; therefore, quick recognition and appropriate management are important to avoid poor outcome.¹⁸ Most evacuations are done before intubation in the operating room (79% versus 21%) to decrease the risk of a difficult airway.¹⁸ Simulation-based education has been used previously to teach rare events to novice learners with a focus on both technical skills and NTS.^{19–26}

During our review of the literature, no evidence was found of an adequate teaching method for the management of post-thyroidectomy hematoma for novice learners. Therefore, to address that gap, our study aimed to determine if Non-Technical Skills for Surgeons (NOTSS) methodology can improve Accreditation Council for Graduate Medical Education (ACGME) competencies when combined with simulation-based education. The six ACGME competencies (patient care, medical knowledge, interprofessional and communication skills, professionalism, practice-based learning and improvement, and system-based practice) were assessed after NOTSS education.¹⁰

Hypothesis

We hypothesized that the NOTSS methodology can improve ACGME competencies when combined with simulation-based education.

Methods

Study design

This study used a randomized-control study design to evaluate ACGME competencies of participants after a simulated case of post-thyroidectomy hematoma. The data collection tool was developed using a modified Delphi method. After completing a literature review, an initial draft of 27 questions was sent by email to five experts who gave feedback about which questions should be removed from the final data collection tool. We then organized one in-person meeting to achieve consensus and to finalize the data collection tool of 22 essential questions (Appendix 1). The team included four surgeons and one anesthesiologist. To be considered an expert, the participants had to be board-certified

in surgery or anesthesia and involved in teaching surgical residents.

Description of the intervention

The investigators proposed the following structure. (1) The intervention group took part in a 30-min NOTSS lecture³³ and a 25-min simulation scenario (10 min for the scenario and 15 min for debriefing; Appendix 2). The NOTSS lecture covers four essential NTS for surgeons, including situation awareness, decision-making, communication and teamwork, and leadership. This content was presented to the intervention group by a trained NOTSS instructor. (2) The control group took part in a 25-min simulation scenario (10 min for the scenario and 15 min for debriefing).

The simulation scenario allowed learners to apply their knowledge to a situation similar to a real-world experience and practice their NTS and technical skills. During debriefing, the intervention and control groups received all components of the NOTSS course.

Study participants

All general surgery residents (post-graduate year [PGY] 1–4) were eligible to attend this post-thyroidectomy simulation-based training. PGY 5 surgery residents were excluded from this study.

Study conduct

A consent form was provided to eligible study participants during weekly morning meetings. One co-investigator reviewed the information on the form with potential participants. After an opportunity to address questions, written consent was obtained. The post-thyroidectomy simulation-based training was conducted by a team of two experienced surgeons, one anesthesiologist, and one experienced nurse. The scenario required the study participant to function as an on-call resident. A low-fidelity trainer/manikin was used to simulate the patient findings, and supporting roles in the scenario were played by colleagues who followed pre-determined standardized scripts.

Outcome

The study's primary outcome was the participants' total performance scores on the six ACGME competencies (patient care, medical knowledge, interprofessional and communication skills, professionalism, practice-based learning and improvement, and system-based practice).

All scenarios were audio-video recorded in blinded fashion. Two independent raters (surgeons) reviewed all videos and, using a pre-determined data collection tool (Appendix 1), scored each participant's performance. The raters did not know the participants and inter-rater reliability was

calculated. Raters were educated on the data collection tool by the research team.

Data management

After giving consent, each participant was provided with a unique identifying number. This number was used for all data analysis and storage. The principal investigator had sole access to the demographic information as it related to the unique identifying number. Study materials were kept in a locked file in the office of the principal investigator. Data materials will be kept for a period of 5 years.

Statistical analysis

The sample size was calculated a priori for the mean difference in average ACGME competencies between the intervention and control groups. Previous literature determining NTS scores demonstrated an average mean difference of 2 between scores and a standard deviation (SD) of 3.1 (standard deviation of the mean difference [SMD], 0.645).²⁸ Assuming a two-tailed test with $\alpha=0.05$, 80% power, an effect size with SMD=0.645, and SD=3.1, 16 participants were required (eight participants per group) to detect a difference in overall average ACGME score of 20% between the control and intervention arms.

Two independent raters rated the performance of the participants in each scenario according to the ACGME competencies. Raters were blinded about the participants' level of education and study group. Scores were assigned for each ACGME competency, summed to provide an overall average ACGME score (0–44 scale) (Appendix 2). Data from both raters were averaged and used as a total for the analysis.

Inter-rater reliability (IRR) was calculated using a variant of kappa known as Gwet's AC1 (category scores) and an absolute agreement intraclass correlation (total score).²⁹ Hypotheses were tested using Friedman's ANOVA and the Durbin-Conover method for post hoc tests with the *jmv* package in R statistical software (<https://CRAN.R-project.org/package=jmv>). All comparisons were made using the Mann-Whitney test. Data were visualized using combined box and stacked dot plots. Missing data were handled using listwise deletion before hypothesis testing, but all data are presented in plots.

Results

This study included 18 residents from PGY 1–4. All eligible residents participated in the study. There was no difference in the number of residents with regard to level of education among the control and intervention arms (Table 1). The IRR was evaluated using intraclass correlation. Two-rater

Table 1. Residents' education level and the study groups (N=18)

	NOTTS combined with SBE (intervention group), n	SBE alone (control group), n	P value
PGY 1	3	2	0.94
PGY 2	2	3	
PGY 3	2	2	
PGY 4	2	2	
Total	9	9	

IRR was performed at the sub-scale level and ranged from 0.31 to 0.78 with an average inter-rater reliability of 0.52.

This study did not show a statistically significant difference in the total performance scores for the six ACGME competencies (patient care, medical knowledge, interprofessional and communication skills, professionalism, practice-based learning and improvement, and system-based practice) among the two study groups (35.2 ± 3.62 versus 31.7 ± 3.75 ; $P=0.077$) (Table 2). There was no statistically significant increase in performance score for any of the six ACGME competencies, however there was a trend for higher scores in the intervention group (Table 3, Fig. 1). There was no statistically significant difference in the performance score for any of the six ACGME competencies by PGY levels (Table 4).

Discussion

This study did not show a statistically significant difference in the total performance scores for the six ACGME competencies (patient care, medical knowledge, interprofessional and communication skills, professionalism, practice-based learning and improvement, and system-based practice) among the two study groups. The results of this study failed to confirm our hypothesis that NOTSS methodology can improve ACGME competencies when combined with simulation-based education.

This study showed a different result in comparison with other studies that demonstrated a positive impact on NTS and an improvement in the performance of different surgical teams after a NOTSS course.^{3–9}

The reason for this difference may be due to the fact that our study had a small sample size (N=18) and a low number of observations (nine for each study group). Other NOTSS studies had higher numbers of observations (up to 43 observations).⁶ A study with bigger sample size

Table 2. Residents' performance according to ACGME competencies

ACGME competencies	Target actions: resident has	NOTTS-SBE (mean, SD)	SBE alone (mean, SD)	P value
Step 1: Identification of postthyroidectomy hematoma				
Interpersonal and communication skills	1. performed introductions	1.33 (0.50)	1.50 (0.56)	0.490
	2. received handover	2.00 (0.00)	2.00 (0.00)	NA
Patient care	3. performed focused physical examination of the neck	1.78 (0.51)	1.56 (0.77)	0.576
	4. identified hematoma	1.89 (0.22)	1.83 (0.35)	0.952
Interpersonal and communication skills	5. called for help (anesthesiologist and surgeon)	1.61 (0.49)	1.28 (0.80)	0.393
	6. called for resuscitation cart	1.83 (0.25)	1.56 (0.39)	0.118
Medical knowledge	7. informed team (nurse, anesthesiologist, and surgeon) about the management plan	1.56 (0.39)	1.33 (0.75)	0.711
Step 2: Management of postthyroidectomy hematoma				
Patient care	8. removed dressing and Steristrips	1.56 (0.58)	1.72 (0.44)	0.578
	9. released skin sutures	2.00 (0.00)	1.94 (0.17)	0.374
	10. released deep sutures	1.50 (0.71)	1.50 (0.66)	0.924
	11. evacuated hematoma	1.67 (0.43)	1.33 (0.71)	0.325
	12. placed temporary packing	0.61 (0.86)	0.22 (0.51)	0.292
	13. considered intubation	1.72 (0.57)	1.56 (0.77)	0.615
Interpersonal and communication skills	14. informed operating room (OR) of take back	1.44 (0.77)	1.33 (0.66)	0.739
	15. exchanged information with the team when the patient's oxygen saturation dropped	1.72 (0.51)	1.61 (0.49)	0.457
	16. worked effectively with the team when the patient's oxygen saturation dropped	1.50 (0.50)	1.50 (0.50)	1.00
	17. listened attentively to the stated needs of information provided by the team during the crisis	1.78 (0.51)	1.39 (0.42)	0.050
Professionalism	18. informed the attending surgeon of situation	1.72 (0.44)	1.56 (0.46)	0.431
	19. demonstrated respect and sensitivity to anesthesia regarding desaturation during difficult airway management (if applicable)	2.00 (0.00)	1.83 (0.35)	0.169
Practice-based learning and improvement	20. recognized that the crisis has been managed	1.67 (0.43)	1.44 (0.85)	0.884
System-based practice	21. verified availability of the OR	1.39 (0.82)	1.22 (0.62)	0.521
	22. verified that the team is ready to transport the patient to the OR for definitive management	1.00 (0.66)	0.72 (0.51)	0.318
Total score (max 44)		35.2 (3.62)	31.7 (3.75)	0.077

SBE, simulation-based education.

Table 3. ACGME competencies by intervention group (N=18)

ACGME competencies (maximum score)	NOTTS-SBE (mean)	SBE alone (mean)	P value
Patient care (16)	12.7 (1.50)	11.6 (1.59)	0.320
Medical knowledge (2)	1.56 (0.39)	1.33 (0.75)	0.711
Interpersonal and communication skills (16)	13.2 (1.50)	11.9 (1.92)	0.131
Professionalism (4)	3.72 (0.44)	3.39 (0.74)	0.330
Practice-based learning and improvement (2)	1.67 (0.43)	1.44 (0.85)	0.884
System-based practice (4)	2.39 (1.45)	1.94 (0.95)	0.284

SBE, simulation-based education.

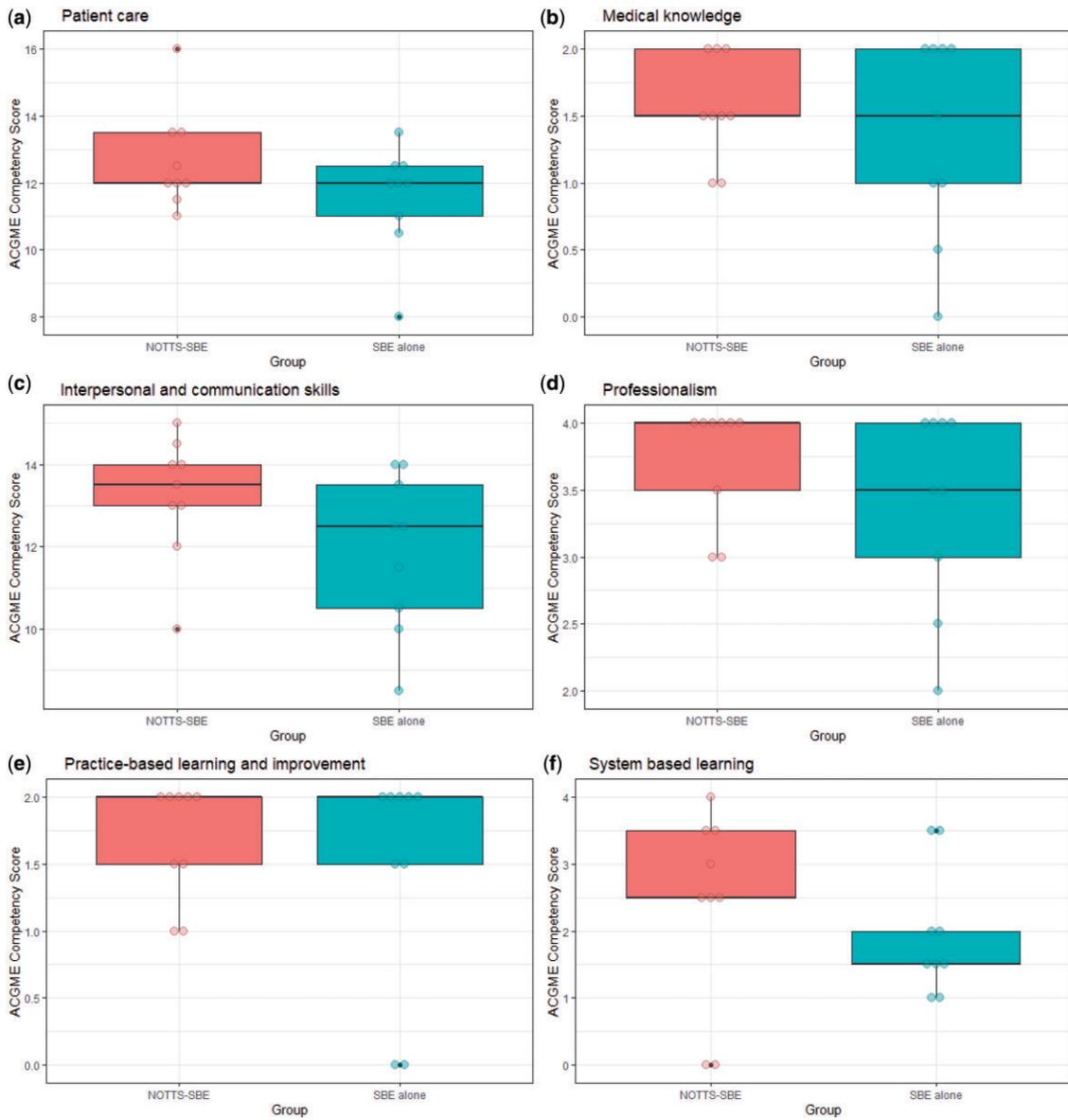


Figure 1. Difference in ACGME competencies among residents.

Table 4. ACGME competencies by PGY subgroups (N=18)

ACGME competencies (maximum score)	PGY 1 and 2 (mean)	PGY 3 and 4 (mean)	P value
Patient care (16)	12.2 (0.94)	12.1 (2.26)	0.856
Medical knowledge (2)	1.25 (0.64)	1.69 (0.46)	0.125
Interpersonal and communication skills (16)	12.5 (1.97)	12.6 (1.71)	0.964
Professionalism (4)	3.45 (0.73)	3.69 (0.46)	0.556
Practice-based learning and improvement (2)	1.85 (0.24)	1.19 (0.84)	0.069
System-based practice (4)	2.00 (1.13)	2.38 (1.36)	0.501

and higher number of observable events may be necessary to have enough power to detect a statistically significant difference.

Other confounding factors in this study included a long delay in the study due to the Coronavirus-19 pandemic. Less retention of skills in the intervention group may have changed the results of the study. Some of the later evaluation scenarios were done under the rules of social distancing, which could alter the efficacy of the teaching.

There was a trend toward high scores in the intervention group. Participants provided extremely positive feedback after the NOTSS and simulation-based education activities. Most participants reported an increase in confidence in all NTS especially the first year residents. They recommended that similar teaching sessions should be organized at the beginning of the residency program. For these reasons, the residency program is considering incorporating the NOTSS course in its simulation-based education curriculum. In addition, the evaluation form used is in line with the ACGME competencies; this may allow easy alignment of neck hematoma and NTS training with the ACGME surgical curriculum requirements.^{10,30}

Simulation-based education has been successfully implemented in teaching for surgical residents. Common areas using simulation in general surgery training include laparoscopy and central line insertion.^{31–39} Our study indicates an additional use of simulation for general surgery training. This simulation-based education for neck hematoma can also be used to train a multidisciplinary team of providers, including surgeons, anesthesiologists, and nurses. The simulation scenario (Appendix 2) facilitates training of both technical and non-technical skills.

Conclusions

The results of this study did not show a statistically significant difference in the total performance scores on the six ACGME competencies among the two study groups. Therefore, this study failed to confirm our hypothesis that NOTSS methodology can improve ACGME competencies when combined with simulation-based education. A study with a bigger sample size and higher number of observable events may be necessary to have the power to detect a statistically significant difference. There was a trend toward high scores in the intervention group and positive feedback after the NOTSS and simulation-based education activities, therefore our residency program is considering incorporating the NOTSS course into its simulation-based education curriculum. In addition, there was a long delay in the study due to the Coronavirus-19 pandemic. Less

retention of skills in the intervention group may have changed the results of the study. Some of the later evaluation scenarios were done under the rules of social distancing, which could alter the efficacy of the teaching.

Conflicts of interest

All authors declare no conflict of interest.

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Appendix 1: Data collection tool: residents' performance according to ACGME competencies

Film number: _____ Rater number : _____

ACGME Competencies	Target actions: Resident has	Resident performance		
		Hit 2	Hit after prompting 1	Missed 0
Step1: Identification of postthyroidectomy hematoma				
Interpersonal and communication skills	1. Performed introductions			
	2. Received handover			
Patient care	3. Performed focused physical exam of the neck			
	4. Identified hematoma			
Interpersonal and communication skills	5. Called for help (Anesthesiologist and Surgeon)			
	6. Called for resuscitation cart			
Medical knowledge	7. Informed team (nurse, anesthesiologist, and surgeon) about the management plan			
Step 2: Management of postthyroidectomy hematoma				
Patient care	8. Removed dressing and Steristrips			
	9. Released skin sutures			
	10. Released deep sutures			
	11. Evacuated hematoma			
	12. Placed temporary packing			
	13. Considered intubation			
Interpersonal and communication skills	14. Informed OR of take back			
	15. Exchanged information with the team when the patient's oxygen saturation dropped			
	16. Worked effectively with the team when the patient's oxygen saturation dropped			
	17. Listened attentively to the stated needs of information provided by the team during the crisis			
Professionalism	18. Informed the Attending Surgeon of situation			
	19. Demonstrated respect and sensitivity to anesthesia regarding desaturation during difficult airway management (if applicable)			
Step 3: Plan safe transfer of the patient to OR for definitive hemostasis				
Practice-based learning and Improvement	20. Recognized that the crisis has been managed			
Systems-based practice	21. Verified availability of OR			
	22. Verified that the team is ready to transport the patient to OR for definitive management			
Total score /44				
Percentage score (%)				

Appendix 2: simulated scenario

See supplementary material.