

Crossover Study in Simulation-based and Problem-based Learning in Difficult Airway Management

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Abstract

Teaching and learning of difficult airway management are considered to be an essential skill in anesthesiology.

Objectives

To determine the learning achievement and relative growth scores by two educational techniques: simulation-based (SBL) and problem-based learning (PBL).

Methods

Thirty-six students were randomly divided into two groups: SBL and PBL in a crossover study design. Comparison the achievement scores and relative growth of knowledge between the two groups were analyzed.

Results

The baseline scores showed no differences between the two groups (19.8 ± 3.4) and (19.5 ± 2.8) respectively.

After the learning courses, the posttest and gain scores of SBL: (24.2 ± 2.3) and (20.2 ± 16.0); significantly showed higher scores than that of PBL: (21.9 ± 2.9) and (10.4 ± 17.6) respectively. After six weeks, the baseline scores showed higher indifferently between the two groups: (25.0 ± 2.8) and (25.4 ± 3.4) respectively. Likewise, the posttest and gain scores of SBL: (27.8 ± 2.9) and (13.7 ± 22.6); appeared to increase as compared to that of PBL: (26.6 ± 2.2) and (8.9 ± 17.9) respectively.

Conclusion

Students undergoing SBL showed higher achievement and relative growth scores as compared to PBL.

Keywords: Simulation Training, Problem-Based learning, Airway Management

Introduction

Teaching and learning of difficult airway management are considered to be an essential skill in anesthesiology. Assessment of the training program requires a currently established guideline¹. Recent studies revealed that the management of the airway was the most sophisticated maneuver for all anesthesia providers, since it is related to morbidity and mortality circumstances^{2, 3}. This appeared in 6.2% of endotracheal intubations in the operating theater. In addition, difficult intubation with ventilation occurred in 1.5% of the procedures; impossible intubation and difficult ventilation 0.3 %; and “can’t intubate, can’t ventilate” (CICV) situation, 0.07%⁴.

Normally, most anesthesia personnel perform endotracheal intubation under general anesthesia. However, they occasionally come across difficult airways. This becomes a life and death condition that may lead to uneventful sequelae. In practice, a difficult airway is defined as either troublesome facemask ventilation or tracheal intubation⁵. As a result, doctors and nurses in anesthesia have to be vigilant in every step including airway assessment, equipment preparation and strategic planning of the process. In addition, updated difficult airway algorithm helps them to manage the patient’s airway at the right time⁶.

After graduation, registered nurses need to spend one more year on a training program to become nurse anesthetists, serving as either an anesthesiologist’s assistant or a general practitioner’s helper. During the one-year training program, nurse anesthetist students intensively study theories and practical skills in anesthesia, using manikins or living patients. However, effective training in airway management results from the learners’ competences and from a diversity of teaching techniques⁷.

Currently, the educational tool in the anesthesia curriculum is typically simulation-based learning (SBL) and problem-based learning (PBL) courses, both of which have been widely accepted in many educational institutes⁸. They yield a promising outcome amongst students of professionalism. The SBL provides high-level learning circumstances to help students gain their experiences⁹. The diagnostic and feedback system helps learners correct their mistakes with confidence¹⁰. However, PBL allows students to present their informative matters, resulting in retention and integration of knowledge with clinical experience. In addition, self-directed learning gives them creative thinking, while instructors act as facilitators to empower students implement their own strategic plan of learning^{11, 12}.

Either SBL or PBL has its unique process to assess participants' core knowledge. Furthermore, difficult airway management has become a distinguished means in the training curriculum. As a result, we designed a crossover study to determine the learning achievement of nurse anesthetist students in difficult airway management.

Objectives

To study the learning achievement and relative growth of knowledge (gain score) of the two learning techniques: SBL and PBL.

Methods

The study has been approved by Siriraj IRB 233/2558 (EC4) and registered by Clinical Trails.gov.NCT02718794. Thirty-six nurse anesthetist students in Academic Year 2015, Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, volunteered to join the study project without any honorarium. The benefit of taking part in the study was only knowledge and clinical experience gained. The students were informed about the significance of the research under the faculty policy as well as the learning objectives in details. After signing the consent form, they were randomly into two groups: A (n = 17) and B (n = 19). As crossover study design, students in group A attended SBL and after 6 weeks, they focused on PBL; and vice versa for group B.

The PBL learning session comprised four different clinical questions together with educational resources for one hour self-study. Consequently, all students spent two more hours on presentation and discussion of knowledge information in front of the class. The SBL learning session consisted of the same clinical scenarios as PBL. All learners spent three hours in the environment of a well-equipped operating theater with a standardized patient or a high-fidelity manikins. Then they joined the debriefing forum given by an attending staff.

The 40-item, multiple choices exam was developed under the table of specifications and knowledge map in regard to difficult airway management guidelines. The paper-pencil test comprised of evaluation of the airway, basic preparation of difficult airway management, strategy of endotracheal intubation and extubation, and follow up care.

The correctness and appropriateness of the test (content validity) were determined by three board-certified anesthesiologists who had at least 10 years of experience in anesthesia, and were not involved in the project. The tryout of the test was performed by 10 novice nurse anesthetists. The IOC (index of item objective congruence) was 0.82 with Kuder Richardson 21 of 0.8. The assessed criterion-referenced item difficulty and discrimination index were 0.4-0.6 and 0.6-0.8 respectively.

The pretest (X1, X2) and post-test ((Y1, Y2) were performed in consequence. The relative growth of knowledge (G1, G2) was calculated as follows:¹³

$$G1 = 100 (Y1 - X1) / (F - X1) \% \qquad G2 = 100 (Y2 - X2) / (F - X2) \%$$

Where F was the full scores of the learning course

Statistics analysis

The test scores and relative growth of knowledge between the two groups were expressed as mean and standard deviation. All categorical data were expressed in percentage. Using the Statistical Package for Social Sciences for Windows, release 18; pretest and relative growth of knowledge were compared by non-dependent t test, whereas post-test by ANCOVA. Statistically significant differences were considered where $p < 0.05$ with a 95% confidence interval.

Results

The demographic characteristics such as gender, age and experience in anesthesia of the two groups showed no statistically significant differences (Table 1).

The baseline scores, AX1 (19.8 ± 3.4) and BX1 (19.5 ± 2.8) showed no statistically significant difference. (Figure 1) After the learning course, the AY1 (24.2 ± 2.3) and AG1 (20.2 ± 16.0) significantly appeared to have higher scores than that of the BY1 (21.9 ± 2.9) and BG1 (10.4 ± 17.6) respectively (Table 2).

After six weeks, BX2 (25.4 ± 3.4) and AX2 (25.0 ± 2.8) showed no statistically significant difference. However, they were much higher than the baseline scores. After the learning course, the BY2 (27.8 ± 2.9) and BG2 (13.7 ± 22.6) showed less differences than the AY2 (26.6 ± 2.2) and AG2 (8.9 ± 17.9) respectively.

The SBL had a higher gain score than the PBL, as 16.9% and 9.7%, with no significant difference.

Discussions

Students took SBL either at the first or second learning course showed higher achievement and relative growth scores. The baseline scores at the beginning of both learning courses were similar between the two groups.

The comparable baseline scores implied that students had the same level of knowledge. Therefore, the intervention applied as learning techniques could provide its unique effects on the students' learning achievement.

Many studies appeared to support our current results - the superiority of SBL to PBL for its learning achievement and practical skills. In the clinical setting, SBL has been used to reduce medication errors, improve physician clinical techniques, increase teamwork and leadership skills, and identify deficiencies in conforming to national guidelines.¹⁴⁻¹⁷

Karen E, et al. conducted a systematic review of thirty-four articles published between 1990 to 2009 on advanced airway management for patients undergoing anesthesia¹⁸. The majority of the studies included simulation education evaluation for a variety of medical, nursing and allied health providers and students. They concluded that simulation might be an effective teaching tool in difficult airway management skills for anesthesia providers.

Shin S, et al. in their meta-analysis on effectiveness of patient simulation in nursing education demonstrated that simulation education in nursing had benefits, in terms of effect sizes¹⁹. When the effects were evaluated through performance, the evaluation outcome was psychomotor skills. In addition, the subject of learning was

clinical with regard to the conditions under which patient simulation is more effective than traditional learning methods.

Steadman RH, et al. in their randomized controlled trial, compared SBL with PBL in thirty-one, fourth year medical students, taking a week for acute care course²⁰. They concluded that SBL showed to improve knowledge in both the academic and clinical setting. It was good for the acquisition of critical assessment and management skill. This might due to the active learning elements associated with psychomotor activity.

Though SBL was considered a powerful generic tool for teaching and dealing with human performance issues. It was associated with many limitations like excessive cost, the need of infrastructure, and trained faculty²¹. In addition, the scope of SBL was very limited dealing with only a few topics. Students were in the good level of preparation²².

The study started when the students have trained in our department for 3 months. Therefore, 6 weeks later, their knowledge were not only retention from the first session but also from their routine work on-the-job. This may explain why the pretest knowledge scores were comparable between the 2 groups.

Conclusion

Nurse anesthetist students undergoing simulation-based learning on difficult airway management showed higher achievement and relative growth scores as compared to problem-based learning.

Glossary

Simulations and Models:

Tools for assessment of clinical performance in an environment closely resembling reality and imitating real clinical problems to rate the examinees' performance on clinical problems that are difficult or even impossible to evaluate effectively without harming a real patient. They permit examinees to make life-threatening errors and provide instant feedback so examinees can correct a mistaken action. Models are mannequins constructed to respond realistically to actions, allowing examinees to reason through a clinical problem without risk to a real patient. Simulation formats have been developed as paper-pencil patient management problems (PMP), computerized versions of PMP called clinical case simulations (CCX), role-playing situations, e.g., standardized patients (SP), clinical team simulations, anatomical models or mannequins, and combinations of all of the above formats. Virtual reality simulations (VR) use computers sometimes combined with anatomical models to mimic realistic organ and surface images and the touch sensations a physician would expect examining a real patient. Written and computerized simulations have been used to assess clinical reasoning, diagnostic plans and treatment for a variety of clinical disciplines. They are expensive to create.²³

Problem-Based Learning (PBL):

In this approach, students learn in small groups supported by a tutor. They initially explore a predetermined problem. The problem contains triggers designed to evoke objectives or concepts which are used to set the agenda for individual or group investigation and learning after the initial session. Subsequent group meetings permit students to monitor their achievements and to set further learning goals as required. The tutor's role is to

offer support for learning and to help reach the expected outcomes. PBL enables students to develop the ability to translate knowledge into practice at an early stage, encourages individual participation in learning and also allows the development of teamwork skills. Students in PBL courses have been found to place more emphasis on "meaning" (understanding) than "reproduction" (memorization). Students must engage in a significant amount of self-directed learning; lectures are kept to a minimum. PBL originated at McMaster University in Canada, and then at Maastricht University, and is now widely adopted in medical schools in many countries. Each school makes its own adjustments to the basic model. It does require a heavy investment in resources (library books, IT, tutorial rooms) as well as requiring education and training for tutors.²³

Airway Management:

Evaluation, planning, and use of a range of procedures and airway devices for the maintenance or restoration of a patient's ventilation.²⁴

Take Home Messages

- Difficult airway management is a life and death situation for anesthesia personnel in their routine work.
- The effective training in airway management results from the learners' competences and from a diversity of teaching techniques.
- We apply simulation-based (SBL) and problem-based learning (PBL) as educational techniques in nurse anesthetist training program.
- Either SBL or PBL has its unique process to assess participants' core knowledge.
- The relative growth scores (gain scores) are calculated by the achievement scores of each paper pencil test.

Notes On Contributors

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Appendices

Figure 1. A crossover study of nurse anesthetist students on difficult airway management with the two educational tools: simulation-based (SBL) and problem-based learning (PBL).

Learning course	SBL	PBL
Student (groups)	A (n = 17)	B (n = 19)
	Pretest X1	
	Post-test Y1	
6 weeks		
Student (groups)	B (n = 19)	A (n = 17)
	Pretest X2	
	Post-test Y2	

Table 1 Participants' characteristics

	A (n=17)	B (n=19)
Gender (M:F)	2:15	3:16
Age		
20-25 yrs.	4(23.5%)	0(0.0%)
26-30 yrs.	9(52.9%)	16(84.2%)
>30 yrs.	4(23.6%)	3(15.8%)
Degree		
Bachelor	16(94.1%)	19(100%)
Master	1 (5.9%)	0(0.0%)
Anesthetic learning experienced		
1-3 month	14(82.3%)	16(84.2%)
4-6 month	3(17.7%)	3(15.8%)
Difficult intubation experienced		
<5 times	15(88.2%)	15(78.9%)
5-10 times	0(0.0%)	1(5.3%)
11-20 times	0(0.0%)	2(10.5%)
>20 times	2(11.8%)	1(5.3%)
Difficult ventilation experienced		
<5 times	16(94.1%)	14(73.7%)
5-10 times	0(0.0%)	4(21.0%)
11-20 times	0(0.0%)	1(5.3%)
>20 times	1(5.9%)	0(0.0%)
Difficult Airway Management experienced		
<5 times	17(100.0%)	19(100.0%)
5-10 times	0(0.0%)	0(0.0%)
11-20 times	0(0.0%)	0(0.0%)
>20 times	0(0.0%)	0(0.0%)

Table 2 The pretest (X1, X2), post-test (Y1, Y2) and relative growth of knowledge (G1, G2) of group A and B during the SBL and PBL learning courses.

Learning course	SBL	PBL	
Student (groups)	A (n = 17)	B (n = 19)	P
Pretest X1	19.8 ± 3.4	19.5 ± 2.8	0.781
Post-test Y1	24.2 ± 2.3	21.9 ± 2.9	0.013*
Growth G1	20.2 ± 16.0	10.4 ± 17.6	0.097
6 weeks			
Student (groups)	B (n = 19)	A (n = 17)	P
Pretest X2	25.4 ± 3.4	25.0 ± 2.8	0.726
Post-test Y2	27.8 ± 2.9	26.6 ± 2.2	0.217
Growth G2	13.7 ± 22.6	8.9 ± 17.9	0.493

Declaration of Interest

The author has declared that there are no conflicts of interest.