USE OF HUMAN PATIENT SIMULATION TO TEACH DIFFICULT AIRWAY MANAGEMENT AND IMPROVE PATIENT SAFETY IN THE NURSE ANESTHESIA STUDENT

by

Karen Ellis Lucisano

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Approved by:

_____
Dr. Laura Talbot

_____
Dr. Lucille Travis

_____
Dr. Claudia Flowers

_____
Dr. Joseph Coyle

_____
Dr. Adam Harbaugh

ABSTRACT

KAREN ELLIS LUCISANO. Use of human patient simulation to teach difficult airway management and improve patient safety in the nurse anesthesia student.
(Under the direction of DR. LAURA A. TALBOT)

Introduction: The objective of this study was to determine if scenario-based training (SB) was more effective than task-based (TB) training in teaching a difficult airway algorithm to nurse anesthesia student.

Methods: Participants were second year nurse anesthesia students. Simulation was used as both a training and testing modality. Subjects were given a 2 scenario simulation based pre-test and a written test, randomized to receive either 1) lecture and task-based training or 2) lecture and scenario-based training. They were then post-tested with the same 2 simulation scenarios and an objective matched written posttest. Performance was videotaped and evaluated by 2 expert observers based on performance against an idealized algorithm, amount and time of desaturation, and time to secure the airway. Data were analyzed using repeated measures ANOVA and students-*t* test. Levels of statistical significance were set at α of .05 (one-tail).

Results: While performance improved in both groups on all outcome variables the SB group's improvement was statistically significant on the number of deviations from the airway algorithm (Pre-test TB= 23.09, Post-test TB= 16.27, Pre-test SB= 24.25, Post-test, SB = 12.83, interaction $F = 2.91$, $p < 0.05$) and written exam (Pre-test TB = 69%, Post-test TB = 73%, Pre-test SB = 70%, Post-test, SB = 81%, interaction $F = 3.30$, $p = 0.05$).

Conclusion: We found mixed evidence that SB training may offer specific advantages, including improved didactic knowledge and compliance with a complex algorithm, in

teaching management of the patient with a difficult airway to novice anesthesia providers. Conversely, the total time of desaturation and lowest desaturation was not statistically significantly different. Subjectively both methods provided a high degree of self confidence in learning and student satisfaction as measured by the Student Satisfaction and Self Confidence in Learning Scale.

Keywords: Human Patient Simulation, Difficult Airway, and Nurse Anesthesia Education

DEDICATION

This dissertation is dedicated to my family. I would like to thank my parents for providing me with the motivation and support to reach beyond what they were able to accomplish. It was through their love and sacrifices that I came to realize the importance of giving back and a drive to always seek excellence. And to my husband who also sacrificed so much to support me in this endeavor. His selflessness and love provided the sustaining power needed to go the distance. And for that I will be forever grateful. Thank you.

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INTRODUCTION

Specific Aims

Inability to secure the airway during the induction phase of a general anesthetic is fraught with the potential for significant morbidity and mortality. Co-morbid disease states likely to pose a significant risk of hypoxic injury during induction include pregnancy, multiple trauma and obesity. In an effort to improve outcomes the American Society of Anesthesiologist (ASA) adopted an algorithm which may be followed when the anesthetist is unable to establish an airway using traditional methods[1]. In spite of the development of these evidence-based guidelines, malpractice claims related to failure to secure the airway persist.[2] Owing to their findings is a need to examine training strategies. Typically, novice practitioners learn airway management on real patients using a bedside apprentice model referred to as "see one, do one, teach one." Exposure to real patients is essential, but sub-standard performance can put patients at risk.

How best to train anesthesia providers for this potentially catastrophic event is poorly understood. Traditionally, non-clinical training has included the use of lecture combined with training stations in which hands on experience with airway adjuncts used in the ASA airway algorithm is obtained. More recently the health care industry has incorporated the use of simulated patients and environments to bring the look and feel of the high stress clinical environment to the learner. In this environment the learner is able to develop the ability to practice application and evaluation of specific objectives. Human patient simulation has been conceived from the airline industry, through simulation, crews

are able to prepare for catastrophic events without the need to place themselves or others in harms way.

The overall goal of this project was to identify the effectiveness of a structured simulation training protocol for anesthesia providers in preparing them for difficult airway management during the induction phase of a general anesthetic. The overall objective was to examine how a system may best utilize human patient simulation as a tool that will ultimately lead to an improvement in patient safety. The rationale for this study was failure to successfully establish an airway in the patient who has been rendered unable to breath may lead to significant morbidity and mortality. Simulation is a relatively new educational modality and current simulation technology lends itself well to recreating this infrequent but high risk event in a no risk environment. The outcomes of this study are relevant to anesthesia training programs and current practitioners and may lead to improved patient safety.

The central hypothesis was scenario-based simulation training combined with traditional classroom lecture will have greater performance improvements of the ASA Difficult Airway Algorithm (DAA)[1], a reduction in the time to secure the airway, and a reduction in oxygen desaturation degree and time as compared to task focused stations with lecture. To achieve our objectives, a group of students (n = 24) were recruited for training and testing during their fifth or sixth semester in a nurse anesthesia graduate nursing program. This allowed us to identify the effect of training under high fidelity simulated conditions on the participant's performance with respect to accuracy and efficiency of difficult airway management. Specifically we:

1. Tested the effectiveness of scenario-based simulation training as compared to task focused stations, for improving time to secure the airway, decreased amount and degree of patient oxygen desaturation, and better compliance with the difficult airway algorithm. Time to secure the airway was measured by mean time to Laryngeal Mask Airway (LMA) insertion and effective jet ventilation. The amount and degree of patient oxygen desaturation was measured by the number and duration of desaturation events and lowest oxygen saturation. Compliance was measured by number of deviations from the DAA. Performance was evaluated against an ideal management plan based upon the DAA.
2. Determined if the scenario-based simulation training is more effective for improving didactic knowledge and learner satisfaction as compared to task focused stations. Didactic knowledge was measured by the percentage of multiple choice questions correct on the DAA multiple choice test. Learner satisfaction was measured by the Student Satisfaction and Self Confidence in Learning instrument (SSSCL).

We expected that a clinically based simulation was more effective in accelerating learning the management of the patient with a difficulty airway in training novice anesthesia providers. If effective, then a randomized control trial would be justified. This is greatly important given that learning and performance are enhanced under these simulated conditions; and justifies the time and cost of human patient simulation as an important strategy to improve patient safety.

Background and Significance

Problems with intubation of the airway are the most common cause of death related to anesthesia. While anesthesia providers become "specialists" in airway management, occasionally they are faced with the patient whose airway require advanced skills to manage. Advanced airway management has traditionally been taught first in the classroom and later in a bedside apprentice model when and if a patient presents. Furthermore, given the vastness of the curriculum and the current trends in practice, it is unlikely that each student would be exposed to an adequate number of experience s to ensure proficiency.[3] Medical and nursing education has been placing a greater amount of resources on simulation over the past 25 years in order to augment the magnitude and strength of student knowledge, provide a standardized and safe arena for learning, and to practice and perfect the future practitioner's skill[4-6]. Simulation would seem to be ideally suited to teach both the technical skills of airway management as well as the dynamic physiologic changes caused by the procedure, anesthetic agents used during the process, and how best to avoid significant pathophysiologic outcomes. More specifically, simulation offers the ability to simulate realistic anatomy and physiology of the respiratory and cardiovascular system and to monitor their function using authentic clinical monitors. Moreover, the simulated environment can more closely mimic the stress of the emergency situation and the need of rapid, life saving action.

Despite the promise of this technology to optimize learning, malpractice claims persist for significant morbidity and mortality outcomes occurring during the induction period[2]. How best to use this technology to teach advanced airway management to the novice anesthesia provider is poorly understood. There have been no experimental studies

published which evaluate the role of simulation in teaching and learning the DAA to the novice anesthesia provider. Chen[7] reported the use of a simulation and lecture curriculum in a renewal course to teach advanced airway management. While no objective measures of learning were reported participants found the course to be useful by improving confidence and performance. Russo[8] examined the use of simulation training for difficult airway management in current practitioners. Six months after the training participants were surveyed indicating improvement in predicative ability and skills in managing the difficult airway patient. The participants also found the design of the simulation activities and scenarios to be more helpful than lecture. Jordan[9] and Parry[10] examined the effectiveness of different simulators used for teaching the DAA. And finally Kuduvalli[11] investigated the effect of training using simulation for managing the patient with unanticipated difficult airway. Current practitioners were evaluated, using standardized simulated scenarios, at 6-8 weeks and 6-8 months after training. They concluded that simulation based training improves performance but there is a decay in skill over time and recommended repeating training in 6 months or less.

Recommendations for managements of the patient with a difficult airway

In an effort to identify patterns of liability related to anesthesia management of patients with a difficult airway claims made between the years of 1985-1992 were analyzed. Death or brain damage related to inability to secure the airway occurred during induction in 62% of the cases[12]. In 1993 the ASA convened a panel of experts and developed Practice Guidelines for Management of the Difficult Airway. The Guideline recommendations include methods to evaluate the airway, prepare for the patient with a known or suspected difficult airway, and methods to secure the airway of the patient with a

difficult airway. Airway management methods were organized into a DAA which provide an organized method for teaching, learning, and evaluating management. Since inception of the Practice Guidelines, liability claims related to failure to secure the airway during induction were reduce to 35% of all claims made[2].

Simulation as a technique for evaluation of clinical performance in difficult airway management

Currently there are no instruments which have undergone extensive validity and reliability testing as evaluation tools to assess performance in management of the patient with a difficult airway in accordance with the ASA DAA. In the only study published to measure performance based upon an algorithm, Kuduvalli et al.[11] based performance on deviation from the United Kingdom's Difficult Airway Society (DAS) algorithm using an ideal management plan derived from the algorithm. While their study used an objective tool for assessment their measured outcome was skill decay over time.

A variety of outcome measures have been examined by anesthesia and other health care provider's performance managing the airway and or adverse respiratory events. These studies were not based upon the DAA. Johnson et al.[13] studied anesthesia resident's performance after the use of simulation for teaching airway management and adverse respiratory events. Resident's performance was evaluated by determining the number of correct diagnosis, effects of training on perceived workload using National Aeronautics Space Administration Task Load Index (NASA-TLX) scores, and performance on US Licensure exam. Still others have used assessment tools that describe the "ideal" management based on algorithms derived from Practice Guidelines or an institutionally

derived checklist[14-18]. Time to completion, number of attempts and success or failure of airway management has also been used as a measure of performance[17,19-22]. And finally a simulated patient's respiratory and hemodynamic response to airway management has been used as objective measures of performance[19,23].

Research Design and Methods

The proposed study was designed to address two specific aims:

1. Test the effectiveness of scenario-based simulation training as compared to task focused stations, for improving time to secure the airway, amount and degree of patient oxygen desaturation, and compliance with the difficult airway algorithm.
2. Determine if the scenario-based simulation training is more effective for improving didactic knowledge and learner satisfaction as compared to task focused stations. Didactic knowledge was measured by the percentage of multiple choice questions correct on the DAA multiple choice test and learner satisfaction was measured by the SSSCL instrument (see Appendix A for author approval).

Overview

This study was a pre-test post-test stratified randomized control group design with participants tested prior to lecture (baseline) and after simulation training. Testing was based upon standardized patient scenarios developed and tested in a previous study[11]. While scenarios were based upon the DAS algorithm, the scenarios were adapted to the DAA. Half of the participants were randomly assigned to undergo simulation training by rotation through stations which allowed practice with various equipment and techniques

used in the DAA (task training group) and the other half to a structured simulation training (simulation training group). Random assignment was made after stratification into either a strata of those who scored in the top 50% on the DAA multiple choice test or those who scored below. Within each strata subjects were randomized in blocks of 4. Random numbers were determined by using SPSS software (see Appendix B). Participants who were assigned an odd number within each strata were placed in the simulation training group and those assigned an even number were place in the stations group. Subjects were assigned and referred to by a two digit research number in order to assure anonymity. The results of this study may help anesthesia educators and practitioner's better design difficult airway training to maximize efficiency of training which may ultimately improve patient safety.

Conceptual Model

Jeffries Nursing Education Simulation Framework will be used to guide this study[24]. The model contains five conceptual components including 1) teacher factors, 2) student factors, 3) student factors, 4) simulation design characteristics, and 5) expected student outcomes. The framework of the model is based upon the combination of theoretical constructs from computer based teaching strategies including adult learning, constructivism, and cognitive learning and simulation based teaching strategies including learner-centered practices, constructivism, and collaboration among individuals with different sociocultural backgrounds. Simulations, unlike traditional educational teacher centered experiences, are student centered. In this framework three major constructs are defined.

The first construct of the Jeffries Theory is that of the interaction of the student, teacher, and educational practices. Teacher serves as both educator and facilitator with various demographical characteristics. Student experience will also vary. Variables here include Program, Level within the Program, and Age. Educational Practices are the final conceptual constructs including type of learning, feedback, student faulty interaction, collaboration, high expectations, diversity in learning, and time to task. Outcomes are the second major construct and variables included are learning, skill performance, learner satisfaction, critical thinking, and self-confidence.

Simulation design characteristics are the final major theoretical construct and include objectives, fidelity, problem solving, student support, and debriefing. A full diagram of the model is presented in Figure 1.

This study was intended to examine the Outcomes portion of the Nursing education Simulation Framework. Learning was assessed by a multiple choice test, skill performance by time and accuracy of care for the simulated patient, learner satisfaction by use of SSSCL, and critical thinking by accuracy of assessment of airway emergency and subsequent care decision pathway.

Sample Criteria, Size, and Statistical Power

Sample size was determined based on three criteria: 1) alpha level of 0.05 (one-tailed test), equates to alpha level of 0.10 two-tailed test and power of 0.80 (ß = 0.2) according to standard statistical procedures[25]; 2) airway simulation literature[11,26], and 3) calculation of effect sizes for key variables that address the Specific Aims from previous studies [11,26]. This study was powered to detect a difference of 1 +/- SD in means between the comparative groups for the primary outcome measure of time to completion. The

software G*Power 3.1.2 was used to conduct the power analysis and sample size estimation; given the use of the aforementioned criteria a total sample size of 22 is required, however, we aimed to recruit 24 subjects to account for a 10% attrition rate noted in a previous study [11].

Criteria for inclusion were: 1) student currently enrolled in the CMC Nurse Anesthesia Program/UNCC and 2) enrolled in fifth or sixth semester or less than one year post graduation. Criteria for exclusion were: 1) student on probation at time of study, 2) students who deviate from the normal plan of study (students who have failed to follow the standard curriculum for the Carolinas Medical Center Nurse Anesthesia Program/UNCC including within the 27 months and/or sequence of course work), and 3) inability to physically perform the techniques that are a part of the DAA. Achievement during the simulation testing was not included in any course grade and all results will be confidential. Participants were recruited from the Carolinas Medical Center Nurse Anesthesia Program and the Department of Anesthesia. Figure 2 provides an overview of the study design.

Procedures

After obtaining informed consent baseline simulation testing was performed on all participants. Each participant was tested using the same standardized simulation scenarios. The scenarios were those used in a previous study of the DAS, adapted for the DAA[11]. There was one scenario that tested the 'can ventilate cannot intubate' arm of the DAA and one scenario that tested the 'cannot ventilate or intubate' arm of the DAA. Baseline performance testing was performed on all participants within a week prior to attending a traditional PowerPoint lecture covering the salient points of the ASA Practice Guidelines for management of the patient with a difficult airway and the DAA. Upon

completion of the lecture half of the participants were randomly assigned to a task training group and the others to a structured simulation group (see Appendix B for procedure). Upon completion of training each participant was retested within one week using the same scenarios as used at baseline. Outcome variables for the cannot intubate can ventilate (CI) and the cannot intubate cannot ventilate scenarios (CICV) were assessed independently by two nurse anesthesia program faculty members (Table 1). The reviewer's were blinded as to what intervention the participant received.

A training session for the raters was held prior to the start of the study. The raters were instructed on the definition of the variables and how they were to be scored. Additionally a trial run of 4 scenarios was taped and scored by the raters. Upon completion of the scoring percent agreement between raters was calculated and a review of the variable and their scoring was done. Any disagreements in ratings were discussed and raters reviewed the taped scenario until consensus could be reached. If there continued to be disagreement between raters, a third rater served as a tie breaker.

Setting

Testing and education was performed in the Carolinas Simulation Center's perioperative suite. The suite contains the METI HPS simulator, an OR table, a cart stocked with anesthesia equipment and simulated medications, a Datex Ohmeda Aestiva anesthesia machine, three video cameras, and a microphone. There was also an airway adjunct cart available to the subject, which contained a fiberoptic bronchoscope, Laryngeal Mask Airways (LMA), an intubating LMA, bougie, lightwand, a cricothyrotomy kit, and a jet ventilator.

Human Patient Simulation

Human patient simulation was used both as a teaching and an evaluation tool in this study. As a teaching tool the structured simulation group underwent simulation training and debriefing for each arm of the DAA. As an evaluation tool the participant underwent baseline assessment with two scenarios. A standardized patient (SP) and scenario was used for each assessment. All participants' performance was evaluated on the METI Human Patient Simulator Version 6.4. Performance was recorded and saved for later evaluation and scoring by two raters.

The METI HPS is a fully automatic, high-fidelity patient simulator specifically designed for training in anesthesia, respiratory and critical care. It has been programmed to automatically mimic human physiology in response to medication, disease states, and to response to a wide variety of treatments. It also has the ability to provide respiratory gas exchange, anesthesia delivery, and patient monitoring with real physiological clinical monitors. Additional information about the simulator can be found at http://www.meti.com/products_ps_hps.htm[27].

Intervention Training Program

Scenario-Based Simulation Training

Scenario based training consisted of the use of the METI HPS that was pre-programmed with four standardized patient scenarios, an anesthesia machine, an anesthesia cart stocked according to normal clinical protocol and the availability of a difficulty airway cart in a remote location. These scenarios differed from the testing scenarios but l provided for end point training in both the patient with both the can ventilate cannot intubate and cannot intubate or ventilate. Upon completion of the four

scenarios a tape of the subjects' performance was reviewed with each subject by a faculty member and evaluated for compliance with the DAA.

Task Based Training

Task-based stations consisted of a part trainer (intubating head) and an airway adjunctive device. Stations included:

1. Fiberoptic bronchoscope
2. LMA, and intubating LMA
3. Bougie whose placement will be assisted with video laryngoscopy
4. Lightwand
5. Cricothyrotomy kit use with jet ventilation and conventional ventilation.

A faculty member provided a demonstration and verbal training in the use of each device. A copy of the ASA Difficult Airway Algorithm was placed at each station so that the subject could see where this adjunct would fit in the DAA. Each subject was permitted to spend 15 minutes of instruction at each station.

Outcome Measures

Outcome variables were based upon each scenario. Primary outcome variables for the CI scenario included: number of deviations from the DAA, time to securing airway, lowest oxygen saturation, total desaturation time. Secondary variables included: number of intubating attempts, success rate for attempted intubation, number intubated, number of episodes of desaturation, and maximum heart rate and blood pressure change.

The categorical variables of "pass" or "fail" was determined using pass rate for this scenario. Criteria used to determine pass or failure were as follows. A grade of "fail" will was assigned to the participant if their patient management strategy results in desaturation

of less than or equal to 80% for a period of greater than or equal to 3 minutes. Conversely a grade of "pass" was assigned if their management strategy did not exceed these thresholds.

Primary outcome variables for the CICV scenario included: number of deviations from the DAA, mean time in seconds to cannula insertion, lowest oxygen saturation, number of desaturation episodes, and duration of desaturation in seconds. Secondary outcome variables included: correct cannula insertion technique, correct confirmation of airway placement, correct adjustment of jet ventilator, and mean time to effective jet ventilation. See table 1 for primary variable study measurement schedule.

Categorical variables of "pass" or "fail" were also be determined using pass rate for this scenario Criteria used to determine pass or failure were as follows. A grade of "fail" was assigned to the participant if their patient management strategy results in desaturation of less than or equal to 80% for a period of greater than or equal to 3 minutes. Conversely a grade of "pass" was assigned if the management strategy did not exceed these thresholds.

The subjective learning experiences for both groups was measured by using the SSSCL. The instrument is a 13-item instrument designed to measure student satisfaction (includes five items) with the simulation activity and self-confidence in learning (includes eight items) using a five-point scale. Reliability of this instrument was tested using Cronbach's alpha: satisfaction = 0.94; self-confidence = 0.87[24]. We administered this instrument at the completion of training and compared mean overall scores between the two groups. The instrument can be found in Appendix C.

A DAA multiple choice test was also administered to both groups. The test was multiple choices in design and contained 30 questions. Performance on the test was compared between the two groups by comparing the mean overall scores between the two groups.

Objective measures of student response during testing scenarios were assessed by measuring participant's peak heart rate and blood pressure. Comparison between the two groups was made by comparing the mean change in these measures from testing scenario 1 and 2. See Table 1 for an overview of variables and their assessment schedule.

Performance Assessment

Simulated physiologic parameters were output to Datex Eggstrom Capnomac Ultima which measured inhaled and exhaled oxygen, carbon monoxide, and inhalation agent concentrations. Heart rate, blood pressure, oxygen saturation, and cardiac rhythm was measured by a Datex Ohmeda AS/3 monitoring system. Simulation testing was taped using METI Vision using 3 separate camera views. A time counter was activated for each tape. Tapes were stored on a secure server that is protected by password access. Files were identified by a number assigned to each participant only.

Participant heart rate and blood pressure was measured by Datex Ohmeda AS/5 monitoring system. Heart rate was measured continuously and blood pressure prior to the start and immediately following each scenario.

Data Management

Data storage and analysis was conducted on a desktop computer with secure login software. The computer storing these data was backed up daily from the computer's hard drive to a secure server, only the primary investigator has access to the hard drive and

server file. Analysis was performed utilizing the SPSS statistical package. Performance recordings were saved onto a secure website with access controlled by secure login and password.

Data Analysis

Descriptive Statistics. Means and standard deviations were calculated for all continuous variables and percentiles for all categorical variables.

Statistical Assumptions. The data was screened prior to analysis by probing the univariate distributions to assess for normality, linearity, and homoscedasticity. Initial evaluation of the data was performed by application of descriptive information for each of the outcome variables to include 1) graphical evaluation of key variables, 2) identification of data outliers and extreme cases, and 3) analysis of variable associations.

Baseline Group Differences. ANOVA and chi-square were used to test for differences in baseline characteristics by group. The two groups were compared for equivalence of potentially confounding variables. Group inequities were controlled in the data analyses by using covariates or other appropriate statistical methods.

Statistical Testing of Specific Aims.

Specific Aim 1: Test the effectiveness of scenario-based simulation training as compared task focused stations, for improving time to secure the airway, decreased amount and degree of patient oxygen desaturation, and better compliance with the difficult airway algorithm. We calculated the mean and percent change in time to secure airway, maximum reduction in oxygen desaturation, maximum time of desaturation, number of DAA deviations, and assign a grade of “pass” or “fail” to airway management strategy. A grade of “fail” was assigned to the participant if their patient management strategy results

in desaturation of less than or equal to 80% for a period of greater than or equal to 3 minutes. Conversely a grade of "pass" was assigned if their management strategy did not exceed these thresholds. Changes and effect estimates were evaluated by computation of repeated measures (within-subject and between subjects) ANOVA. Statistical tests were applied according to established ANOVA procedures[25].

Specific Aim 2: Determine if the scenario-based simulation training is more effective for improving didactic knowledge and learner satisfaction as compared to task focused stations.

Didactic knowledge was assessed by a DAA multiple choice test. The percentage correct on the DAA multiple choice test was calculated by taking the total number of correct question on the test divided by the total number of questions. Based on this score a grade of "pass" or "fail" was assigned. A grade of "pass" was assigned if the score was 83% or greater and "fail" if less than 83%. Changes and effect estimates were evaluated by computation of repeated measures (within-subject and between subjects) ANOVA for the mean scores on the DAA multiple choice test. Statistical tests were applied according to established ANOVA procedures[28]. A pool of 60 questions was used for this test. Half of those questions were administered at baseline and the other half after intervention. In order to evaluate the performance of the questions the full 60 question test were administered to nurse anesthesia student underclassmen following the difficult airway lecture and an item analysis was performed. Face validity was examined by gaining expert opinion regarding questions and their relationship of testing objectives. Experts included 2 CRNA members of a nurse anesthesia faculty and 1 anesthesiologist members of that same faculty [29]. Changes and effect estimates were evaluated by computation of repeated

measures (within-subject and between subjects) ANOVA for the mean scores on the DAA multiple choice test. Statistical tests were applied according to established ANOVA procedures[28].

Learner satisfaction was assessed by administering the SSSCL. The difference in mean scores for each group in each of the two content areas (satisfaction and self confidence) of the SSSCL was assessed using Student's *t*-test.

Limitations

Because the subjects had two exposures to the same measure (simulations) there may have been a risk that any change seen was due to the initial exposure to the measure rather than a real change in performance. There was also a risk that the simulations will not have the level of fidelity to adequately reflect a true clinical situation. Therefore performance and learning may have been affected by the ability to adequately simulate the conditions in which it intended. The sample for this study was one of convenience in which all participants were from the same anesthesia program and at the same level of training in that program. Therefore, the study may represent a threat of bias introduction and the results may not be generalizable to the majority of the nurse anesthesia population. And finally while this study was intended to improve patient safety we be trained and tested in simulated environment. Translation of the effects of training to the clinical environment is difficult to measure. We believe this will be the next phase of research which will need to be conducted.

Human Subjects

Recruitment of Participants and Consent Procedures

Participants for the study were recruited from a group of currently enrolled nurse anesthesia students. Participation was voluntary and the decision to participate did not affect course grade or continued enrollment in the program. An overview of the study and the opportunity to have any questions was provided during the consent process. Verbal consent was obtained prior to study participation. The following criteria for waiver of written consent were presented to institutional review board at the clinical facility and the university.

1. The research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside the research context and the only record linking the subject and the research is the consent document.

2. The principal risk is potential harm resulting from breach of confidentiality.

Waiver of written consent was granted. Each subject was asked whether they wanted documentation linking them to the research; their wishes were followed. Because the principle investigator is also the director of the program, consent was obtained from a program faculty member prior to study inclusion.

Potential Risks

The risk to participants were those of any simulation exercise and included the possibility of injury related to misuse of equipment, slipping and or falling, and a potential for deleterious effect of performance being recorded. If there is a significant benefit to scenario training those participants in the task focused training group may be at risk for reduced learning.

The study was conducted by nurse anesthesia program faculty utilizing currently enrolled students as participants. There was a potential risk of faculty bias towards student participants based on previous exposure and or performance in the study. There may also have been a risk of coercion in that the student participant may fear that a refusal to participate or poor performance may affect course grade or standing in the program.

Procedures for Protecting Against Risks

An overview of the equipment to be used during simulation testing was given during the lecture. The simulation center had procedures in place to ensure appropriate function and safety of the simulation area. At the completion of the study each participant was afforded the opportunity to undergo training in the opposite arm of intervention if they so desired.

Subjects were free to withdraw from the study at any time without reprisal. Participating faculty members were counseled regarding these risks and an agreement to maintain participants' rights was obtained prior to their participation. Student participant were informed that performance in the study would in no way affect course grade or standing in the program. Subjects who chose not to participate were offered the option to receive the traditional method of lecture and task based training.

Confidentiality

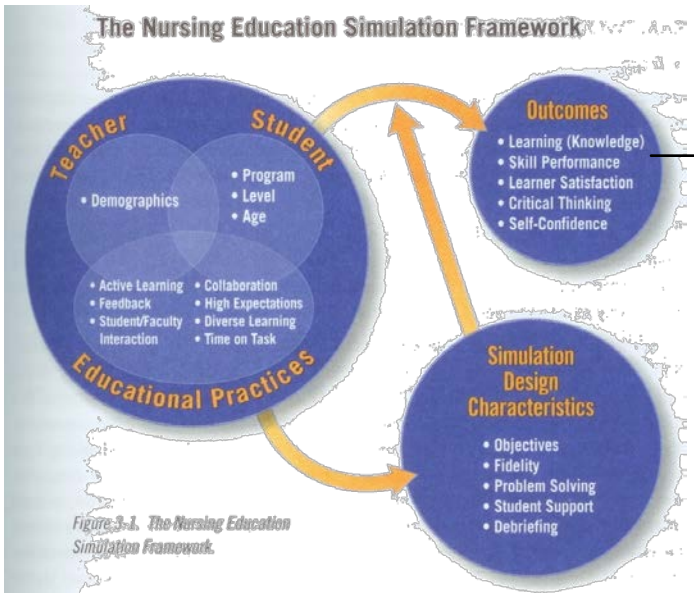
Participants were assigned a two digit study number in which all study related data was referenced. Data storage and analysis was conducted on a desktop computer with secure login software. The computer storing these data was backed up daily from the computer's hard drive to a secure server, only the Primary Investigator had access to the

hard drive and server file. Performance recordings were saved onto a secure website with access controlled by secure login and password.

Files were identified by a number assigned to each participant only. Results of the study were reported in aggregate form without the use of any subject identifiers.

Table 1: Overview Of Variables And Their Assessment Schedule

Variable	Instrument	Baseline Pre-Lecture	Post Simulation Training
Performance Assessment CI Scenario	Number of deviations from DAA	X	X
	Time to securing airway	X	x
	Lowest oxygen saturation	X	X
	Total desaturation time	X	X
Performance Assessment CICV Scenario	Number of deviations from DAA	X	X
	Time to cannula insertion (securing airway)	X	X
	Lowest oxygen saturation	X	X
	Number of desaturation episodes	X	X
	Duration of desaturation episodes	X	X
Participant Physiologic Response	Participant Peak Blood pressure	X	X
	Participant Peak Heart Rate	X	X
Subjective Evaluation of Simulation Learning Experience	SSSCL		X
Knowledge Test	DAA Multiple Question Test	X	X
Demographic Variables	Age, gender, year and month in program, current GPA, # intubations	X	



Specific Outcomes	Assessment
Learning	DAA Multiple choice test
Skill Performance	Time and compliancy with DAA
Learner Satisfaction	SSSCL
Critical Thinking	Accuracy of assessment and resultant care pathway
Self Confidence	SSSCL

Figure 1: Simulation Framework

Jeffries[24]

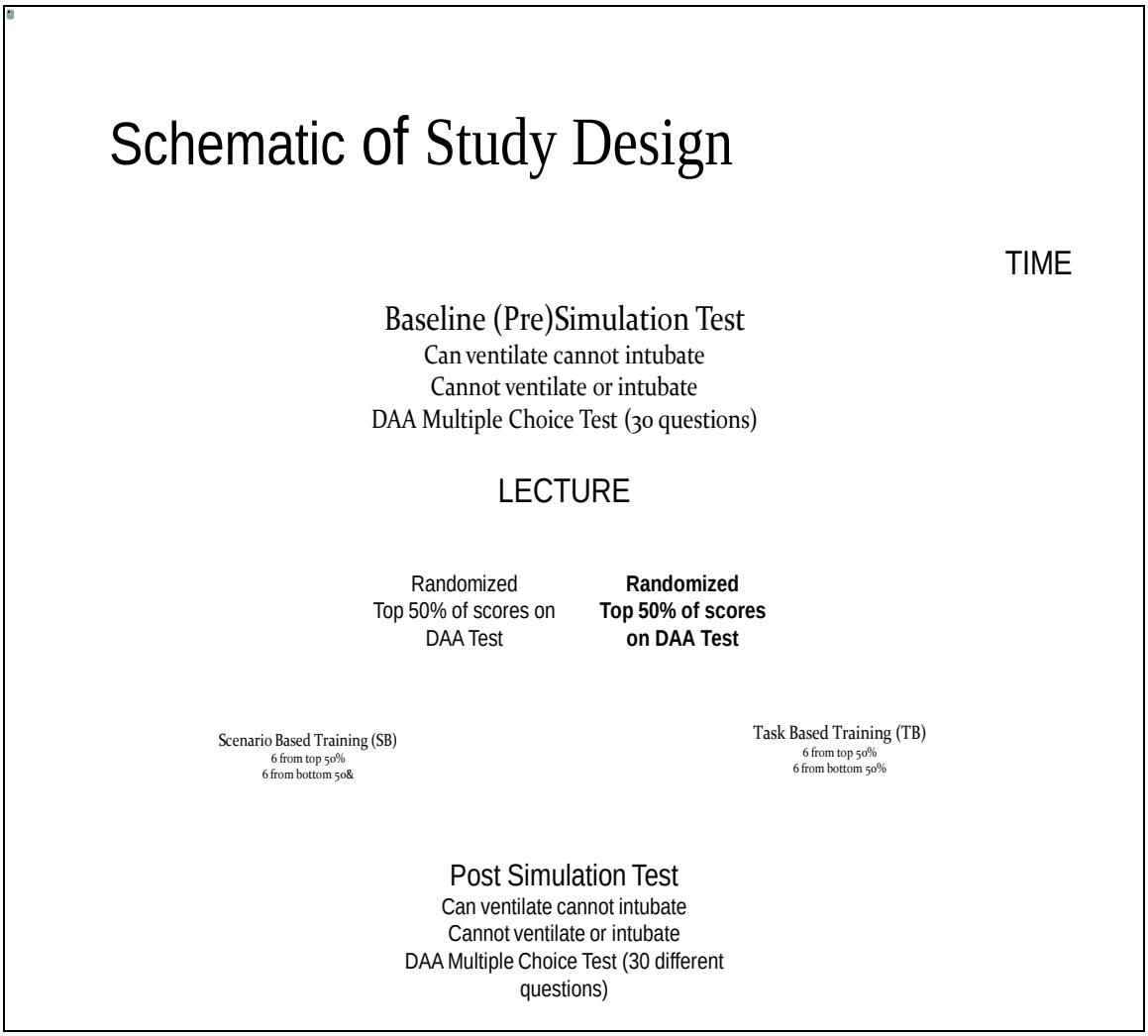


Figure 2: Schematic of Study Design

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JOURNAL ARTICLE I

SIMULATION TRAINING FOR ADVANCED AIRWAY MANAGEMENT FOR ANESTHESIA AND OTHER HEALTH CARE PROVIDERS: A SYSTEMATIC REVIEW

Introduction

Inability to secure the airway during the induction phase of a general anesthetic carries the potential for significant morbidity and mortality. Co-morbid disease states likely to pose a significant risk of hypoxic injury during induction include pregnancy, multiple trauma and obesity. Obesity is of particular concern because it increases the risk of difficult airway in addition to reducing functional residual capacity (FRC) and increasing metabolism ultimately leading to a reduction in hypoxia tolerance time. In the United States more than 30% of all adults and 15% of children are obese.[1] This high prevalence of obesity and the need to act rapidly and efficiently to ensure an uninterrupted supply of oxygen have led to the need to ensure that anesthesia providers are competent both in the knowledge and technical skills of difficult airway management.

In an effort to improve outcomes, the American Society of Anesthesiologists has adopted an algorithm that can be followed when the anesthetist is unable to establish an airway using traditional methods. However, in spite of these guidelines, malpractice claims related to failure to secure the airway persist.[2]

Typically, novice practitioners learn airway management on real patients using a beside apprentice model. Exposure to real patients is essential, but sub-standard performance can put patients at risk, especially when traditional airway management is ineffective and an alternate approach is urgently needed. Even seasoned practitioners

require recurring practice to hone their skills for rapid resolution. To avoid the risk of harming patients, a structured simulation training protocol may be used to prepare anesthesia providers for difficult airway management.

Human patient simulation (HPS) offers the ability to provide both anesthesia students and providers a structured and standardized experience and to demonstrate proper management of uncommon but high risk events with no danger of injury to the patient. This paper reviews the literature on human patient simulation for training anesthesia and other health care providers in advanced airway assessment and management.

Search Strategy

We used four electronic databases: CINHAL (January 1, 1995 to September 25, 2009), Medline (January 1, September 25, 2009), PsyINFO (January 1, 2000 to September 25, 2009), and Web of Science (January 1, 1990 to September 25, 2009). For the CINHAL search, we used the following search terms: “airway management “AND “simulation”. This search obtained 16 hits. We searched Medline using two different indexes. We searched Medline by the PubMed index, using the search terms “airway management” AND “simulation” AND “anesthesia”, and received 444 hits. We also searched Medline by the CSA Illumina index, using the search terms “airway management” AND “simulation”, and received 33 hits. Curiously, when we added “anesthesia” to the search term in this index, the number of articles returned fell to 6. PsycINFO was searched with the terms “airway management” AND “simulation” and produced 4 hits. And finally, we searched Web of Science using “airway management”

AND “simulation” and received 126 hits; we then refined the subject area to “anesthesia” and received 32 hits (Figure 3).

Two independent reviewers applied the eligibility criteria for the review to the methods section of each article from the selected databases. The criteria were as follows: (1) experimental or quasi-experimental design, (2) inclusion of a simulated advanced airway management training process for anesthesia or other health care providers, and (3) clearly stated study objectives with measured outcomes. The reviewers engaged in detailed discussions to resolve any disagreements on articles for study inclusion.

Results

A total of 129 studies were considered for review; 41 of those articles were duplicates, and one was not available in English. The 87 non-duplicated articles were screened for possible inclusion in the review based upon the predetermined inclusion criteria: use of an experimental or quasi-experimental design, a simulated advanced airway management training process for anesthesia or other health care providers, and clearly stated study objectives with measured outcomes. Thirty-four of those studies were considered further. During this phase the full article was acquired and reviewed in a more detailed evaluation. Of those studies 15 were randomized controlled trials[3-17], 8 were descriptive studies[18-25], and the remaining 11 studies used simulation as a tool to evaluate equipment or techniques or a specific simulator’s level of fidelity[26-36]. In accordance with the pre-determined inclusion criteria, 15 articles[3-17] were included in this review (Figure 3).

Study Samples

The study samples varied widely. They included physician and paramedic teams[9], respiratory therapists[4], flight nurses and paramedics[5], pediatric residents and fellows[15], medical and dental residents[7,8,12-14], and registered nurses, dental, and other students[16]. There were six studies that included anesthesia residents and/or anesthesia providers[6,7,10,11,13,17](Table 1). Sample sizes ranged from 12-120.

Study Purpose

Study purposes included:

An analysis of the effects of simulation on single or multiple airways task completion[3,5,8]

A comparison of the effects of simulation training over time[4,9,10]

An analysis of the effects of different types of simulators and techniques on learning[6]

An analysis of the effects of non-human interfaced simulation[7,13,16]

To study the effects of an actual human based simulation[12,14,15,17]

To evaluate the different types of methods used to assess performance deficiencies[11]

Outcome Measures

Outcome measures varied greatly and included:

Single and multiple measures of performance compared to a predetermined checklist[3,4,8-10,12,13,15,17,36]

Time to completion of a specific task[3,4,7,13,15] and number of attempts[6,16]

Subjective and/or self-perceived value of the simulated experience[5]

Measurement of efficient and non-efficient time[15]

Analysis of performance based upon generally accepted guidelines using several different reporting modalities[11]

Types of Airway Management Evaluated

Specific types of airway management evaluated included pre hospital airway management[3,5], fiberoptic intubations[4,7,15], assessment skills and airway management of unanticipated adult and pediatric difficult airways[10,17], establishment of a mask airway during an arrest scenario[5,8,9,12,14,16], use of a specific intubation laryngoscope[13], airway management of trauma patients[11], and the use of an airway adjunct[6].

Difficult Airway Algorithm (DAA)

Our review failed to identify a study of the effects of simulation on skill improvement and retention for management of the patient with a difficult airway using the nationally recognized DAA from the United States. We did identify one such study in the United Kingdom. Kudavalli et al.[10] evaluated performance using guidelines developed by the Difficult Airway Society of the United Kingdom for management of unanticipated difficult intubation in the adult non-obstetric patient. The aim of the study was to evaluate the decay of the effects of training over time. In this case-control study, all participants underwent simulation based training. The authors used a structured approach and found that training effects were sustained at a 6-8 week retest but not at the subsequent 6-8 month retest. They also found a reduction in misuse of equipment with training. They concluded that training should be repeated at 6 month intervals or less.

Discussion

Simulation has been used for airway management training by multiple medical and allied health groups. Study designs to evaluate the use of this training and teaching method have varied widely (see Table 2). In spite of their heterogeneity the outcomes of these studies support the effectiveness of this training modality. Thus findings of this systematic review confirm that simulation may be an effective tool to teach airway management skills and provide support for techniques that may be used in the DAA for the anesthesia provider.[3,5,8,12,14-16]

Few studies established a valid method of evaluating the potential or actual effects of this training on patient safety and the transition of skills from the lab to the patient. Of the outcome variables used to detect learning in the simulation laboratory included in the review, most used objective measures of performance, including a weighted and non-weighted check list, and/or time to completion of a task. The ways these skills translated to bedside care and patient safety was investigated by only one study. Crabtree et al.[4] studied the correlation between simulated performance of fiberoptic intubation and clinical skills. While they did not find a significant correlation, they believed their outcome measure of "time to completion" not to be sensitive enough to detect improvement in overall skill performance.

Simulation can include the use of whole body, part trainers, virtual reality, and computer based trainers. The task being taught, the availability of trainers and time flexibility appear to be the most important variables to consider in developing the most effective simulation design. For example, Kudavalli[10] examined the effects on management of a patient with a difficult airway using whole body, scenario based

simulation training for a group of non-novice anesthesia providers. The purpose of the training was to achieve competency in complex decision making and advanced skills. Fidelity to the actual clinical environment was considered key in developing the specifics of the simulated scenario. Pott and Santrock[13] studied the effectiveness of simulation in developing a single complex motor skill (Bullard Laryngoscope). Self-instruction via a PowerPoint presentation and use of a part task trainer were used, and all learners were deemed competent after training.

Limitations of the Review

As with all systematic reviews the accuracy of a literature review depends on the appropriate use of search terms and search procedures for the data bases searched. While we endeavored to use the broadest search terms and worked closely with a librarian, if not described fully in the abstract, it is possible that some relevant studies were missed. Standardized outcome criteria by which to measure the effects of training are notably dissimilar in the studies.

Recommendations

Additional research is needed to further evaluate the use of simulation as a tool to teach advanced airway management to anesthesia students and current practitioners. The DAA has been suggested as a potential basis upon which to design both the simulation and subsequent evaluation of performance. Management of the patient with a difficult airway, whether anticipated or not, is not a matter of if; it is a matter of when. Yet exposure to this emergency clinical event is sporadic, as are opportunities for teaching during these events. High fidelity human patient simulation would seem to be an ideal

method to provide educational opportunities, including both teaching and practice, yet studies to investigate this methodology are lacking.

If future studies support the use of human patient simulation as an adjunct to didactic training for management of the patient with a difficult airway, educators could develop standardized curriculum and outcome criteria that is pre-programmed (including simulator programming) and learner centered. Virtual reality simulators programmed with standardized teaching (knowledge), training (skill) and performance benchmarks may be attractive to both students and educators.

TABLES

Table 1: Review of clinical research studies of the use of simulation as an educational or evaluation tool to enhance training of anesthesia providers in difficult airway management

Ref Number First Author (year of pub)	Purpose	Sample	Design	Type of Airway Simulation	Outcome Measures	Conclusion
17 Johnson (2008)	Exploration of how principles of part task training (PTT) and variable priority training (VPT) would improve anesthesia residents adverse airway management and respiratory events	22 first year anesthesia residents Control group standard didactic and simulation based training (n=11) Experimental group standard and didactic training with addition PTT and VPT training (n=11)	Baseline assessment of in training exam score, US Licensure Exam I-III Performance in 7 simulation based scenarios , graded at the beginning and end of one year of training Scenarios were time limited Performance evaluated by two independent blinded observers	Both pediatric and adult unanticipated difficult airway and other respiratory events	Number of correct diagnosis Weighted task scores Number of correct responses to comprehension questions Ned NASA-TLX scores (perceived workload)	All metrics improved in both groups Experimental group able to complete 9% more tasks than control Experimental group showed a greater increase in correct diagnosis from baseline (p=ns) Perceived workload decreased by 30% from baseline in both groups

Table 1: (cont'd)

Ref Number First Author (year of pub)	Purpose	Sample	Design	Type of Airway Simulation	Outcome Measures	Conclusion
13 Pott (2007)	To determine if a complex motor skill can be taught without the use of active expert participation	Novice users of Bullard laryngoscope (n=28) Attending anesthesiologists, anesthesia residents, and medical students not experienced in use of Bullard laryngoscope	Prospective descriptive study	Intubation with Bullard laryngoscope. Instruction by PowerPoint presentation prepared by experts. Bullard laryngoscope, ETT, and mannequin head were also used	Competence was evaluated via a checklist Time to intubation, total time to prepare scope and intubate, and time used to study the slideshow and practice	Course completed in 21 minutes or less, were successful at first attempt to intubate, assembled and successfully intubated in 5 minutes or less Study shows structured self learning programs and mannequin simulation can be effective methods to teach a complex motor skill

Table 1: (cont'd)

Ref Number First Author (year of pub)	Purpose	Sample	Design	Type of Airway Simulation	Outcome Measures	Conclusion
11 Mackenzie (1996)	To compare the performance of deficiencies of airway management captured by three types of self report with those identified by video analysis	48 trauma patient encounters	Non-experimental, observational study	Performance deficiencies in airway management as identified by the anesthesia record, the anesthesia quality assurance (AQA)report, and post trauma treatment questionnaire(PTQ) as compared to video analysis	Found 28 performance deficiencies in 11 cases by video analysis There were no performance deficiencies noted Two deficiencies were noted on the anesthesia record The PTQ identified 8 of 11 cases in which deficiencies were noted by video analysis	Compared to video analysis other types of reports missed the majority of deficiencies Most frequent deficiency was failure to adhere to OR procedure The use of video analysis to identify performance deficiencies and their factors The use of a no fault self-reporting mechanism may also be useful

Table 1: (cont'd)

Ref Number First Author (year of pub)	Purpose	Sample	Design	Type of Airway Simulation	Outcome Measures	Conclusion
7 Goldman (2006)	To test the hypothesis that a virtual reality (VR) airway simulator can be used to teach fiber optic intubation (FOI) skills	Medical residents Novice non-training residents who did not use the VR simulator (n=4) Novice training group all residents who used VR simulator over a one week period. (n=11) Experts attending anesthesiologists (n=4)	Observational Study	Intubation of an adult using FOI Intubation	Time to intubation prior to and following a 4 day training period Time was measured for both an adult virtual reality FOI scenario and a fresh human cadaver at two weeks after training	Both novices and experts improved time to intubation VR FOI, only significant in novice group In the cadaver group time to intubation was the same in the novice training an d expert group but longer in novice non-training group VR airway simulator appears to offer an effective tool for training in FOI and may offer a tool for assessment of readiness before trainees attempt this technique on live patients

Table 1: (cont'd)

Ref Number First Author (year of pub)	Purpose	Sample	Design	Type of Airway Simulation	Outcome Measures	Conclusion
13 Goldberg (1990)	To evaluate the risk of a simulation drill designed to increase the skill of anesthetists in dealing with unexpected difficult intubations	40 patients randomly assigned to two groups Control group (n=20) intubation by standard techniques Simulation group (n=20) intubation of a difficult airway simulated and performed with the aid of endotracheal introducer	Controlled prospective study	Intubation using airway adjunct	Risk was assessed by changes in vital signs, oxygen saturation, ischemia, arrhythmias, esophageal intubation (EI), or pulmonary aspiration	No significant differences between the groups in any of outcome indicators except EI; there were five EI in the simulation group and none in the control group The hazards that EI poses should be considered before this simulation drill is replicated

Table 1: (cont'd)

Ref Number First Author (year of pub)	Purpose	Sample	Design	Type of Airway Simulation	Outcome Measures	Conclusion
10 Kudavalli (2008)	Measure the effects of training on compliance with national guidelines for the management of unanticipated difficulty airway and/or ventilation More specifically the effect of formal training on performance over time	21 British anaesthetists	Prospective case-control interventional study Performance in two scenarios were measured at baseline, and at 6-8 weeks and 6-8 months after training on the Difficult Airway Society (DAS) algorithm	Two scenario occurring in adult simulated patients Scenario 1 cannot intubate, cannot ventilate (CICV) Scenario 2 cannot intubate, can ventilate (CI)	Management of scenarios scored by single observer based on "ideal" management plan derived from DAS guidelines	**CI scenario** Significant increase in time to insert LMA or ILMA at 6-8 month interval Significant reduction in deviations from guidelines at 6-8 weeks only CICV scenario Significant, sustained improvement in technical skills of cricothyroidotomy, no significant reduction in mean duration of O2 saturation from baseline which was no longer present at 6-8 months Significant reduction in deviations from guidelines at both time intervals In both scenarios a sustained reduction in improper use of equipment

Table 2: A comparison of overall design of human patient simulation studies

	Design	Study
Sample	Physician and paramedic teams	3
	Respiratory therapists	4
	Flight nurses and paramedics	5
	Pediatric fellows	15
	Medical residents and dental residents	7,8,12,14
	RN, dental and other students	9,16
	Anesthesia residents and practitioners	6,7,10,11,13,17
Purpose	Effect of simulation on airway task completion	3,5,8
	Comparison of effects of simulation training over time	4,9,10
	Analysis of effects of learning	6
	Analysis of effects of non-human interfaced simulation	7,13,6
	Effects of human based simulation	12,14,15,17
	Evaluate methods used to asses performance deficiencies	11
Outcome Variable/s	Single and multiple measures of performance based on checklist	3,8,9,10,12,14
	Time to task completion/number of attempts	3,4,6,7,12,13,15
	Subjective value of simulation training	5
	Measurement of efficient and non-efficient time	15
	Analysis of performance using different reporting modalities	11
Type of Airway Management Evaluated	Pre hospital	3,5
	Fiberoptic intubation	4,7,15
	Assessment skills and management of unanticipated adult and pediatric difficult airways	10,17
	Mask airway during arrest	5,8,9,12,14,16
	Non traditional intubation equipment	13
	Airway management in trauma patient	11
	Airway adjuncts	6

FIGURES

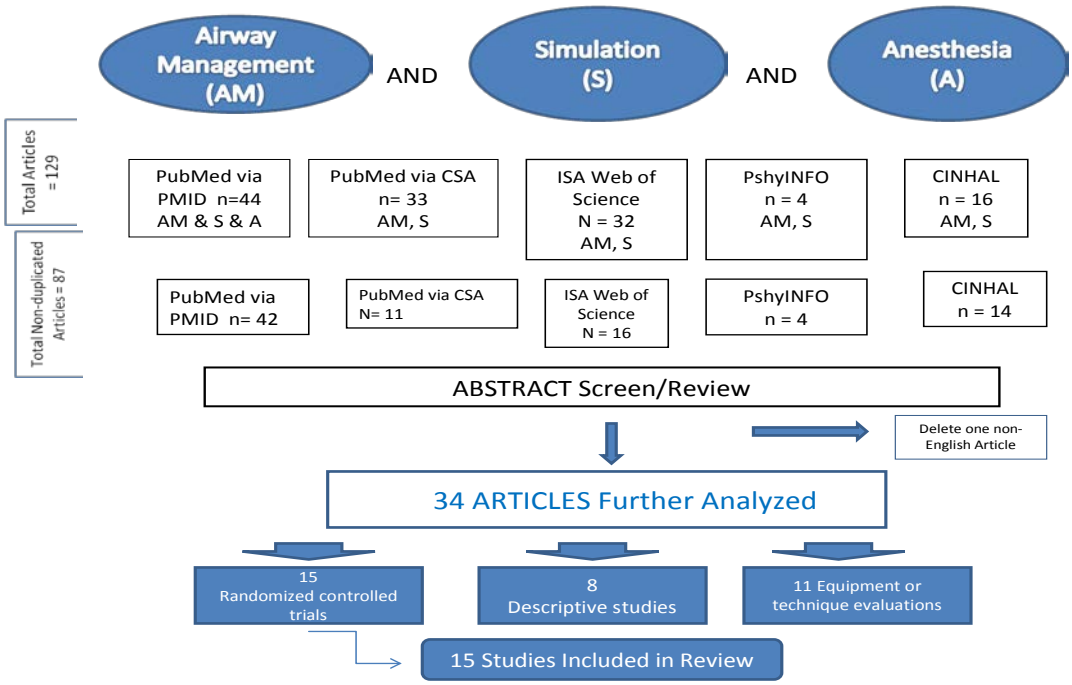

Figure 3: Graphic of search

JOURNAL ARTICLE II

USE OF PATIENT SIMULATION TO TEACH DIFFICULT AIRWAY MANAGEMENT AND IMPROVE PATIENT SAFETY IN THE NURSE ANESTHESIA STUDENT

Introduction

Problems with intubation of the airway are the most common cause of death related to anesthesia.[1] While anesthesia providers become "specialists" in airway management, occasionally they are faced with the patient whose airway requires advanced skills to manage. Advanced airway management has traditionally been taught first in the classroom and later in a bedside apprentice model when and if a patient

presents. Furthermore, given the vastness of the curriculum and the current trends in practice, it is unlikely that each student would be exposed to an adequate number of experiences to ensure proficiency.[2] Medical and nursing education has been placing a greater amount of resources on simulation over the past 25 years in order to augment the magnitude and strength of student knowledge, provide a standardized and safe arena for learning, and to practice and perfect the future practitioner's skill.[3-5] Simulation would seem to be ideally suited to teach both the technical skills of airway management as well as the dynamic physiologic changes caused by the procedure, anesthetic agents used during the process, and how best to avoid significant pathophysiologic outcomes. More specifically, simulation offers the ability to simulate realistic anatomy and physiology of the respiratory and cardiovascular system and to monitor their function using authentic clinical monitors. Moreover, the simulated environment can more closely mimic the stress of the emergency situation and the need of rapid, lifesaving action.

Despite the promise of this technology to optimize learning, malpractice claims persist for significant morbidity and mortality outcomes occurring during the induction period.[6] How best to use this technology to teach advanced airway management to the novice anesthesia provider is poorly understood. There have been no experimental studies published which evaluate the role of simulation in teaching and learning the American Society of Anesthesiologist Difficulty Airway Algorithm (DAA) to the novice anesthesia provider. Chen[7] reported the use of a simulation and lecture curriculum in a renewal course to teach advanced airway management. While no objective measures of learning were reported participants found the course to be useful by improving confidence and performance. Russo[8] examined the use of simulation training for difficult

airway management in current practitioners. Six months after the training participants were surveyed indicating improvement in predicative ability and skills in managing the difficult airway patient. The participants also found the design of the simulation activities and scenarios to be more helpful than lecture. Jordan[9] and Parry[10] examined the effectiveness of different simulators used for teaching the DAA. And finally Kuduvalli[11] investigated the effect of training using simulation for managing the patient with unanticipated difficult airway. Current practitioners were evaluated, using standardized simulated scenarios, at 6-8 weeks and 6-8 months after training. They concluded that simulation based training improves performance but there is a decay in skill over time and recommended repeating training in 6 months or less.[11]

In an effort to identify patterns of liability related to anesthesia management of patients with a difficult airway claims made between the years of 1985-1992 were analyzed. Death or brain damage related to inability to secure the airway occurred during induction in 62% of the cases.[6] In 1993 the American Society of Anesthesiologist (ASA) convened a panel of experts and developed Practice Guidelines for Management of the Difficult Airway. The Guideline recommendations include methods to evaluate the airway, prepare for the patient with a known or suspected difficult airway, and methods to secure the airway of the patient with a difficult airway. Airway management methods were organized into a DAA, which provide an organized method for teaching, learning, and evaluating management. Since inception of the practice guidelines, liability claims related to failure to secure the airway during induction were reduce to 35% of all claims made.[6]

Currently there are no instruments which have undergone extensive validity and reliability testing as evaluation tools to assess performance in management of the patient with a difficult airway in accordance with the DAA.[12] In the only study published to measure performance based upon an algorithm, Kuduvalli[11] based performance on deviation from the United Kingdom's Difficult Airway Society (DAS) algorithm using an ideal management plan derived from the algorithm. While their study used an objective tool for assessment their measured outcome was skill decay over time.

A variety of outcome measures have been examined by anesthesia and other health care provider's performance managing the airway and or adverse respiratory events. These studies were not based upon the DAA. Johnson et al.[13] studied anesthesia resident's performance after the use of simulation for teaching airway management and adverse respiratory events. Resident's performance was evaluated by determining the number of correct diagnosis, effects of training on perceived workload using the National Aeronautics Space Administration Task Load Index (NASA-TLX)[14] scores, and performance on US Licensure exam. Still others have used assessment tools that describe the "ideal" management based on algorithms derived from practice guidelines or an institutionally derived checklist.[11,15-20] Time to completion, number of attempts and success or failure of airway management has also been used as a measure of performance.[18,21-24] And finally, a simulated patient's respiratory and hemodynamic response to airway management has been used as objective measures of performance.[21,25]

In this study we aimed to test the effectiveness of scenario-based (SB) simulation training as compared to task-based (TB) stations, for improving time to secure the airway, decreased amount and degree of patient oxygen desaturation, and better

compliance with the difficult airway algorithm and to determine if the scenario-based simulation training is more effective for improving didactic knowledge and learner satisfaction.

Methods

Following institutional review board approval, all members of a cohort of nurse anesthesia students were invited to participate in the study. At the time of data collection students had completed 4 out of seven semesters of study. Participation was voluntary and performance outcome was confidential and not counted towards formal course grades.

Procedures

Performance evaluation was carried out using a high fidelity simulator (HPS® Simulator, CAE Healthcare Sarasota, Florida, USA) in a mock operating room in the simulation center. Performance was recorded via a proprietary audio video recording system (METIvision, CAE Healthcare Sarasota, Florida, USA). Simulator monitoring included SpO_2, ECG, invasive and non-invasive blood pressure. End title gas analysis was also monitored (Datex Engstrom Capnomatic Ultima, GE Healthcare, Wauwatosa, WI, USA). Subject heart rate and non-invasive blood pressure was also monitored (Phillips V24C, Phillips Electronics North American, Andover, Massachusetts, USA). Subjects were provided a standardized scenario that described their simulated patient information, the induction scenario, available equipment, available personnel, and their role (sole anesthesia provider in rural operating room). An anesthesia cart which

contained 2 laryngoscope handles, a variety of blades (3 MAC, 4 MAC, 2 Miller), oral airway in a variety of adult sizes, nasal airways in a variety of adult sizes, McGill forceps, and tongue blades was placed opposite the anesthesia machine. A difficult airway cart was stored in the next room and available only by request. Equipment contained on the cart included: laryngeal mask airway (LMA, air-Q size 3.5, Cookgas, Clearwater, FL, USA), reinforced endotracheal tube and stabilizer rod specifically designed for intubation via LMA (LMA Fastrach ETT and LMA Fastrach ETT Stabilizer Rod size 7.5mm, Laryngeal Mask Company Limited, LMA North America, San Diego, CA, USA), lightwand intubating stylette (Surch-Lite Orotracheal Lighted Intubation Stylette, Bovie, Clearwater, FL, USA), # 18 gauge angiocath, malleable intubating stylette (Introducer Coude Tip 15 french, SunMed, Largo, FL, USA), flexible fiberoptic laryngoscope with a portable light source (5.2 mm x 65 cm Karl Storz, Endoscopy America, El Segundo, CA, USA), Melker emergency cricothyroid catheter set (4mm uncuffed, Cook Critical Care, Bloomington, IN, USA), and a high pressure jet ventilation system (Manual Jet Ventilator Kit, Mercury Medical, Clearwater, FL, USA),

Each subject's performance was evaluated in response to both a 'cannot intubate can ventilate' (CI) and a 'cannot intubate cannot ventilate' (CICV) scenario (Appendix D). Pre-testing included simulation based testing and a 30 question multiple choice written exam. Within 1 week of completion of testing, subjects received a 90 minute lecture describing the DAA followed by being randomly assigned, based upon performance on the DAA written exam, to either receive TB or SB training (Appendix E) for the DAA. Randomization based upon DAA exam pre-test was performed by first ranking all scores and stratifying by each set of identical scores. Within each strata 50%

of the subjects were randomly assigned to either the TB or SB group. Within one week of completion of training post-testing was carried out (same scenarios as pre-test), a 30 question multiple choice exam (30 different questions that were matched by objectives), and the Student Satisfaction and Self Confidence in Learning Survey (SSSCL) was administered.[26]

Instrumentation

Permission to use the SSSSCL survey was granted from the National League of Nursing (NLN). The instrument was a 13-item instrument designed to measure student satisfaction (includes 5 items) with the simulation activity and self-confidence in learning (includes eight items) using a 5-point scale. The tool had been previously tested for reliability (Cronbach's alpha: satisfaction = 0.94; self-confidence = 0.87).[26]

Didactic knowledge was assessed by a DAA multiple-choice test. A pool of 60 questions was developed for the study. Half of those questions were administered as a pre-test baseline and the other half as a post-test. In order to evaluate the performance of the questions the full 60 question test were administered to nurse anesthesia student underclassmen following the difficult airway lecture and an item analysis was performed. Face validity was examined by gaining expert opinion regarding questions and their relationship of testing objectives. Experts included 2 members of a nurse anesthesia faculty and 1 anesthesiologist members of that same faculty. Based upon point-biserial correlation (r_{pb}) questions for each test were chosen by the level of performance and organized by objective. An equal number of high and low performing questions by objective were chosen for each test by alternating the choice of questions with the highest r_{pb} in 1 objective category to the pre-test and the high performers of the next objective

category to the post-test. For example there were four questions which fell under the first objective category. Questions 1 and 3 performed higher than 2 and 4. Question 1 and 2 were assigned to the pre-test and 3 and 4 to the post-test. The coefficient of equivalency between the two halves of the test (0.33 and 0.50) was estimated to be the corrected reliability coefficient for the entire test (using the Spearman Brown prophecy formula).[27]

Simulator Settings

For both scenarios the induction agents were given when the subject indicated they were ready for induction. For the CI scenario the preprogrammed 'standard man' was used with the following alterations: functional residual capacity was decreased to 1800 and shunt was increased to 0.18. These alterations were instituted for the entire scenario. For the CICV scenario the "standard man" setting and the aforementioned alterations were instituted but not until the final induction agent was administered.

Variable Definitions

Primary outcome variables for the CI scenario included: number of deviations from the ideal DAA, time to securing airway which was defined as the time at which the first end title CO_2 wave form was noted after placement of the endotracheal tube (ETT) inserted through the laryngeal mask airway, lowest oxygen saturation as recorded on the trend plot, total desaturation time which was defined as the total amount of time in which the oxygen saturation fell below 80%. Additionally the student was assigned a grade of 'fail' if the total desaturation time was $\geq$ 3 minutes. The ideal DAA algorithm was scored by summing the number of deviations from an idealized patient management algorithm developed by 2 nurse anesthesia faculty members (based upon DAA). The possible number of deviations ranged from 0-15. Actual pre-test scores ranged from 5-13 and

post-test from 3-11. A deviation was assigned if the subject failed to perform the step or failed to perform the step in the correct order.

Primary outcome variables for the CICV scenario included: number of deviations from the ideal DAA, mean time in seconds to securing the airway which was defined as the time at which the first end title CO_2 wave form was noted after placement of a cricothyroid cannula, lowest oxygen saturation as recorded on the trend plot, and total desaturation time which was defined as the total amount of time in which the oxygen saturation fell below 80%. Additionally the student was assigned a grade of 'fail' if the total desaturation time was $\geq$ 3 minutes. The ideal DAA algorithm was scored by summing the number of deviations from an idealized patient management algorithm developed by 2 nurse anesthesia faculty members (based upon DAA). The range of possible number of deviations were 0-20. Pre-test scores ranged from 11-18 and post-test from 4-18. A deviation was assigned if the subject failed to perform the step or failed to perform the step in the correct order.

Simulations were evaluated from audio video recording which included 2 different cameras to record the actual performance for an overhead and foot of the bed angle, 1 camera recording the end tidal gas monitor, a trend plot, simulator vital signs output recording, and event log. Two reviewers rated simulation variables independently, scores were compared for agreement. If disagreement was noted both reviewers were asked to review the specific event. If there was agreement after the review that value was used. The process continued until agreement could be reached. We were able to gain 100% agreement with all variables.

An ‘ideal’ management plan was developed for each scenario which was developed by expert consensus and based upon the DAA (Appendix F). The scenarios were designed such that subjects were given physical and verbal and clues to force them down the DAA pathway in which the scenario was designed to evaluate. Subjects were given a written report of their patient and the planned surgical procedure. They were then taken to the simulated operating room and allowed time to prepare for the case. When the subject indicated they were ready induction agents were administered virtually and the subjects were informed. During both scenarios the subject had a circulating nurse available. If additional assistance was requested they were informed of unavailability. A difficult airway cart was available but only by request. If the subject requested a fiberoptic bronchoscope they were informed that it was broken. The scenario was allowed to continue until 1 of the following endpoints was reached: airway was secured, simulated patient expired, or ten minutes elapsed from the time of the administration of induction drugs. Upon completion of the first scenario the student was given 5 to 10 minutes to rest after which time the second scenario evaluation was started. The order in which the scenarios were administered was random but the order was the same for each subject during the pre and post-tests. Demographic data collected included age, number of intubation attempts prior to study participation, current grade point average (GPA), and gender. A more detailed discussion of each scenario can be found in Appendix D.

Statistical Analysis

Where appropriate, means and standard deviations were calculated. Nonparametric data were analyzed using Mann-Whitney *U* tests. Parametric data were analyzed using repeated measures ANOVA or Student’s *t*-test. P value of ≤ 0.05 was

considered statistically significant.[28] All data were analyzed using a statistical software package (IBM SPSS Statistics 20; Armonk, NY, USA).

Sample

Sample size was based on 3 criteria: 1) alpha level of 0.05 (one-tailed test), and power of 0.80 (ß = 0.2) according to standard statistical procedures[29]; 2) airway simulation literature[11,30], and 3) calculation of effect sizes for key variables that address the specific aims from previous studies.[11,30] The study was powered to detect a difference of 1 +/- SD in means between the comparative groups for the primary outcome measure of time to completion. The software G*Power 3.1.2 was used to conduct the power analysis and sample size estimation. The projected sample size of 22 was estimated. We recruited 24 subjects to account for a 10% attrition rate noted in a previous study[11]

Results

Twenty-three students chose to participate in the study. Eleven were randomly assigned to the TB group and twelve to the SB group. All subjects completed the study and there was no missing data. Analysis of group demographics revealed no statistically significant differences between the two groups (Table 3).

The purpose of this study was to compare two grouping conditions (TB and SB groups) on the performance and cognitive knowledge improvement in nurse anesthesia students. A repeated measures ANOVA was conducted to examine the effect of grouping conditions on the pre-test/post-test variables, which measured both practice and cognitive knowledge. There were two independent variables, with one between subjects factor (grouping conditions) and one within subjects factor (pre-test and post-test) and 7 outcome variables including time to secure airway, amount and time of oxygen

desaturation, number of deviations from DAA, pass/fail score, performance on a written exam, and satisfaction based upon a survey. Performance measure outcomes in the CI and CICV testing scenarios were combined and were compared pre and post intervention for all variables except the time to secure the airway.

The results of the repeated measures ANOVA, means, and standard deviations for the number of deviations from DAA, lowest desaturation, DAA exam score, and pass/fail score are reported in Table 4. The primary test of interest for repeated measures ANOVA is the interaction effect. The assumption of homogeneity of variance-covariance matrixes was tenable with all variables except time to secure the airway (results listed in Table 4).

A statistically significant reduction in the number of deviations from the DAA in the SB group compared to the TB group was found (Pre-test TB = 23.09, Post-test TB = 16.2, Pre-test SB= 24.25, Post-test, SB = 12.83, interaction $F = 2.91$, $P < 0.05$ (one-tail). Analysis of the written exam scores revealed outliers in both groups. We found 1 outlier in the pre-test, (TB group 40%) and 4 in the post-test, (3 TB group 60%, 63%, 80%, 1 TB group 57%). Repeated measures ANOVA including all outliers did not reveal a significant group effect (Pre-test TB= 65.76%, Post-test TB = 71.21%, Pre-test SB = 69.72%, Post-test SB = 78.61%, interaction F = 0.676, P = 0.210). To determine the effect of the outliers we calculated the improvement in performance by subtracting the pre-test performance from that of the post-test for all subjects. Using these results we ran a non-parametric test (Mann-Whitney U) to compare improvement in scores between the two groups (outliers included). On the post-test the SB group showed a significant improvement in scores (Mean Rank = 15.54) than did the TB group (Mean Rank = 9.23);

Mann-Whitney U = 35.50, p = .03). There were no other significant interactions for the groups by pre-test/post-test.

For the variable time to secure the airway on the pre-test no subjects were able to secure the airway either before the scenario time limit had been exceeded or the simulated patient had expired. The lack of variation violated an important assumption for the use of repeated measures ANOVA. Therefore, we calculated a one way ANOVA for the CI and CICV scenarios on the post-test only. We did not find a statistically significant difference between the group's performance on either scenario as measured by the mean time to secure the airway in seconds (CI scenario TB = 404, SB = 449, F = 0.381, P = 0.261; CICV scenario TB = 455, SB = 400, F = 0.831, P = 0.186). The results of the one way ANOVA for the time to secure the airway are reported in Table 5.

The results of the repeated measures ANOVA, means, and standard deviations for the pre-test and post-test scores are reported in Table 6. We found a statistically significant improvement in performance in all variables from pre-test to post-test except in the variable of the number of pass/fails.

We did not find a difference in the subjective measures of the student's experience as measured by the SSSCL instrument. Mean scores for student satisfaction with learning was 22.73 for the TB group and 21.75 for the SB group (P = 0.398). Mean scores for student self confidence in learning was 34.36 for the TB group and 32.75 for the SB group (P = 0.331). The results of the Student's t-test for the SSSCL instrument are reported in Table 7.

Discussion

Subjects who underwent SB training were found to have a statistically significant greater increase in improvement in their ability to manage the patient with a difficult airway with respect to two of the outcome variables: number of deviations from the DAA (performance) and score on written test (cognitive knowledge). We believe this study is the first to offer evidence that SB training may have specific advantages, including improved didactic knowledge and compliance with a complex algorithm, in teaching management of the patient with a difficult airway to novice anesthesia providers. Of equal importance with respect to the other measured variables, we found that subjects in the SB group, compared to those in the TB group, improved equally in their ability to manage these complex care scenarios. We believe that the findings in this study provide important evidence to support the use of scenario-based training to teach this important skill and knowledge based care. The ability to be able to see, touch, feel, and react to critical events as they occur in the clinical arena allows for the learner to be able to apply knowledge and skills to critical patient events and receive feedback of their effects. In TB training the learner is able to perform the hands on part of this care but are not able to experience this within the context of the look and feel of the clinical environment or to get critical feedback cues to direct the decision process of what to use when.

The inability to find statistically significant differences in all of the outcome variables may be related to a variety of reasons. Pre-test scenario performance was poor among all subjects with the variables time to secure the airway and total time of desaturation. For example, in the CICV scenario pre-test, only one of twenty-three subjects was able to manage desaturation effectively. Based upon the standardized

simulator settings chosen for the scenario, failure to provide oxygenation via a needle cricothyrotomy or cricothyrotomy within three hundred thirty seconds resulted in the patient developing a lethal non-recoverable arrhythmia. This led to a minimal degree of variability during the pretest in time of desaturation (limited by death of simulated patient) and time to secure the airway (subjects had not training in placement of needle cricothyrotomy, cricothyrotomy, and use of jet ventilator) outcome variables. The study was designed and powered based upon the use of repeated measures ANOVA to assess the effect of dependent variables. The lack of variability in the pre-test scenarios violated an important assumption underlying the use of this test (normal distribution of the variable within the study population) with respect to the two variables. We also believe it represents the important and complex relationship between scenario design to overall study design.

We did not find a statistically significant difference in learner satisfaction and self-efficacy using the SSSCL instrument. Based upon these findings we believe that both methods of training appear to offer a high degree of satisfaction to the learner including subjective experiences of both satisfaction and self-efficacy.

Our study may have limitations. We conducted this study with novice anesthesia providers who were at the same place in their training and enrolled in the same program. The results of this study may not be generalizable to all nurse anesthesia students or other anesthesia providers.

Another potential limitation was the small sample size. The effect of outliers in small sample sizes is of much greater magnitude in comparison to those with larger size

samples. While we followed acceptable methods of treatment of outliers it may be more desirable to have a larger sample size to limit the effects of outliers.

A training effect may have led to a greater increase in skill performance among the members of the SB group as their training was performed on the same simulator and process as was used for testing. However, we believe this effect would have been limited to simulation based outcome variables yet we also found statistically significant results with cognitive based variable.

While were not able to detect significant interactions for the groups by pre-test/post-test in the majority of outcome variables, we did find a statistically significant difference in two variables which may represent two different domains of learning; skill based learning and cognitive knowledge. We believe this may offer evidence to support the use of scenario-based training to teach novice anesthesia providers how to manage the patient with a difficult airway.

Based upon the finding in this study recommendations for further research include conducting a similar study in a larger and less homogeneous sample and further inquiry into scenario designs which may be better suited to novice anesthesia providers. The addition of post-testing intervals beyond the immediate intervention period may also be helpful to examine the effects of training on skill retention. And finally, studies that could evaluate the effects of simulation based training on care outcomes of actual patients are also needed.

TABLES

Table 3: Demographics

Variable	Group	N	Mean	Std. Deviation
Age years	TB	11	28.63	2.11
	SB	12	30.67	5.66
# Intubations	TB	11	126.36	22.54
	SB	12	127.92	28.54
GPA	TB	11	3.89	0.15
	SB	12	3.92	0.10
Gender	TB	M 3	F 8	
	SB	M2	F10	

Table 4: Results of repeated measures ANOVA by time and group

Between Subjects		TB N=11		SB N = 12		*F interaction*	*P (interaction, one-tail)*	*Box's M/P*
		Pre	Post	Pre	Post			
Number of Deviations from DAA (maximum number of deviations = 35)	mean	23.09	16.27	24.25	12.83	2.914	.05	6.147/.14
	SD	2.87	6.67	2.13	4.15			
Lowest Desaturation (SpO_2 % saturation)	mean	28.63	49.27	29.5	44.71	0.171	.34	.210/.98
	SD	18.39	33.04	18.2	29.78			
DAA Exam Score* (% questions correct)	mean	69	73	70.00	80.610	3.30	.04	5.513/.19
	SD	5.270	2.357	8.028	5.125			
Pass/Fail** (SpO_2 did not exceed 80% or less for $\geq$ 3 minutes)	mean	1.00	1.181	1.00	1.250	0.028	.87	4.319/.28
	SD	0.632	0.405	0.603	0.754			

TB indicates task based group, SB scenario based group.

DAA indicates difficult airway algorithm, SD standard deviation.

*Outliers excluded (TB $N = 8$, SB $N = 11$).

**Pass score indicated number of scenarios passed (0 = 0 of 2 passed, 1= 1 of 2 passed, 2 = 2 of 2 passed).

Table 5: Results of one way ANOVA for mean time to secure the airway during the post-test

		TB Group N = 11	Standard Deviation	SB Group N = 12	Standard Deviation	*F*	*P* (one-tail)
Mean time to secure airway *seconds*	Scenario A	404.36	173.36	454.91	133.79	0.381	0.272
	Scenario B	448.58	170.02	399.67	154.77	0.831	0.186

Table 6: Results of repeated measures ANOVA by time of test

Within Subjects		Pre N=23	Post N = 23	*F factor*	*P (factor, one-tail)*
number of deviations from DAA (maximum number of deviations = 35)	mean	23.695%	77.193%	12.117	0.0015
	SD	2.530%	5.814%		
lowest desaturation (SpO_2 % saturation)	mean	29.087	46.891	7.479	0.006
	SD	17.876	30.739		
total time desaturation (seconds)	mean	58.174	93.783	7.479	0.006
	SD	35.751	61.479		
DAA Exam Score* (% questions correct)	mean	69.649%	77.193%	12.117	<0.01
	SD	6.839%	5.801%		
Pass/Fail** (pass = SpO_2 did not exceed 80% or less for $\geq$ 3 minutes)	mean	1.000	1.217	1.130	0.150
	SD	0.603	0.600		

DAA indicates difficult airway algorithm, SD standard deviation.

*Outliers excluded (TB *N* = 8, SB *N* = 11).

**Pass score indicated number of scenarios passed (0 = 0 of 2 passed, 1= 1 of 2 passed, 2 = 2 of 2 passed).

Table 7: Student Satisfaction and Self Confidence in Learning Instrument results

		TB	**SB**	***T***	***P***
Student Satisf	mean	22.73	21.75	0.863	0.398
	SD	2.533	2.864		
Student Conf	mean	34.36	32.75	0.995	0.331
	SD	3.695	4.048		

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APPENDIX A: NATIONAL LEAGUE OF NURSING (NLN) APPROVAL TO USE SSSCL

Email from NLN dated November 30, 2010 2:49 pm

It is my pleasure to grant you permission to use the “Educational Practices Questionnaire,” " Simulation Design Scale" and “Student Satisfaction and Self-Confidence in Learning” NLN/Laerdal Research Tools. In granting permission to use the instruments, it is understood that the following assumptions operate and "caveats" will be respected:

It is the sole responsibility of (you) the researcher to determine whether the NLN questionnaire is appropriate to her or his particular study.

1. Modifications to a survey may affect the reliability and/or validity of results. Any modifications made to a survey are the sole responsibility of the researcher.
2. When published or printed, any research findings produced using an NLN survey must be properly cited as specified in the Instrument Request Form. If the content of the NLN survey was modified in any way, this must also be clearly indicated in the text, footnotes and endnotes of all materials where findings are published or printed.

I am pleased that material developed by the National League for Nursing is seen as valuable as you evaluate ways to enhance learning, and I am pleased that we are able to grant permission for use of the “Educational Practices Questionnaire" Simulation Design Scale" and “Student Satisfaction and Self-Confidence in Learning” instruments.

Alyss Doyle Coordinator of Educational Programming | National League for Nursing | www.nln.org doyle@nln.org | Phone: 800-669-1656 x145 | Fax: 212-812-0391 | 61 Broadway | New York, NY 10006

APPENDIX B: STRATIFIED RANDOM ASSIGNMENT PROTOCOL

Stratified Random Assignment Protocol

Purpose: To randomly assign study participants who have been stratified into either the top 50% of scorers on the DAA multiple choice test at baseline and those who scored below into the Task Based Training Group (TB) (control group) or the Simulation Based Training Group (SB) (intervention group).

Who: Principal Investigator

When: After all participants have completed their baseline assessment.

NOTE: If it is necessary to generate the random assignment protocol before all participants have completed the baseline assessments, the protocol should be generated by a non-tester and results should be kept from testers until after all testing has been completed for that participant.)

Materials: Laptop with SPSS software

Inclusion/Exclusion Screening Form

Procedure:

1. Create a new blank data file in SPSS.
2. Enter the Study ID numbers of all participants who have agreed to participate and are eligible based on the Screening Questionnaire.
3. Go to DATA menu and select “SELECT CASES.”
4. Select “RANDOM SAMPLE OF CASES” and click on SAMPLE.

5. Select the option that allows you to randomly select "X" cases form the first X cases.
6. If there is an even number of participants, the number to select will be exactly half the total number of participants. For example, if there are 12 participants, select "Exactly 6 cases from the first 12 cases." Click "CONTINUE" and then click "OK."
7. All the cases assigned a value of "1" will be in the TT group. All the cases assigned a value of "0" will be in the ST group.

NOTE: When there are an odd number of cases, we will need to select either 1 extra person or one less person for the SB group. The first time this occurs, we will select one extra person for the SBT group; the second time this occurs, we will select one less person for the ST group, etc.

APPENDIX C: STUDENT SATISFACTION AND SELF-CONFIDENCE IN LEARNING INSTRUMENT

Student Satisfaction and Self-Confidence in Learning

Instructions: This questionnaire is a series of statements about your personal attitudes about the instruction you receive during your simulation activity. Each item represents a statement about your attitude toward your satisfaction with learning and self-confidence in obtaining the instruction you need. There are no right or wrong answers. You will probably agree with some of the statements and disagree with others. Please indicate your own personal feelings about each statement below by marking the numbers that best describe your attitude or beliefs. Please be truthful and describe your attitude as it really is, not what you would like for it to be. This is anonymous with the results being compiled as a group, not individually.

Mark:
1 = STRONGLY DISAGREE with the statement
2 = DISAGREE with the statement
3 = UNDECIDED - you neither agree or disagree with the statement
4 = AGREE with the statement
5 = STRONGLY AGREE with the statement

Satisfaction with Current Learning	**SD**	**D**	**UN**	**A**	**SA**
1. The teaching methods used in this simulation were helpful and effective.	○1	○2	○3	○4	○5
2. The simulation provided me with a variety of learning materials and activities to promote my learning the medical surgical curriculum.	○1	○2	○3	○4	○5
3. I enjoyed how my instructor taught the simulation.	○1	○2	○3	○4	○5
4. The teaching materials used in this simulation were motivating and helped me to learn.	○1	○2	○3	○4	○5
5. The way my instructor(s) taught the simulation was suitable to the way I learn.	○1	○2	○3	○4	○5
Self-confidence in Learning	**SD**	**D**	**UN**	**A**	**SA**
6. I am confident that I am mastering the content of the simulation activity that my instructors presented to me.	○1	○2	○3	○4	○5
7. I am confident that this simulation covered critical content necessary for the mastery of medical surgical curriculum.	○1	○2	○3	○4	○5
8. I am confident that I am developing the skills and obtaining the required knowledge from this simulation to perform necessary tasks in a clinical setting	○1	○2	○3	○4	○5
9. My instructors used helpful resources to teach the simulation.	○1	○2	○3	○4	○5
10. It is my responsibility as the student to learn what I need to know from this simulation activity.	○1	○2	○3	○4	○5
11. I know how to get help when I do not understand the concepts covered in the simulation.	○1	○2	○3	○4	○5
12. I know how to use simulation activities to learn critical aspects of these skills.	○1	○2	○3	○4	○5
13. It is the instructor's responsibility to tell me what I need to learn of the simulation activity content during class time..	○1	○2	○3	○4	○5

 Revised December 22, 2004

APPENDIX D: TESTING SCENARIOS

Testing Scenario A

Cannot Intubate Can Ventilate (CI)

During routine induction of anesthesia in an adult non-obstetric patient

A 55- year old man with a body mass index of 30 and ASA I.

No factors suggestive of a difficult airway on pre-operative assessment.

Undergoing anesthesia for lumbar discectomy for incipient cord compression.

Plan is to ventilate prone with and ETT.

After full monitors are applied he is induced with propofol 200 mg, fentanyl 50 mcg, and vecuronium 10 mg.

Facemask ventilation will be permitted.

Direct laryngoscopy reveals a Grade 4 Cormack and Lehane view via tongue swelling.

the tongue will remain swollen and larygospasm will be activated unless an LMA is attempted but successful completion of the scenario will require the placement of an ETT via the LMA. If an ETT is placed bronchial occluder will be activated which will be deactivated if mask ventilation or LMA with or without ETT is placed.

If the subject requests the FOB they will be informed that it is malfunctioning

The following changes will be made to the standard man scenario and instituted prior to induction:

FRC reduced to 1800ml (default 2000)

O2 consumption increased to 675ml/minute (default 200)

Shunt increased to 0.18 units (default 0.02 units)

The scenario will continue until the patient is successfully intubated, death occurs, or ten minutes lapse from the time of final induction agent administration.

Testing Scenario B

Cannot Intubate Cannot Ventilate (CICV)

During routine induction of an adult non-anesthetized patient in an adult non-obstetric patient.

A 55- year old man with a body mass index of 30 and ASA I.

No factors suggestive of a difficult airway on pre-operative assessment.

Undergoing anesthesia for lumbar discectomy for incipient cord compression.

He would need to be ventilated prone with and ETT.

After full monitors are applied he is induced via the computer with the administration of propofol 200 mg, fentanyl 50 mcg, and vecuronium 10 mg.

Initial attempts at mask ventilation fail in spite of the use of oral and nasal airways.

Direct laryngoscopy reveals a Grade 4 Cormack and Lehane view and the patients oxygen saturation falls rapidly.

The tongue will be swollen, laryngospam activated, airway occluded, and bronchial occlusion will be instituted until a needle cricothyrotomy of cricothyrotomy are successfully placed at which time bronchial occlusion only will be discontinued.

All other attempts to ventilate or intubate will be rendered unsuccessful by the aforementioned simulator settings.

The following changes will be made to the standard man scenario and instituted at the time of administration of the final induction agent:

FRC reduced to 1800ml (default 2000)

O2 consumption increased to 675ml/minute (default 200)

Shunt increased to 0.18 units (default 0.02 units)

The scenario will continue until the patient is successfully intubated, death occurs, or ten minutes lapse from the time of final induction agent administration.

APPENDIX E: TRAINING SCARNARIOS

Scenario Based (SB) Training Scenarios

Cannot intubate can ventilate

1. Patient was a 46 year old male, 72 inches tall and weighed 350 pounds. He was undergoing a ventral hernia repair. The history consisted of no previous anesthetic, no airway abnormalities noted, no history of sleep apnea, baseline vital signs were normal and room air saturation was 96%.

   Upon induction the subject was allowed to ventilate without incident but was unable to intubate with a standard laryngoscope. Upon placement of an intubating LMA and passage of an endotracheal tube (ETT) into the larynx ventilation was accomplished. The use of a bougie and or lightwand intubation device did not result in intubation of the trachea and establishment of adequate ventilation. While a fiberoptic bronchoscope was available it was reported as non-functional for this case.

2. Patient was a 24 year old female, 60 inches tall and weighed 150 pounds. She was undergoing a laparoscopic cholecystecotomy. The history will consisted of no previous anesthetic, no airway abnormalities noted, no history of sleep apnea, baseline vital signs normal and room air saturation of 100%.

   Upon induction the subject was allowed to ventilate without incident but unable to intubate with a standard laryngoscope. Placement of an LMA would result in successful ventilation. Proper use of a bougie and or lightwand intubation device also provided for intubation of the trachea and

establishment of adequate ventilation. While a fiberoptic bronchoscope was available it was be reported as non-functional for this case.

Cannot intubate cannot ventilate

3. Patient was a 72 year old female, 60 inches tall and weighs 300 pounds. She was undergoing a left lower leg amputation. The history consisted of previous anesthesia without incident, insulin dependent diabetes, a Mallampati score of 4, limited neck range of motion, and poor dentition. She was febrile with a temperature of 102^0 F. No airway abnormalities were noted, no history of sleep apnea. Baseline vital signs included a blood pressure of 160/110 and a heart rate of 125.

   Upon induction the subject was unable to ventilate resulting in a rapid desaturation. Attempts to intubate with a laryngoscope were forced to be unsuccessful as was the use of an LMA, intubating LMA, lightwand, or bougie. Desaturation continued during unsuccessful attempts to intubate. Successful intubation of the trachea was only successful with the use of a fiberoptic bronchoscope. Once the ETT was placed adequate ventilation was permitted.

4. Patient was a 52 year old male, 64 inches tall and weighed 250 pounds undergoing a internal fixation of a fractured humerus. The history consisted of previous anesthesia without incident, hypertension, a Mallampatii score of 3 normal neck range of motion, and edentulous. He was afebrile, and denied a history of sleep apnea. Baseline vital signs included a blood pressure of 140/90 and a heart rate of 105.

Upon induction the subject was unable to ventilate resulting in a rapid desaturation. Attempts to intubate with a laryngoscope were forced to be unsuccessful as was the use of an LMA, intubating LMA, lightwand, bougie and fiberoptic bronchoscope. Desaturation continued during these unsuccessful attempts to intubate. Successful intubation of the trachea would only be successful with the use of a cricothyrotomy. Once the cricothyrotomy was placed adequate ventilation was permitted.

Task Based (TB) Training

Task-based stations

Task-based stations consisted of a part trainer (intubating head) and an airway adjunctive device. Stations included:

1. Fiberoptic bronchoscope
2. LMA, and intubating LMA
3. Bougie whose placement will be assisted with video laryngoscopy
4. Lightwand
5. Cricothyrotomy kit use with jet ventilation and conventional ventilation.

A faculty member provided a demonstration and verbal training in the use of each device. A copy of the ASA Difficult Airway Algorithm was placed at each station so that the subject could see where this adjunct would fit in the DAA. Each subject was permitted to spend 15 minutes of instruction at each station.

APPENDIX F: IDEAL DAA MANAGEMENT PLAN

Cannot Intubate Can Ventilate	**Pre**	**POST**
SCENARIO A	SCORE	SCORE
Attempt to ventilate		
Attempt initial intubation		
Perform at least one of the following		
Use of different blade		
Head repositon		
Attemtp second intubation attempt		
Call for help		
Request difficult airway cart		
Perform at least one of the following		
Bougie		
ILMA		
lighwand		
ILMA Insertion		
inflates LMA		
Inserts ETT with stabilizer		
inflates ETT		
checks for ETCO2		
deflates LMA		
removes stabilizer bar prior to extubation of LMA		
If unsuccesful returns to mask ventilation		
Outcome of scenario		
Airway not secured =1		
Airway secured not following the DAA =2		
Airway secured following =3		
# of deviations	0	0

APPENDIX F: (CONT'D)

	Pre	POST
SCENARIO B	SCORE	SCORE
Attempt initial ventilation		
Perform at least one of the following:		
reposition head		
place oral or nasal airway		
two person mask vent		
Attempt initial intubation		
Perform at least one of the following		
Use of different blade		
Head repositon		
Attemtp second intubation attempt		
Call for help		
Request difficult airway cart		
Attempt ILMA x 1		
Place needle cricothyrotomy		
uses syringe		
aspirates during insertion		
removes needle		
uses 3.5 ett adapter or jet ventilor		
attempt jet/machine ventilation		
Place cricothyrotomy		
places guidewire through catheter		
threads dilator/cannula over guidewire		
nicks skin prior to dilator/cannula insertion through skin		
removes dilator		
connects circuit		
confirms ETCO2		
Outcome of scenario		
Airway not secured		
Airway secured not following the DAA		
Airway secured following		
# of deviations	0	0