ORIGINAL ARTICLE

Instructor-based Real-time Multimedia Medical Simulation to Update Concepts of Difficult Airway Management for Experienced Airway Practitioners

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Background: We integrated lecture, real-time multimedia display and medical simulation into a new renewal airway management training protocol for experienced nurse anesthetists.

Methods: Trainees of the Taiwan Association of Nurse Anesthetists from northern Taiwan and junior residents from our department were enrolled into the training program. A 4-hour renewal curriculum in the management of airway emergencies was developed, which consisted of a 2-hour general lecture (including 4 divided sections) and a 2-hour instructor-based real-time multimedia medical simulation of 4 specific techniques. After detailed explanation of each specific instrument at the beginning of each simulation, the instructors demonstrated accurate and successful management of 4 airway crises from clinical experience by using a standardized human patient simulator situated on the stage of the conference room. Meanwhile, real-time display of instructors' performance, responsive physical parameters and images from specific instruments were conducted by video camera and video processor, and projected on a 3-frame screen. Brief summary and feedback were performed after each simulation. Trainees completed a questionnaire 6 months after they participated in the training program.

Results: Two hundred and forty-two nurse anesthetists and 13 young residents were trained with this protocol. The questionnaire revealed that the renewal training program was useful. Participants updated their knowledge of difficult airway management, gained more confidence, improved performance, and provided effective assistance in handling airway crises.

Conclusion: Renewing practice guidelines and teaching airway management skills, especially for difficult airway crises and protection of personnel, continues to be an important issue. Instructor-based real-time multimedia simulation is a fast, useful and systematic renewal educational method for many participants with extensive experience of airway management to update their knowledge about difficult airway management, and acquire improved decision-making and communication capabilities, skills of specific airway management. [*J Chin Med Assoc* 2008;71(4):174–179]

Key Words: airway, crisis resource management, multimedia, simulation

Introduction

Loss of airway and machine mishap were the most terrible crises during anesthesia in the past. There have been more and more improvements in technology for safety inspection of anesthetic machines, and also for airway management. The incidence of machine mishap has decreased. However, airway crisis during clinical practice persists after progressive inventions in airway management instrumentation.

Traditional airway management training promotes learning through lectures, discussion, reading, and extensive patient care experiences. However, this uniform training has arguable drawbacks, such as patient

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and personnel safety, inefficiency and long training duration. The complexity of clinical conditions may make training strategies more difficult to develop. Importantly, individual resident or nurse anesthetists may not experience scenarios that are rare or unusual in manner and with a frequency that is sufficient to prepare them for similar circumstances in the future.

Successful management of difficult airway and airway crisis relies heavily on teamwork, conversance with treatment algorithms, and facility in and proficiency with available alternative instruments. The *Difficult Airway Algorithm* was developed by the American Society of Anesthesiologists (ASA) in 1993.[1] As mentioned above, many alternative methods have been invented for management of airway crisis, including evolutional videolaryngoscope and laryngeal mask airway (LMA), etc. The *Difficult Airway Algorithm* was updated and published in 2003.[2–4] However, after brief investigation, we found that the new guidelines were not well known and popularized, especially among nurse anesthetists. Furthermore, most of them had no notion of how to assist the doctor during a specific procedure, such as fiberoptic intubation (FOI) through LMA, and there was no renewal airway management protocol for nurse anesthetists.

Specific training in managing clinical crises and optimizing teamwork in acute situations was begun just over a decade ago within anesthesiology by Gaba and colleagues and was termed *Anesthesia Crisis Resource Management* (ACRM). ACRM is a conceptual framework for responding to crisis that was first developed by the airline industry in the early 1970s.[5] The ACRM curriculum, which was originally designed for anesthesiologists, is now applied to many areas of medicine and health care where acute care medical skills and teamwork are essential for effective team performance.[6]

The purposes of full-scale simulation have been reported as being to assess medical student performance in anesthesia-related scenarios,[7] to detect gaps in medical student knowledge in anesthesia,[8,9] to observe and quantify technical performance of novice anesthestists,[10] and to evaluate physicians with lapsed medical skills.[11] Most importantly, the standardized patient simulator has been operated to simulate such critical illnesses as cardiac events and airway crisis under the principles of ACRM for junior residents and advanced cardiovascular life support training in many hospitals.

This was the first time that we integrated the lectures, screen and simulation-based scenarios for advanced airway practitioners. We report the program to popularize the *Difficult Airway Algorithm* and new alternative methods by using this new multimedia approach for experienced nurse anesthetists.

Methods

Description of the pilot program

The participants were certificated nurse anesthetists in northern Taiwan who were recruited from the Taiwan Association of Nurse Anesthetists (TANA) for this renewal of airway management by using e-mail. The trainees from TANA and junior residents from our department were enrolled into the training program. All of the trainees from TANA were working at different hospitals at the time of this program. A 4-hour curriculum in the management of airway emergencies was developed, which consisted of a 2-hour general lecture and then a 2-hour multimedia medical simulation. The intention of this program was to integrate medical knowledge, practice and decision-making into realistic simulation. All sections were conducted in the large conference room of the hospital and instructed by board-certificated anesthesiologists, nurse anesthetists and specialists in medical simulation. The handouts for the lecture and medical simulation were sent to each participant by post 2 weeks before the training program.

Lecture

The 4 sections of the 2-hour lecture were: (1) difficult airway management and patient safety; (2) prediction of difficult intubation, practice guidelines and decision-making in difficult airway management; (3) the role of nurse anesthetists in difficult airway management; and (4) advanced airway management.

Instructor-based real-time multimedia medical simulation

There were 4 divided sections focusing on 4 specific devices of difficult airway management according to the resources available in northern Taiwan. These 4 sections included nasal FOI, FOI via LMA, new videolaryngoscope (GlideScope®; Saturn Biomedical Systems Inc., Burnaby, British Columbia, Canada), and cricothyrotomy (Table 1). After detailed explanation of each specific instrument at the beginning of each section, 1 standardized human patient simulator (SimMan®; Laerdal, Stavanger, Norway) situated on the stage of the conference room was operated to simulate 4 different airway crises from clinical experience (Table 1). Importantly, the airway of the "patient" could be simulated as being in various difficult airway conditions. An operator, in an adjacent control room,

Table 1. Four sections of instructor-based real-time multimedia medical simulation

Section	Scenario	Steps of procedure
Nasal FOI	C3-6 spondylolisthesis after car accident (anticipated difficult airway)	Identify limitation of neck motion Preparation of FOB and ETT Preparation of patient Perform bronchoscopy via nasal route Advance of ETT
FOI through LMA	Unanticipated difficult intubation after multiple attempts	Perform LMA placement Confirm successful ventilation through LMA Perform FOI through LMA Confirm successful intubation Change to 7.5# ETT by tube exchanger
GlideScope®	Failed intubation in a hypognathic patient	Preparation of videolaryngoscope Preparation of ETT (pre-curve or use specific stylet) Perform intubation
Cricothyrotomy	Unexpected extubation in a patient with difficult intubation on arrival at PAR	Confirm cannot ventilate and cannot intubate Perform cricothyrotomy Confirm successful ventilation Perform ACLS

FOI = fiberoptic intubation; ETT = endotracheal tube; LMA = laryngeal mask airway; PAR = post-anesthesia recovery room; ACLS = advanced cardiovascular life support.

operated the computer to change the vital signs and physiologic responses to simulate an evolving clinical situation.

The lecturer described the scenarios designed to focus on specific aspects of team performance and airway management algorithm at the beginning of each simulation session. The instructors from the anesthesiology department demonstrated the correct techniques and the lecturer commented on the demonstrations during each simulation session. The multimedia simulation displayed on a 3-frame screen in a real-time fashion consisted of: (1) close-up of instructors' performance and accurate procedures from video camera, or images from fiberoptic bronchoscope (FOB) or videolaryngoscope; (2) frames of scenarios and steps to perform the proper procedures; (3) responsive physical parameters (Figure 1). For example, during the second scenario, the FOB was prepared to perform intubation through LMA. The video adapter was connected to the FOB on the small camera at its tip. Through video processor, the pictures during the whole procedure of FOI through LMA were displayed on the center of the screen. During the last scenario, a real-time display of a close-up of instructors' performance was achieved by video camera. At the conclusion of each scenario, the lecturer provided a brief summary and feedback on the simulation.

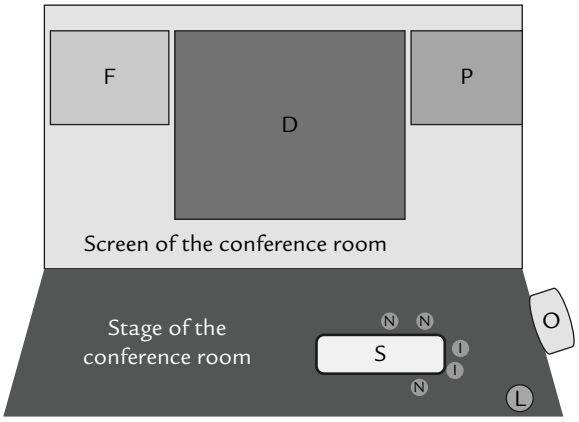

Figure 1. Instructor-based multimedia simulation on a 3-frame screen by real-time display. The SimMan (S) was situated on the stage of the conference room. The operator (O) operated the computer to change the vital signs and physiologic responses. The lecturer (L) gave a commentary by real-time expositions. The instructors (I = instructor; N = nurse anesthetist) demonstrated the accurate techniques. Real-time multimedia display on the 3-frame screen: F = ongoing frames of scenarios and steps of procedures; D = real-time display of images from video camera, FOB or videolaryngoscope; P = responsive physical parameters.

Evaluation

A written course feedback survey in the form of a questionnaire was administered 6 months after the trainees had participated in the program.[6–11] Participants were asked to assess: (1) the overall quality of the program; (2) whether or not the program goals were met; (3) the quality of the lectures; (4) the quality of multimedia simulations; (5) the realism of the scenarios; (6) the quality of the simulation environment and equipment;

(7) the usefulness of the program; (8) the augmentation of airway management concepts and techniques in clinical application; and (9) further familiarity with the steps of specific procedures on a 5-point Likert scale ranging from excellent to poor (1 = poor, 2 = fair, 3 = adequate, 4 = very good, 5 = excellent). In addition, free text comments were solicited.

Results

Characteristics of participants

Two hundred and fifty-five participants were trained in this program. Among them, 13 were junior residents, 80 were nurse anesthetists from our anesthesiology department, and 162 were nurse anesthetists from other hospitals. All nurse anesthetists were certificated and experienced in airway management.

Program evaluation

Questionnaires for course feedback were obtained from 189 participants (response rate, 70%). There were no exclusions of the questionnaires and results. Overall evaluation was extremely positive. The means and standard deviations of the 8 course evaluations (overall program, meeting course goals, lecture, multimedia simulations, realism, environment and equipment, usefulness of the program, and augmentation of abilities) are depicted in Figure 2.

The survey data were: overall program, 4.56 ± 0.49; course goals met, 4.38 ± 0.6; quality of lecture, 4.45 ± 0.57; multimedia simulations, 4.44 ± 0.57; realism, 4.42 ± 0.57; environment and equipment, 4.4 ± 0.57; usefulness of the program, 4.3 ± 0.62; augmentation of abilities 4.8 ± 0.39; and familiarity with procedures 4.8 ± 0.47. There were no fair or poor ratings by any participant.

Free text comments of the participants revealed that the training program was quite useful. Participants described the course as filling an important void in their update on the airway management algorithm. Examples of comments are: "Nurse anesthetists improved communication with anesthesiologists in difficult airway management after participating in multimedia medical

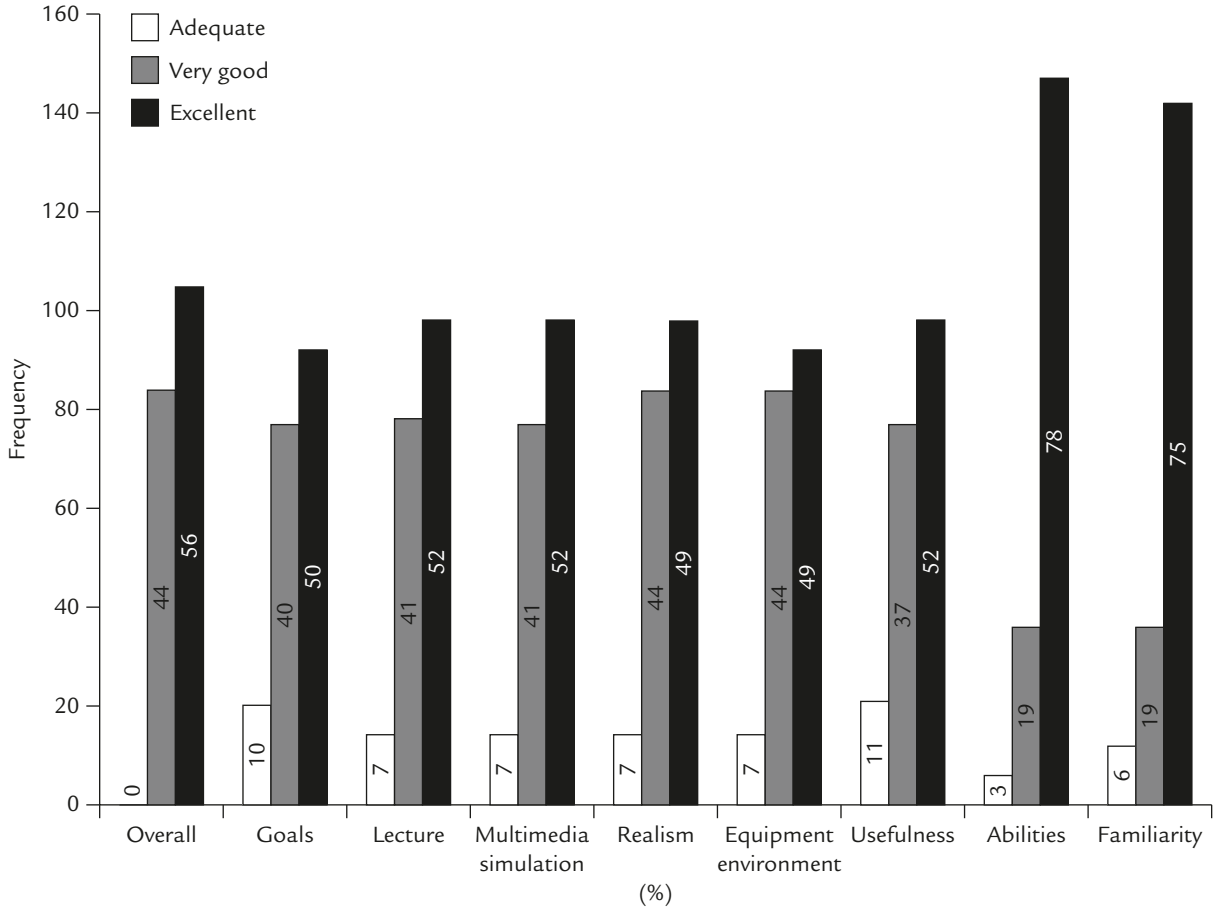

Figure 2. Course feedback from participants was organized by questions on a 5-point Likert scale ranging from excellent to poor. There were no ratings of fair or poor.

simulation"; "This is a valuable program for anesthetists to update about accurate airway management and new alternative devices."

Most importantly, most survey respondents appreciated the real-time display of all images on a 3-frame screen. After this multimedia simulation, they comprehended how these advanced procedures could be performed, and they acquired more skill and ability to do well in similar clinical cases.

Discussion

Establishing an airway is of paramount importance in the field of clinical anesthesia, and teamwork is one of the most important cornerstones during difficult airway management. Effective assistance from nurse anesthetists is crucial for successful intubation. This heavily relies on familiarity with the *Difficult Airway Algorithm* and the preparation of equipment. Though there are advanced inventions in airway management technologies, there is no uniform and effective training protocol for experienced airway practitioners to update their knowledge and techniques. Furthermore, the importance of optimal airway management and protection of health care personnel is greatly appreciated after the outbreak of severe acute respiratory syndrome (SARS) in many countries.[12]

In a case of unanticipated difficult intubation, we performed FOI through LMA. The images of the whole procedure were displayed on a monitor through the video adapter and the video processor assembly. We found unexpectedly that the display of real-time images could be greatly appreciated in teaching image-guided airway management. In order to help nurse anesthetists to acquire skills and update their medical knowledge for airway management, we designed the new renewal training protocol using lecture and medical simulation.

To our knowledge, this is the first program to enroll such a large number of trainees and systematically train "experienced practitioners". Compared to the uniform, long-duration and non-systematic traditional education methods, the renewal training protocol provided a faster, more methodical, effective, useful, and enjoyable learning method. The general lecture by certified anesthesiologists in 2 hours may provide basic and advanced knowledge about airway management, since medical knowledge is crucial in clinical practice. The newly designed interactive lecture was more diverse and the content richer. It not only focused on a systematic review of anatomy but also the new algorithm in both routine and emergent airway management, especially in the prediction of difficult airway, algorithm of decision-making, patient safety and role play of assistance. All participants agreed that the lecture was useful for updating them on guidelines in clinical practice and accomplished the desired purpose. We advocate that structured lecture for airway management in detail before simulation is necessary, especially for those participants who already have extensive experience in airway management.

Use of patient simulators has become widespread in anesthesiology just as in other areas. Full-scale simulation has been applied for many purposes.[7–11,13–17] In many countries, most medical simulations are conducted in a simulation center with a small number of participants in the simulation room.[7–11,13–17] This program was different from conventional medical simulation in many aspects. First, there was a large number of participants in this program. Second, the standardized human patient simulator was situated on the stage of the conference room rather than in a simulation room. Third, multiple frames of images were displayed in a real-time fashion (real-time multimedia simulation). Fourth, ongoing frames of scenarios and steps of procedures were simultaneously displayed. Fifth, the scenarios were simulated and "the patient" was treated by the instructor (instructor-based simulation).

As mentioned above, most study participants were included from TANA and were experienced in daily airway management practice. We hypothesized that experience was a key requirement to developing requisite skills, and that they could easily understand and realize the improvements in the practice guidelines and the procedures during specific techniques after lecture and medical simulation. In order to be viewed by every participant, we situated the simulator on the stage of a big conference room and simulated the scenarios with multimedia images. By the means of real-time multimedia display on the 3-frame screen, participants could clearly watch the images of video camera, FOB or videolaryngoscope, ongoing frames of scenarios and steps of procedures, and responsive physical parameters. From the results and questionnaires, we found multimedia simulation to be of worth for trainees who have experience in airway management. By real-time multimedia simulation, most of the trainees knew how to provide assistance during a specific procedure.

To the best of our knowledge, this is the first report to combine real-time multimedia display with simulation in renewal airway management training for such a large number of experienced practitioners. Unlike participant-based medical simulation, we designed this instructor-based medical simulation of

4 different scenarios focused on anticipated and unanticipated airway crises. In other words, each of the scenarios was simulated and conducted by the instructors. During most difficult airway management, the nurse anesthetists play the role of assistant. During the simulations, instructors of both anesthesiologists and nurse anesthetists demonstrated successful management including accurate decision-making and techniques, preparation of equipment, proper cooperation between anesthesiologists and nurse anesthetists. Most of the participants agreed that the instructor-based simulation was useful and practical, and they gained more confidence in clinical practice afterwards. The questionnaires also revealed that instructor-based simulation training was perceived by trainees to be more enjoyable and beneficial.

In conclusion, it is our opinion that a large number of participants with extensive airway management experience can update their knowledge about difficult airway management from general lecture, and acquire better abilities of decision-making and communication, skills of specific airway management, from instructor-based multimedia medical simulation. Also of note, they can gain more confidence, improve performance and learn how to effectively assist in handling airway crises.

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