How to Initiate and Perform Simulation-based Airway Management Training More Effectively and Efficiently in China?

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Key words: Airway Management Training; China; Simulation

Introduction

While airway management is a fundamental skill set for many healthcare professionals, the difficult airway management has long been recognized as one of the most challenging tasks facing healthcare providers. As yet, failure to properly manage airway conditions remains a significant source of patients' morbidity and mortality.[1] To avoid or reduce medical errors and improve patient safety and outcomes, training for healthcare providers for airway management skills is essential.

Simulation is an educational technique that allows interactive and at times immersive activity by recreating all or part of a clinical experience without exposing patients to the associated risks.[2] In the last decades, the number and range of simulation technologies used for education of healthcare providers are growing exponentially because of concerns over patient safety and needs for improving the quality of medical services.[2-6] Since the first article describing the use of simulators to teach tracheal intubation to anesthesiology residents in 1969,[7] simulation in the airway management field has become more popular and has made tremendous advances in many countries, affirming the validity and superiority of simulation training.[1,3,4,8,9] However, simulation-based airway management training has just been the initial stage and progressing slowly in China due to the high expenses of simulation equipments and materials and the lack of professional educators who can devote themselves' heart and soul to this arduous task. The aim of this article is to give some suggestions about how to initiate and perform simulation-based airway management training more effectively and efficiently in China.

Access this article online

Quick Response Code:

Website: www.cmj.org

DOI: 10.4103/0366-6999.176073

Updating Airway Management Training Concepts

Although there have been tremendous advances on airway management during the last decades in China, difficult airway remains one of the leading causes for patients' morbidity and mortality. An important question is, are advanced airway management skills being taught and used? A disturbing fact is that when it comes to what the majority of anesthesiologists would consider the most important technical skill that they must possess, namely airway management, few residency and continuing educational programs provide the systematic and effective airway management training. The vast majority of anesthesiologists learn and practice advanced airway management techniques haphazardly in clinical settings.[10] The consequence is that many airway providers are not truly comfortable when managing a difficult airway using advanced techniques.

On the other hand, as the "culture of safety" becomes increasingly the focus of medical care, it influences the character of clinical skills training and eyes have turned toward the improvement on the training method of healthcare providers. The time-honored apprenticeship

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Received: 16-10-2015 **Edited by:** Yuan-Yuan Ji
How to cite this article: Yang D, Deng XM, Xue FS, Zhi J. How to Initiate and Perform Simulation-based Airway Management Training More Effectively and Efficiently in China?. Chin Med J 2016;129:472-7.

model has come under challenge. As we know, almost every healthcare provider will experience the stress of managing a difficult airway, especially for the "can't intubate and can't ventilate (CICV)" crisis situations. Perhaps, both the technical and nontechnical (i.e., crisis management) skills required to manage these crises have not been rehearsed, practiced, or experienced in months or even years. Decay and attrition of skills are inevitable and demonstrable. However, the fact is that even though healthcare providers seldom have that kind of "hand-on" opportunities to master these lifesaving techniques, they must be prepared and quite qualified to manage the rare, life-threatening situations.[11] Also, it is well known that it is impossible to train healthcare providers exclusively on real life cases, which may not happen in due time and may not include all aspects necessary for efficient training.[12] Given that healthcare providers must be competent with many different procedures and algorithms to ensure the patient safety, and an excellent practical training in both technical and nontechnical skills is mandatory.

Undoubtedly, how to perform airway management training more effectively and efficiently is a big challenge for Chinese medical educators. Simulation-based airway management training is a potential tool that can help achieve this goal because it allows healthcare providers to learn, practice, and perfect their crafts without a potential harm to patients. The available evidence shows that simulation-based airway management training can improve learner outcomes compared with no intervention and other educational activities,[1] which is consistently associated with large effects for knowledge, skill, and behavioral outcome measures. Also, the scenario-based training using simulators can enable the trained healthcare providers to manage airway in the stressful, time-pressured situation of an airway emergency, which can provide a realistic training to develop crisis management and communication skills as well as to practice how to use the human and technical resources effectively, that is nontechnical skills for crisis resource management. These skills are most required in dynamic and crisis situations, which may be the best practice in a simulated patient setting since it is difficult to justify preemptive training for critical situations in real emergencies during a time of "high-quality care" and an increasing discussion about patient safety.[9,12,13]

The survey on China simulation education status of anesthesiology in 2010 shows that compared with many developed countries, the simulation education in China is still in the preliminary stage.[14] Even though simulation-based airway management training programs have been initiated in many medical colleges of China, most of them are just basic airway management trainings and progressing slowly. Given that a large number of studies have demonstrated the efficacy,[15-17] cost-effectiveness,[18] and advantages of simulation training in terms of patient safety and outcomes,[8,9] one would expect that Chinese airway educators should embrace this new teaching modality and fully make use of simulation to assist effectively airway management training, improving the technical and non-technical skills of difficult airway managements that the healthcare providers require to master.

Getting Support from Executive Department of Education

Simulation-based airway management training is effective and does not put patients at a risk of medical complications[19] but it comes at a price. In fact, the high cost of many simulators has become a key criticism of technology-enhanced simulation. Indeed, both policy makers and stakeholders want to know the cost-effectiveness of simulation-based airway management training and make an informed decision about education expenditures.[20] In addition, the large amount of financial, space, and personnel investments of simulation-based airway management training will inevitably bring the great pressure to decision-makers. It is worth noting that simulation-based airway management trainings incur significant costs, but benefits resulting from lifesaving, shorter hospital stays, or earlier return to work must be realized by hospitals, third-party payer, or employers.[18] Educators, affiliated healthcare systems, payers, healthcare industries, and governments should recognize the value of simulation training and provide essentially political and financial supports. It can be beneficial in the long term only if the training education provided is effective and affordable.

Meanwhile, as the training expenditures rise with an increased emphasis on technology-based education, a comprehensive evaluation on the costs of simulation-based airway management training against its outcomes is needed to know how to best allocate resources and demonstrate the value of the investments in medical education. Considering simulation training is very costly in terms of time, personnel, and money, more studies are also required to determine whether the simulation training really helps achieve the educational objects and whether the practical training is superior to theoretically classical teaching methods. Undoubtedly, the results of evaluation and studies are important to gain continued support and resources for the curriculum.[21] In addition, simulation educators must confront the hospital managers and policy makers with the need for training in airway management field and persuade them of the curriculum's importance based on the evidence of educational researches.

Establishing Viable Airway Management Simulation Training Site

According to the obtained support and resources as well as immediate and long needs, simulation-based airway management training site can be just one room or one part of big simulation education center. The first step to establish a viable simulation-based airway management training site is to identify immediate and future trainees such as medical students, residents or attending physicians in anesthesiology, emergency, or intensive care. The second is to create a

potential course list for each group and decide the types and the contents of courses that want to teach. The next is the design of airway management training environments. It will need many thoughtful considerations regarding the establishment of a simulated environment including audio and video needs and turn your creative ideas over to the architects and allow them to create the blueprints of your facility. Because the budgets are usually tight, the use of funds must be very conservative. Most of funds are allocated for task training devices and high-fidelity simulators. Since most simulation-based airway management training sites or centers are affiliated with universities or hospitals, one may talk with the operating room supply managers and get outdated or opened but not used supplies from office furniture such as desks and chairs to patient room items such as beds, stands, tables, old anesthesia machine, and tracheal tube . They may be willing to set an area aside where people can drop off and simulation educators can pick up to maximize cost-effectiveness.

Educational resources for simulation-based airway management training include the low-fidelity airway trainers and task-training devices for basic skill training, high-fidelity computer-based simulators for technical and nontechnical skill training,[22] virtual airway simulators and part-task training devices for fiberoptic training,[15] and cadaveric porcine airway model[23] and low-fidelity model[24] for cricothyrotomy and surgical airway training. With the advances in medical technology, the number and utility of airway management equipment available to healthcare providers have significantly increased. It is out of question that these new tools have greatly improved the practice of airway management and simplified the approach to the airway management.[25] However, many airway tools may lead to confusion among healthcare providers as they attempt to choose the most appropriate tools to manage a particular airway situation. In simulation training, therefore, it is important to introduce the airway tools which can produce the most reliable clinical results, such as Macintosh laryngoscope, classic laryngeal mask airway (Laryngeal Mask Company, Henley-on-Thames, UK), Fastrach® (Laryngeal Mask Company, Henley-on-Thames, UK) or Cookgas® (Mercury Medical Company, USA) intubating laryngeal mask airway, King laryngeal tube (King Systems, Noblesville, IN, USA), fiberoptic bronchoscope (Olympus LF-DP, Tokyo, Japan), GlideScope® video laryngoscopes (Verathon Medical, Bothell, WA, USA), light wand (Surch-Lite, Aron Medical, USA), Cook® airway exchange catheters (Cook Medical, Bloomington, IN, USA), and Bougie (Cook Medical, Bloomington, IN, USA).

The cost of simulation typically increases as fidelity increases, but several studies consistently show that low-fidelity models can provide the same results of airway management training as the high-fidelity counterparts but is less expensive.[19,24,26,27] For example, Friedman *et al*.[24] demonstrate that a simple, inexpensive model for cricothyrotomy training may achieve the same effect on objectively rated skill acquisition as does an expensive simulator. In addition, Graeser *et al*.[26] find that simulation-based bronchoscopy training is useful for improving performance regardless of the fidelity of the simulators ranging from nonanatomical phantoms to high-fidelity reality simulators. Local, practical issues, such as cost and portability of simulators, should dictate available simulation modalities in each teaching hospital. The costs of simulation-based airway management training may also be reduced by matching the educational intervention to the learner's needs. However, it still requires further studies to determine where and when to be the best for situating high- and low-fidelity simulators within a curriculum.[20] Medical educators need to justify the costs of simulation education and, therefore, the documentation of simulator effectiveness and efficiency as a teaching tool is necessary to allow the appropriate use of various simulators.[28] Beyond that, it must make the manufacturers of fidelity simulators to recognize the existence of a potential world market, especially if the prohibitively high prices are reduced.[26]

Staff Consideration and Instructors' Training

When running simulation-based airway management training, labor costs and the lack of professional instructors will be the biggest enemy in China. At present, many instructors who are "airway experts" and interested in the simulation-based airway management training only are volunteers or receive a low pay. In the long run, therefore, the instructors may lose main revenue from clinical works when taking time to teach. In this case, the instructors will be dwindling appetite for teaching very soon if they could not gain ideal payment. Also, many faculties without enough experiences on clinical airway management and teaching often cannot fully utilize the expensive facilities and equipments to bridge the gap between theoretical and realistic of airway management and very few provide an opportunity for trainees to learn from errors. To address the above issues, full-time or part-time faculties and instructors who are familiar with simulation-based airway management training and simulators are needed.[3] In addition, it is more important to use "simulation experts" to train more instructors for running their own courses. With the right systems, there would be no reason why one cannot train hundreds and thousands of trainees per year with one staff.

Every simulation-based airway management training site needs to have one person with the visions of where the future is going and a good understanding of simulation-based airway management training. Alone use of technical and spatial equipment can no longer guarantee optimal learning, because "simulators do not teach!" Not surprisingly, teachers remain paramount in the learning process.[29] It is the duty for directors of simulation-based airway management training to have the instructors and facilitators being properly trained because teaching in simulation environment is much more different than that of teaching in a typical classroom setting, and instructor training and refresher courses are essential for

optimal simulation training.[30] The time spent on conducting instructors' training before the first course being taught is very important. Instructors including clinical specialists should change the traditional apprenticeship model, that is, to learn and master the basic and advanced features of simulators and partial task-trainers, detailed review of the software and how to load a preprogrammed scenario and run the software on the fly, operations of the simulator properly, and saving trainee performance data and how to debrief in order to provide more helpful guidance and debriefing for trainees, as well as actively involve them in curriculum design and curriculum improvement activities. Careful preparation is needed to get the most of the training. Perhaps, it may be helpful to pilot the course with only a few participants who are highly motivated and who forgive the instructors if something goes wrong during the first course. If a scenario is prescribed using the simulator software, the participants not recognizing the specific problem or initiating treatment different from what instructors expect might surprise them. The instructors should always react and change the most important settings by hand rather than letting the simulator drive in the automatic mode.[21] In a word, faculty development based on evidence and proven theories of learning will be essential to ensure that simulation educators are optimizing a potentially resource intensive and expensive teaching modality.[3,31]

Designing the Optimal Curriculum

Optimal curricular design should conform with the clinical practice and have the characteristics of typicality, standardization, and universal guidance following the difficult airway management algorithm. Therefore, curricular contents and difficult airway scenarios for trainees and teachers should be made by collaboration with simulation training instructors and airway management specialists.

Educators who design the simulation-based airway management training curriculum face further choices, such as which model to use, how to ensure learners retain the skills, and how to provide feedback.[1] As we know, it is insufficient to exercise the skill only. For airway management, each single task is part of a complex treatment. Some tasks have to be performed in highly dynamic situations and under time pressure. Training of these tasks requires simulation of the patient and a real or simulated environment such as monitoring, ventilator and airway management team. However, the high-fidelity simulation training is expensive.

There is no doubt that perfect curricular design is the foundation of translation and retention of the technical and nontechnical skills required for difficult airway management. When setting up a curriculum in the airway management, its objectives, teaching methods, and resources must be carefully considered. A six-step approach to curriculum design is a useful tool for teachers establishing simulation-based airway management training.[21,32] In addition, it is worth mentioning that airway management training scenario development is a time-consuming process. Thus, time will need to be set aside for creating scenario programming.

In contrast to traditional technical skills, the simulation community conventionally refers to these competencies as nontechnical. Nontechnical skills have been identified as particularly important for management of emergency and crisis situations, for example CICV situations which are dynamic, evolving, and require constant re-assessment. However, nontechnical skills are not inherent despite being based on behavior. Thus, nontechnical skills must be formally taught even though they are increasingly rare in modern day medicine. In fact, probably more time is required to develop a curriculum for nontechnical skills because they are more difficult to teach and assess than the technical skills.[8] Simulation instructors should pay more and more attention to training on the crisis management skills, and many simulation training centers are committed to developing the simulation curriculums to help trainees obtain and retain nontechnical skills.

It has been shown that the most important factors for crisis management simulation training are environmental fidelity[3,8] and deliberate practice.[8,33] Environmental fidelity is important as a context for learning, particularly for learning of nontechnical skills, as it forces the team to address communication barriers unique to its environment, such as role identification and the interpretation of nonverbal cues when offered from behind masks and surgical gowns. Improving environmental fidelity means incorporation of all structural and mechanized elements that would be present in the management of similar scenarios in the clinical realm.[3,8]

Deliberate practice refers to a process that allows learners to focus on intensive practice of specific tasks in a controlled setting while receiving coaching and formative assessment through timely and thoughtful feedback from an expert supervisor.[8] Simulation is ideal for deliberate practice because it offers standardized conditions and the ability to repeat the same tasks without compromising patient safety. The participants will have the opportunity to repeat the way they perform a particular procedure or respond to defined crisis so that the positive reinforcement can be developed and their self-efficacy can be improved. Therefore, deliberate practice can offer constant skill improvement, not just skill maintenance.[33] McGaghie *et al*.[33] deem that deliberate practice is a key variable in rigorous simulation research and training.

In addition, it will be benefit from self-regulated learning of trainees which is a means to decrease costs by efficiently using instructor time.[34] Another important issue is that simulation-based airway management training must be ongoing, as skill retention fades over time, particularly for the skills that are rarely used, such as those required for management of life-threatening CICV situations. Improvements in most technical skills can be maintained for 6 months, though there are some indications of deterioration.[35] Kuduvalli *et al*.[35] further emphasize that

long-term retention of both technical and nontechnical skills requires frequent reinforcement. Thus, periodic retraining is essential for achieving skill retention. However, the optimum interval for retraining is a subject of discussion, and there is no evidence for any clear-cut intervals for specific skills.[17,35] To a large extent, it may depend on the actual needs of the trainees for specific skills and the available resources provided by simulation training sites or centers.[1]

Other Considerations

China is a developing country in simulation-based airway management training. Lacking awareness of simulation education and its capabilities, and no enough funding for high-fidelity equipment and maintenance costs, space, staffing, and their training create major problems for the implementation of simulation-based airway management training. With the vigorous development of simulation training in healthcare, the communication and cooperation between national and international simulation centers should be strengthened to expand, enrich, and perfect the fields and modalities of simulation-based airway management training; constantly improve and increase the effect and influence of simulation-based airway management training through more educational investment, and let more and more healthcare providers and patients benefit from simulation training.

In conclusion, simulation training serves to bridge the gap between classroom instruction and the practical application in airway management education. It can effectively improve the technical and nontechnical skills of trainees. Undoubtedly, in the near future, there will be more studies that offer strong evidence to validate and support the effectiveness and superiority of simulation-based airway management training. The assessment and analysis supporting the cost-effectiveness of simulation training may also be used to acquire the support needed to sustain education programs which meet the demands of the evolving healthcare system. Certainly, experienced instructors and thoughtful curriculum design are indispensable in optimizing the benefits of simulation-based airway management training. With the improvement of these conditions, there are ample reasons to believe that simulation-based airway management training will be implemented more effectively and efficiently in China. To accelerate this process, we call that Chinese health and education supervisors pay more attention to clinical values, significances, and required conditions of simulation-based airway management training. It is time to establish a high-effective simulation training system of airway management in China.

Financial support and sponsorship

This study was supported by grants from Project of Science and Technology Activities of Preferred Overseas Personnel in 2012 and China Scholarship Council in 2013 (No. 201308110450).

Conflicts of interest

There are no conflicts of interest.

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