Research Article

The Usefulness of 3-Dimensional Virtual Simulation Using Haptics in Training Orotracheal Intubation

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Objectives. Airway control is the most critical treatment. The most common and basic method of endotracheal intubation is orotracheal intubation. To perform accurate and rapid tracheal intubation, appropriate education and training are required. We developed the virtual simulation program utilizing the 3-dimensional display and haptic device to exercise orotracheal intubation, and the educational effect of this program was compared with that of the mannequin method. Method. The control group used airway mannequin and virtual intubation group was trained with new program. We videotaped both groups during objective structured clinical examination (OSCE) with airway mannequin. The video was reviewed and scored, and the rate of success and time were calculated. Result. The success rate was 78.6% in virtual intubation group and 93.3% in control group (P = 0.273). There was no difference in overall score of OSCE (21.14 ± 4.28 in virtual intubation group and 23.33 ± 4.45 in control group, P = 0.188), the time spent in successful intubation (P = 0.432), and the number of trials (P > 0.101). Conclusion. The virtual simulation with haptics had a similar effect compared with mannequin, but it could be more cost effective and convenient than mannequin training in time and space.

1. Introduction

Airway control is the first and most critical treatment. The “A” in the ABCs demands that no other action may take place until the airway is secure. If the airway is not secure, nothing can help the patient. The endotracheal intubation can be accomplished by a variety of methods. The method of choice will be dictated by physician preference and experience, the patient’s condition, and the type of equipment available. Because all doctors with acute care responsibilities are expected to be competent in airway management, appropriate education and training were required [1]. In education of medical student, the teaching program was contained to train them to perform orotracheal intubation with mannequin. And the orotracheal intubation was a test among objective simulation constructive examination (OSCE) for Korean Medical License Examination.

Orotracheal intubation is basic technique in securing airway of patients [2]. But, actually, it was difficult for many medical doctors to conduct the procedure when emergent situation, because they had not been trained enough. Although other airway management techniques, such as supraglottic...
airway, were relatively easy and did not need large amount of
effort and time to train the procedure these skills need specific
device and these devices could not be always prepared.
Therefore, there is a need to provide training in orotracheal
intubation as the basic method of airway management.
Generally, orotracheal intubation was educated using airway
mannequin. However, it is hard for many medical personnels
to be trained with mannequin because of limited time and
space. We developed the 3-dimensional simulation program
for medical students to exercise orotracheal intubation easily.
And the educational effect of this computer program was
compared with the traditional training method using airway
mannequin.

2. Method

This was a prospective randomized observational study and
it was approved by the Chung-Ang University Hospital
international review board.

2.1. 3D Virtual Simulation Program. We developed the com-
puter program in which students could be trained to exercise
orotracheal intubation in 3-dimensional simulation. This
included the anatomy from nasopharynx to trachea. The
anatomic reconstruction of program was done from the data
of healthy volunteer who was male and 25 year old. Neck
CT was examined by 256 channels MDCT and the high-
resolution images were collected. These images were used
to reconstruct to 3D image and the image of laryngoscope
was emerged to produce the sequence that vocal cord was
visualized by laryngoscope. Haptics was used to train in the
handling technique of endotracheal tube (Figure 1). Due to
using haptics, the students could not advance the endotra-
cheal tube when they handled the tube to the wrong direction.
When the tube was placed in trachea correctly, the program
shows the success message in monitor.

2.2. Evaluation of the New Simulation Program. After
informed consent, 29 undergraduate medical students were
enrolled. They were 5th grade in 60-year medical school.
Exclusion criteria were any previous experience with orotra-
cheal intubation training. Students were randomized into two
groups. Both groups were instructed about the anatomy of
airway and method of orotracheal intubation from prepara-
tion to confirm the airway for 1 hour. And the control group
exercised the procedure with airway mannequin (Laerdal
Medical, Stavanger, Norway). Virtual intubation group was
trained with haptic device and computer with 3D monitor
in other place. Each group had no idea about the training
method of the other group and they exercised the procedure
for 1 hour. After 2 hours of resting time, we tested students by
OSCE with airway mannequin. We videotaped both groups
during OSCE, then reviewed and scored them, and the
rate of success and time were calculated. We determined
the success of intubation with tracheal placement of tube.
The score from OSCE and data from video analysis were
compared using Student’s t-tests and x2-tests with SPSS 19.0
(SPSS, Chicago, IL, USA). A P value <0.05 was considered
statistically significant.

3. Result

There was no statistical difference in age and gender between
the two groups. The success rate was 78.6% in virtual
intubation group and 93.3% in control group (Table 1, P =
0.273). There was no difference between the two groups in
overall score of OSCE (21.14 ± 4.28 in virtual intubation group
and 23.3 ± 4.45 in control group, P = 0.188), the time spent
to successful intubation (P = 0.423), and the number of trials
(P = 0.101).

4. Discussion

Orotracheal intubation is the primary and preferred method
of airway management. Every physician must master this
skill. It was done mainly in emergency situations except
anesthesia. In this situation, most physicians might be con-
fused and hesitate to perform orotracheal intubation because
they had not been trained enough and had a fear of failure
and complications of the procedure. And endotracheal intu-
bation itself can evoke a transient but marked response on
manifested as hemodynamic changes [3]. Therefore, many
medical schools and medical facilities had a curriculum to
train students and houseman in airway management.

In medical schools students attend didactic lecture in
orotracheal intubation and practice with airway mannequin.
In order for orotracheal intubation to success, it is important
to visualize vocal cord and insert endotracheal tube inside the
vocal cord to place the tube in tracheal. And it needs a lot of
practice for accurate and rapid procedure. Mannequins have
been used generally as a tool to teach invasive procedures
to medical personnel and students. With airway mannequin,
students exercise mainly the handling of laryngoscope to
visualize vocal cord and advancing endotracheal tube to
trachea. In addition to the experience of the actual handling
of the device, they could practice the whole sequence of
procedure from preparing patients and devices to confirming
the security of airway. The simulation with mannequin is
free to ethical problems. But it needs the mannequin and
many other devices such as oral airway, bag valve mask,
laryngoscope, and endotracheal tube. This equipment is
expensive and could be destroyed during simulation. Many
students could not be trained at the same time because the

Figure 1: The virtual intubation program with 3-dimensional
display and haptic device.
We tried new educational device for orotracheal intubation utilizing a 3D monitor and haptic device. Using this program, students can understand the anatomy of the airway and learn to place the tube in the trachea. The previous educational method to train, orotracheal intubation used airway mannequins and fresh frozen cadaver. Using the cadaver provided real training, but it was not available for a large number of medical personnel [4]. The overall score of OSCE that evaluated the full process of intubation did not differ. Although the virtual intubation group did not actually handle the laryngoscope and endotracheal tube, they understood the anatomy of airway and succeeded repeatedly, resulting in no difference in the success rate. Previous studies reported that the 3D virtual simulation was effective in training specific procedure such as gastro-intestinal endoscopy and neurosurgery [5–10]. However, there was no study for virtual simulation to train orotracheal intubation.

Virtual simulations in this study had several advantages. They are free of ethical problems because students do not practice with real patients. And it is cost-effective because computer with 3D monitor and haptic device can be used for a long time. It can be used for self-training on any computer without any additional equipment [11, 12]. On the other hand, airway mannequin may break down due to long-term use and is needed to change expensive consumable. For macrosimulation using mannequin, the large space such as simulation center is needed, but this program only requires smaller space with installed the computer and haptic device. For an educational aspect, students can each select the difficult step and practice only their part, making destruction learning possible.

5. Limitation

The 3D computer simulation used in this study was prototype, so it was possible to train only handling the endotracheal tube in orotracheal intubation. Namely, one hand grasping the tube could be exercised. It could not train the other hand that grasps the laryngoscope to visualize vocal cord. This step is critical for successful orotracheal intubation. In this study, the students’ failure in test was due to this step. In process of orotracheal intubation, the confirmation of correct placement of tube is important, and also the preparation of procedure preoxygenation of patient were important. However, this program could not train these steps. It is necessary to be supplemented because is inadequate.

6. Conclusion

The training of orotracheal intubation was necessary for medical people for airway management. The virtual simulation with 3-demsional display and haptic device had similar effect on training in the procedure compared with airway mannequin. And this program could be more cost effective and convenient for students to practice the procedure in time and space. Therefore, the virtual intubation programs with 3-dimensional display and haptic device could be alternative to traditional training method with airway mannequin.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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