STUDY OF THE EFFECTIVE METHODS TO DETECT THE 
CAUSE OF A VENTILATOR’S ALARM GOING OFF

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Abstract: The purpose of this study is to effective methods for inexperienced nurses (novices) to detect the cause of a ventilator's alarm going off. In order to protect the patient's life from danger, it is essential to ascertain the cause of the alarm as soon as it goes off. Therefore, an effective training method is required. Nurses working in the ICU were the subjects for this experiment. There was a difference in a working time between Nurses. At first the guidance screen was constructed based on the experts’ behavioral pattern. But the novice’s working time did not change very much. Therefore the guidance screen was modified to select the situation. Then the working time was shorter than using the trial screen. In conclusion it was considered that a method displaying on the guidance screen only the confirmation item required to handle the situation is effective for novices.

1. BACKGROUND AND THE PRESENT SITUATION

A mechanical ventilator is medical equipment essential to modern medicine as a life supporting apparatus. Nurses working in an intensive care unit (ICU) are often engaged in operating a mechanical ventilator. Among the nurses who manipulate and monitor a mechanical ventilator, there are experts as well as novices. In this study, the experts denote nurses who had worked in the ICU for more than three years and novices denote nurses who had worked in the ICU for less than three years.

Even if they are novices, they are still required to manipulate and monitor the ventilator at the same level as the experts. Moreover, they need to be able to deal with situations when an alarm beeps.

In order to protect the patient’s life, it is essential to ascertain the cause of the alarm as soon as it goes off. Therefore, an effective training method is required.

An operational difference is expected to exist between experts and novices in emergency measures taken when the ventilator’s alarm goes off. This difference may affect the patient’s life. Therefore, novices are asked to ascertain why the ventilator’s alarm beeped and to cope with the emergency in the same manner as experts of greater experience.

To understand the emergency measures presently taken by nurses when the ventilator’s alarm goes off,
we performed several simulations and investigated the behavior and remarks of the nurses during their performance of emergency measures. Consequently, a difference was observed between the experts and novices in the time required to perform the task from the alarm going off to the nurse handling it (average task achievement time). The average task achievement times were 34.3 ± 5.85 s and 96.2 ± 26.17 s for the experts and novices, respectively (Figure 1). Moreover, based on the analytical results of the nurses’ behavior and remarks, a difference was observed in the thought process of experts and novices, as shown in Figure 2. Since the experts can use their experience to determine the measures to be taken, their thought process is considered to be a knowledge driven type. On the other hand, since the novices cannot use their acquired knowledge effectively according to the situation, their thought process is considered to be a sequential search type.

In order to promptly ascertain the cause of the alarm as soon as it goes off, the novices must be trained to think like the experts at the time of confirmation.
2. PURPOSE

The purpose of this study is to propose training methods to enable novices to cope with an emergency appropriately when the ventilator’s alarm goes off. As one of the training methods, we investigated a method of using the guidance screen, which displays the confirmation items according to the situation when the situation is selected.

3. METHODS

Nurses working in the ICU were the subjects for this experiment. We deemed nurses who had worked in the ICU for less than three years as novices, and we selected seven of them as the subjects of the experiment.

For this experiment, we used a ventilator (Servo Ventilator 900C, hereinafter referred to as “Servo 900C”, Siemens AG, Germany); a personal computer (FMV-830MT, hereinafter referred to as “the PC”, Fujitsu Ltd., Japan); and an AD converter unit (TUSB-1612ADSM, hereinafter referred to as “the AD converter”, Turtle Industry Co., Ltd., Japan). As shown in Figure 3, the PC and the AD converter were installed on the main body of the Servo 900C. As shown in Figure 4, the AD converter was connected to the Servo 900C’s alarm board with soldered lead wire, and the alarm signals were inputted into the PC through the AD converter. Visual Basic 6.0 (Microsoft Corporation, USA) was used to make the program.

The screen was made to change from the basic screen to the guidance screen for actions to be taken when the alarm was raised. Moreover, the program was made to display the next screen when the screen was touched according to the situation. The subjects’ emergency measures were investigated when the alarm went off. The alarm used for this experiment was the respiratory minute volume alarm, which went off due to an alarm setting range error. Because it was possible that the subjects could memorize the task if the alarm setting range error alarm was raised only, other malfunctions were also randomly made that can be considered as causes of the respiratory minute volume alarm, such as removal of the humidifier section, removal of the water trap section, removal of the patient circuit and airway tube, removal of the cap section of rotating connector’s cap section, and air leakage from the cuff.
Fig3. Equipments

The time required to perform the task between the alarm going off and the nurse handling it was measured. Moreover, the subjects’ behavior and remarks were recorded by video camera.

The experiment was performed as follows: (1) the time when the alarm went off was the initiation of the experiment; (2) when the alarm went off, the subjects started to investigate the cause of the alarm; (3) when the cause was detected, the subjects started to perform countermeasures; and (4) when the alarm lamp went out, the experiment was completed. The subjects were asked to speak their thoughts as much as possible during the operation.

4. CONSTRUCTION OF THE GUIDANCE SCREEN

Because it is important to note the appropriate confirmation behavior according to the situation, the guidance screen was constructed to display the confirmation items according to the situation when the situation was selected (a situation selection method). The constructed guidance screen is shown in Figure 5.

5. RESULTS

The average task achievement time was 38.0 ± 4.65 s when the guidance screen was used. The comparison of the average task achievement time with and without the guidance screen is shown in Figure 6. The confirmation process of the subjects to investigate the cause of the alarm when the guidance screen was used is shown in Figure 7. As shown in Figure 7, the subjects could detect the cause of the alarm in a similar manner to the experts.

6. DISCUSSION

The average task achievement time with the guidance screen was significantly shorter than that without
the guidance screen (Fig 6). This was considered to be because the subjects did not perform unnecessary confirmation behavior. It was also considered to be because only the confirmation item required to handle the situation was displayed on the screen and the subjects could perform the task along with the sequential screens.

As shown in Figure 2, a difference was observed in the thought process of experts and novices. The novices could not remove the alarm and repeated unnecessary confirmation behavior. The reason for this was considered to be that although the respiratory minute volume alarm was raised, the novices could not understand why the meter for the amount of ventilation showed the predetermined amount of ventilation. When the predetermined amount of ventilation is secured, the novices must understand that there is no circuit’s removal and they must check the alarm setting range error. However, they checked the circuit’s removal because they did not have sufficient knowledge to judge the situation or they could not remember the countermeasures due to insufficient experience.

It was considered that although the novices had sufficient knowledge of items to be confirmed (declarative knowledge); they did not have sufficient knowledge of items to be applied according to the situation (procedural knowledge).

It was considered that by acquiring expert procedural knowledge, information processing to ascertain the cause of the alarm became simple and the time required for ascertaining the cause of the alarm could be shortened. However, it was considered that if the experts’ declarative knowledge was displayed on the screen only, the novices could not understand the situation where the predetermined amount of ventilation was secured, and they might apply the displayed experts’ declarative knowledge automatically without considering the situation. Therefore, it was considered that in order to apply the acquired declarative knowledge according to the situation, a circumstantial judgment, which is a part of procedural knowledge,
was necessary for the novices to be added to the guidance screen.

Then, the experts’ circumstantial judgment was added to the guidance screen. Figure 7 shows that although it was conditional that the novices’ circumstantial judgment was correct, the novices could perform the confirmation process in the same manner as the experts. The novices were considered to have acquired the experts’ behavioral pattern by repeating the simulation, in which the situation could be correctly judged and the appropriate item could be selected according to the situation.

The mechanical ventilator is a medical apparatus that can be operated safely with technical mastery. By training medical workers based on the results obtained in this study, the technical skill to operate the mechanical ventilator can be securely acquired.

It is considered that the guidance screen for the confirmation items, which is used when the ventilator’s alarm goes off, must be constructed in such a way that the situation is handled by nurses and that the confirmation items suitable for the situation are displayed on the guidance screen. Since newly recruited nurses can be trained effectively by repeating the simulation using the guidance screen, the situation selection method can be used as part of the method to train nurses.

7. CONCLUSION
The guidance screen displaying confirmation items when the ventilator’s alarm goes off was constructed based on the experts’ behavioral patterns. As one of the training methods to cope with an emergency when the ventilator’s alarm goes off, the simulation using the guidance screen displaying appropriate confirmation items, which could be selected due to the circumstantial judgment, was considered effective for novices.

8. REFERENCES

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