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Technical Support System for Puncture Training on Special Blood Vessels in Hemodialysis

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Abstract: This study deals with the teaching/training of puncture operation for the clinical engineering university students. It is known in hemodialysis treatment when inserting a needle into the blood vessel of a patient, high level of accuracy is required including the force, angle and needle tracks. For such the reason, we proposed a technical support system for the puncture operation on the special blood vessel of patient in hemodialysis. The training system was constructed on a PC, and an arm model was used for the exercises of holding and insertion angle of puncturing. The effectiveness of training was proved with the answers from the trained students.

Keywords: Training System, Skill Science, Clinical Engineer, Support to Operations

1. Introduction

With the recent progress in clinical medicine field, the development of systems using the advanced computer technologies both in information and engineering to support simulation training has been taken into account (Sueda, 2010). Clinical engineering is such a field in which a clinical engineer faces a wide range of tasks including operations of multiple medical machines, and the management and maintenance of them. To fulfill the tasks requires complex techniques and rich expertise. However, it is very difficult to get such a large sum of knowledge, skill and experience within the limited university time in which students are always with less operation practice and particularly for frequent trouble-shooting. For providing a better care and more effective medical treatment, it is desired that clinical engineers, together with doctors and nurses to form a strong team, play a quite an important role. It is therefore important to develop a strong support system for the training of qualified clinical engineers. In order to solve the above problems, we have carried out a series of study for construction of teaching/training systems with highly simulated medical operations. For obtaining higher training efficiency towards the final goal of such a training system with low cost, rich experiences and repeatability, we proposed in this study one for clinical engineers using the up-to-now knowledge from our sequential researches (Kanehira, et al., 2014). In addition to conventional e-learning for general knowledge, special attention was paid to the practical operation on medical machines (Kanehira, et al., 2016).

We chose a training system for puncture operating in hemodialysis, the needle's angle, trace, and force feeling has been studied in our preliminary works. However, our earlier works did not consider the necessity for puncture on special (or abnormal) blood vessels of the patients. In this study, the training system for puncture on possible special blood vessels in hemodialysis was taken into account. The system should be able to carry out repeated exercises on not only the normal but also on special blood vessels, and with a real-timely evaluation on the quality of the puncture operation. The effectiveness of the system when used by students should be proved. For this purpose, standard index from experienced clinical engineers and teachers, in combination with camera and action analysis software, were included in the system for evaluation.

2. Hemodialysis and Dialysis Puncture Technique

Hemodialysis is the operation to take out the dirty blood from a patient with disabled kidney, to purify it through a dialyzer and to put the clean blood back to his body. Each operation normally takes a 4-hour time, and the operation must be repeated every 2 days. According to the report from the Japanese Dialysis Society, the number of patients with dialysis treatments in Japan is 324,986, that is, one of each 386 Japanese is experiencing dialysis.

The operation is started from a "puncture" operation by holding a needle and stinging into the blood vessel. The puncture operation must be repeated two times for each treatment, including one needle sting to take out the blood from vessel and another to return it to vessel by putting needles into the special shunts put earlier in the blood vessel. The needle should be stung precisely into the shunts at a proper angle under a difficult condition that blood vessels are structurally complex and visually hidden underneath the skin. Therefore, a puncture operation is always more difficult and dangerous compared with normal injections. Furthermore, an erroneous puncture operation may result in accidents such as heavy blooding. The puncture is one of the most important techniques for hemodialysis. Furthermore, for the prevention of postoperative complications, an improvement over puncture technique is an urgent need.

Undoubtedly, punctures with high levels of precision are required for such operation. However, it is impossible to allow students to do practical puncture on patients during his clinical training. As the result, it can be imaged how anxious and uneasy the student may be when he faces a patient for the first time. However, there has not yet been such a training system up to the present time upon our best knowledge. In order to solve the above problems, we proposed the following training system for "puncture" operation for hemodialysis.

3. Puncture Technique Training System for Special Blood Vessels

3.1 System Configuration

An electronic textbook was first constructed aiming the puncture on the special blood vessels of the patient. An arm model was used for students to puncture like practically, and teacher's data were prepared in the system for real-time comparison. The configuration of the system is shown in Fig.1.

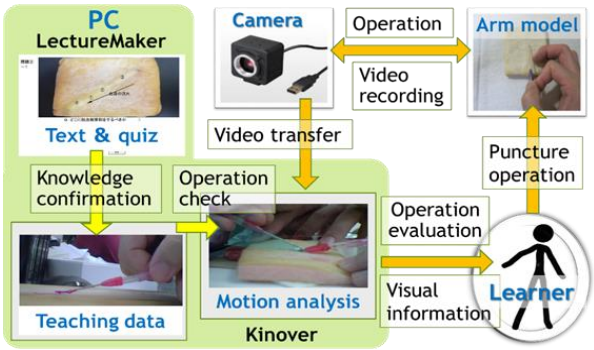

Figure 1. Configuration of the puncture training system

The system include a PC, an arm model, and an operative set with camera. The software Lecture Maker for making textbook and Kinover for motion analysis were also built in the system.

Multiple choice questions (choose 1 from 4 questions) on puncture on the national test level was provided for the learning and confirmation of basic puncture knowledge. A puncture needle in practical puncture was used. An arm model was made with skin similar to the human being, was put on the underlay with 3 different blood vessels, namely the normal, the narrowed, and the bend.

A camera was set with certain distance from the arm, and connected with PC to transfer real timely the operation information, and display the pictures on the screen. For the evaluation of student's operation, teacher's data were prepared in the system for comparison.

The flow of the using system is as the following. The student is firstly asked to answer the multiple choice questions on the electronic textbook to confirm their basic knowledge of puncture. Second, they do simulated puncture exercise using the system and compare their results with those of the teacher standard. After the exercise, the student puncture on the arm model while pictures of operation are taken at the same time. The pictures are then sent to PC for action analysis, and the results are compared and eventually an evaluation is given. Such operations with the system are repeatable, using blood vessels of not only the normal but the special or abnormal.

3.2 Verification of system

For the evaluation of the effect of system, verification test was done over 10 students in our department. The test was done in 3 days with each person, with test sequence on blood vessels of bend, normal and narrowed, respectively. The test was done as (1)-(6) of the following:

(1) Basic knowledge confirmation with multiple choice questions using electronic textbook; (2) Learning of holding and insertion of puncture from teaching video; (3) Referring the teaching pictures on screen, ding puncture on the arm model, repeating the exercise referring pictures of both teacher's and own operations; (4) After enough above exercise, the student does puncture operation without referring the teaching data, recording the movement and transferring to PC; (5) Operation angle data and so on were produced and compare with teaching standard, the results were analyzed to give a comparison and evaluation; (6) A questionnaire was make to confirm.

Questionnaire with questions as "is the system useful in dealing with 3 different blood vessels?", or "is that useful with a comparison to teaching standards?", and so on, were provided and answers were obtained after practical operation with 5-stage evaluation. Answers as "the exercise is quite useful after the confirmation of basic knowledge" was mostly obtained. About 70% students got confidence, and almost 100% students demonstrated the wish for further use of the system. It is good to obtain such positive results which will drive us for further development on the system. On the other hand, other opinions as "it is difficult to image the whole arm from only the part of its model", or "it should be with more types of blood vessels", have also been notified.

4. Conclusion

This study proposed a technical support system for the puncture operation on the special blood vessel of patient in hemodialysis. The training system was constructed with electronic textbook for basic knowledge learning/confirmation, a puncture insertion exercise set, teaching standard for evaluation, and data analysis/comparison software. The students experience the operation in such a vivid environment, evaluated from the PC and correct their mistakes real-timely. The effectiveness of training was proved with the answers from the trained students. Based on the experiment results, further improvement by providing a more real arm model and an increase in blood vessel types will be taken into account for our next study.

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