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Case Report

Virtual reality education program including three-dimensional individualized liver model and education videos: A pilot case report in a patient with hepatocellular carcinoma

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Three-dimensional (3D) modeling of the liver can be especially useful for both the surgeon and patient to understand the actual location of the tumor and planning the resection plane. Virtual reality (VR) can enhance the understanding of 3D structures and create an environment where the user can focus on contents provided. In the present study, a VR platform was developed using Unreal Engine 4 software (Epic Games, Potomac, MD, USA). Patient's liver based on magnetic resonance image was imported as a 3D model that could distinguish liver parenchyma, vascular structure, and cancer. Preoperative education videos for patients were developed. They could be viewed inside the VR platform. To evaluate the usefulness of VR education program for patients undergoing liver resection for hepatocellular carcinoma, a randomized clinical trial evaluating the knowledge and anxiety of the patient was designed. The case presented in this report was the first experience of performing the VR education program and examining the knowledge and anxiety using questionnaires. When the knowledge score increased, the anxiety score also increased after the education program. Based on findings of this pilot case study, the timing and place where the questionnaire will be answered can be modified for formal initiation of the randomized controlled study to examine the usefulness of VR in patient education.

Key Words: Hepatocellular carcinoma; Virtual reality; Education

INTRODUCTION

With the development of new technology such as virtual reality (VR), many studies have evaluated the feasibility and usefulness of VR in the field of medicine [1]. Yang et al. [2] have evaluated the effect of preoperative VR experience of using magnetic resonance imaging (MRI) of patients undergoing arthroscopic surgery due to injury on patients' anxiety. In their study, the VR group showed higher satisfaction score and felt less stress postoperatively. Liver is a solid organ with high vascularity and complex inner structures. Unlike its simple outer morphology, its complex inner structure necessitates the surgeon to be highly experienced to perform hepatectomy. Therefore, three-dimensional (3D) modeling of the liver can be especially useful for both the surgeon and patient to understand the actual location of the tumor and planning the resection plane. This case presents the initial experience of examining the preoperative anxiety and knowledge of patient's status before and after patient education system using VR.

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CASE

Virtual reality patient education program

The authors developed a VR platform enabling multi-user access with visualization of patient-specified 3D model of a patient's liver. The 3D model of the patient liver was obtained using Materialise Mimics Medical software (Materialise, Leuven, Belgium) and imported to the VR platform using Unreal Engine 4 software (Epic Games, Potomac, MD, USA). The viewer can adjust the transparency of different structures to enable visualization of inner structures of the liver including portal vein, hepatic vein, and tumor. The space inside the VR platform was designed as an education room mimicking the actual education room of our hospital. The doctor user has the authority to run the education program by manipulating the 3D model and play the education video. The patient user and family user could only watch and listen to the education program. Patient education videos were produced regarding liver, hepatocellular carcinoma, surgery, laparoscopy, and complication after surgery. The following six topics are discussed in the education videos: the role of liver and why hepatocellular carcinoma occurs, details on surgical resection of hepatocellular carcinoma, the extent of liver resection and limit for future liver remnant, the difference between open and laparoscopy, the role of gallbladder and situations when gallbladder is resected during hepatectomy, and postoperative complication after liver resection. The VR education program was provided to the patient using Oculus Quest (Meta, Menlo park, CA, USA). Before and after the patient education VR program, questionnaires designed to evaluate anxiety and knowledge were answered by the patient. State-Trait anxiety inventory-X (STAI-X)-1 and -2 were used to evaluate the anxiety of the patient. A questionnaire that could evaluate the knowledge of the patient was developed by our team. It included questions regarding general knowledge of liver surgery and patient-specified information [3,4]. STAI-X-1 and -2 knowledge questionnaire can be provided by the authors upon request.

Patient

A 66-year-old female patient was diagnosed with a 2.5 cm-sized hepatocellular carcinoma located on segment 8 adjacent to the middle hepatic vein. Due to its sophisticated location, surgical resection was recommended by the multidisciplinary liver malignancy team. The patient had chronic hepatitis B viral hepatitis. She was under antiviral medication.

The main tumor was located on segment 8 with a diameter of 2.5 cm. The 3D model of the tumor showed the tumor's sophisticated location abutting to the middle hepatic vein (Fig. 1A). The VR education program was applied for the patient in an education room located on the same floor of the patient's admission room (Fig. 1B). The 3D model imported into the VR platform visualized the tumor location and the right liver planned for resection and the left liver which was planned to be remained (Fig. 1C). An education video for liver resection

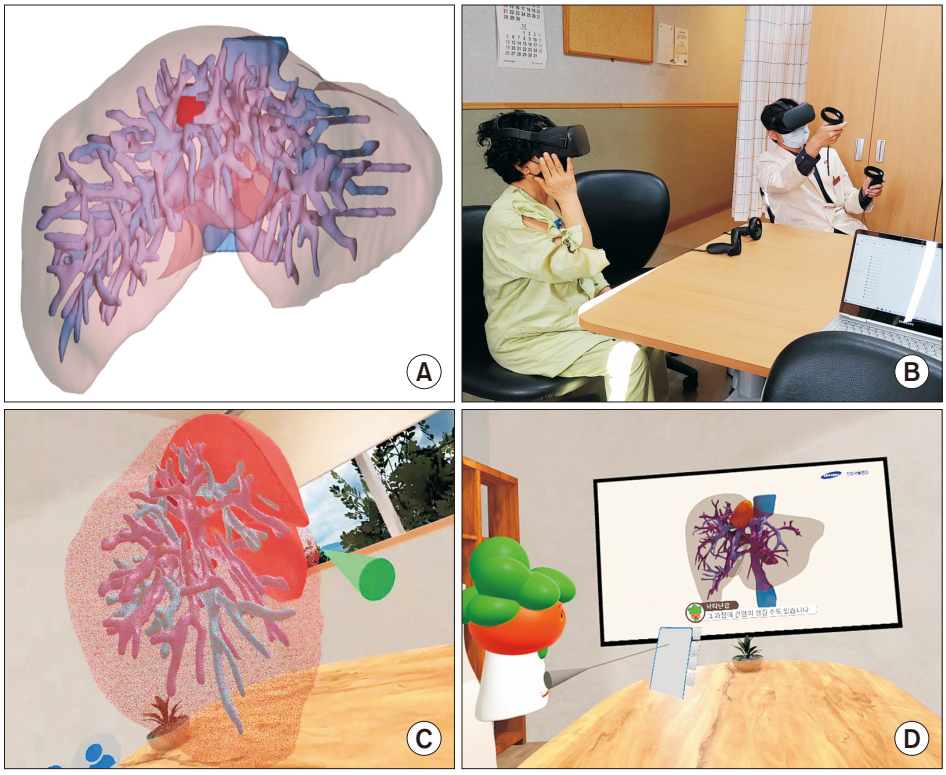

Fig. 1. Pictures of the virtual reality (VR) education program. (A) Three-dimensional (3D) model of the tumor showing the tumor's sophisticated location abutting to the middle hepatic vein. (B) The VR education program was applied by the author to the patient before operation. (C) The 3D model imported into the VR platform visualized the tumor location within the liver. (D) An education video for liver resection patients was also played in the VR platform.

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patients was also played in the VR platform (Fig. 1D). The education video is uploaded as a video file (Supplementary Video).

Questionnaires for anxiety and knowledge

On the day of patient's admission, which was two days before the operation, first examinations were done. The patient was accompanied by her family during the examination. On the next day, which was one day before the operation, VR education program was applied for the first time since its development. After the education program, second examinations were done. During the education program, her family member did not attend the education program due to hospital policy restricting family's visit due to COVID-19. STAI-X-1 and STAI-X-2 scores were 41 and 25, respectively, before the education program. These scores changed to 54 and 50, respectively, after the education program. Knowledge scores before and after the education program were 9 and 16, respectively.

DISCUSSION

The 3D imaging can provide better understanding of complex anatomical structures for both the surgeon and patient. However, 3D model visualized in a two-dimensional screen can restrict the viewer from understanding the true depth of inner structures embedded within the liver. VR can provide true 3D experience which can enhance anatomical understanding including depth. VR can also create reality which can provide a better environment for the user to focus on its contents. The case presented in this report is a pilot study for investigating the clinical usefulness of VR for educating patients to enhance their knowledge and reducing their preoperative anxiety. This study was designed as a randomized controlled trial with a process presented in Fig. 2. For this purpose, STAI-X-1 and -2 were used to evaluate the anxiety score while questionnaire for evaluating the knowledge was newly developed. The knowledge questionnaire consisted of 13 questions with points 1 to 3, summed up to 20.

While a clinical study using the questionnaires before and after the VR education program was designed to be performed as a randomized controlled study, this pilot case was designed to test the VR platform as an education program and test the protocol for examining the questionnaire. The actual clinical trial will be comparing pre-post changes between the VR group and the control group. The primary goal was to examine the change in the knowledge of the patient. The secondary goal was to examine the change in preoperative anxiety. As expected, knowledge score increased after the education program. On the other hand, both scores of STAI-X-1 and -2 were increased after the education program. The finding that the anxiety score increased after the education program was interesting. It needs cautious interpretation. The time points for answering the questionnaires were different in many aspects. Post-education questionnaire was answered right after the education program

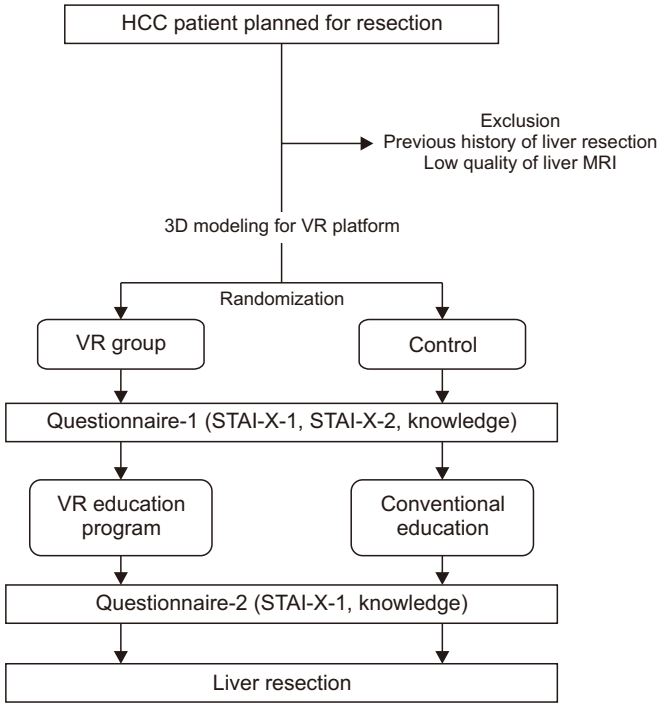

Fig. 2. The protocol for a clinical trial. HCC, hepatocellular carcinoma; VR, virtual reality; 3D, three-dimensional; STAI, State-Trait anxiety inventory-X.

which included surgical plan and possible complications that might occur after the operation. The patient attended the education program without the attendance of her family members which could have increased her anxiety with the feeling of being alone. On the other hand, the pre-education questionnaire was answered right after the admission of the patient while her family member was present. The places where these questionnaires were answered were also different. While pre-education questionnaire was answered in her inpatient room where belongings of the patient were displayed along with the presence of her family member, the post-education questionnaire was answered in the education room while authors of the present study were present in the same room. The information of surgical aspects, postoperative recovery, and potential occurrence of postoperative complications might have awakened the patient's awareness that she was going to undergo a major surgery. Thus, the actual time and place where the patient will be answering the questionnaire should be cautiously selected to minimize influence of other factors besides the VR education program itself.

The fact that the patient's anxiety score increased after the VR education program elevated our expectations for designing a clinical trial. While reducing preoperative anxiety is generally accepted as a good clinical practice, improving the patients' knowledge on their health status is more important. It is set as the primary goal of our future study. It would be an interesting

point to see whether those two goals can be achieved together. Increased knowledge and decreased anxiety will be the best achievement that can be expected. Increased knowledge accompanied by increased anxiety will give clinicians an important question of how detail the education should be to have the best outcome of the patient.

The clinical trial using the VR education program accompanied with the questionnaires will be performed on hepatocellular carcinoma patients younger than 70 years who are planned to undergo their first operation. New technologies such as VR are increasingly applied to the field of medicine. This pilot case study was performed for better design of our future clinical trial. It enabled us to review our plans and modulate the protocol for a better design before the actual study initiation.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.14701/ahbps.21-163.

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CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTIONS

Conceptualization: JR, DK, JC, HL. Data curation: JR, DK, JC. Methodology: JR, GSC, JMK, JWJ. Visualization: JR. Writing - original draft: JR, SL. Writing - review & editing: JR, SL.

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