Training of lung cancer surgery through metaverse including extended reality in the smart surgical room in Seoul National University Bundang Hospital, Korea

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Non-face to face training during the COVID-19 pandemic era

COVID-19 has made it difficult to provide medical training across borders. It has become virtually impossible to see high-tech medical equipment from other countries and observe surgery to learn. A "metaverse" education method is also being introduced in the medical field. This introduction is because demand for non-face-to-face education is growing as overseas medical staff who visited Korea to learn medical technology from around the world and medical students who should practice have fewer opportunities to face patients directly due to COVID-19. Efficient surgical training is indeed tricky with available imaging systems such as zoom. In order to solve these limitations, new digital changes using metaverse technology are also emerging in the Korean medical community [1]. In this Editorial, I would like to introduce the training course in metaverse held in Korea and write down expectations about how it will be used in the medical field in the future.

Case of training of lung cancer surgery through the metaverse
On May 29, 2021, the 6th Outreach program using the extended reality (XR) technology platform was held under the supervision of the "Asian Thoracic Surgery Education Group" at the 29th Online Conference of the Asian Heart and Thoracic Surgery Society in 2021 [1]. More than 200 thoracic surgeons from Asian countries attended the Outreach program and received training. Surgeons from Manchester University Hospital and National University Hospital in Singapore also accessed the virtual environment to visit the system and had active discussions.

Participants in the program wore a head-mounted display (HMD) in their respective laboratories or experienced a real place in a virtual environment with their laptops. The 360-degree environment has been implemented with HMD and laptops through recent platform upgrades. After setting up an individual's avatar like a game, the participant entered a virtual classroom and took lectures on lung cancer surgery techniques and trends of virtual, mixed technology (Fig. 1), and continued discussions in real-time while observing the surgical process in a virtual environment. Lung cancer surgery education was conducted in this way when high-resolution virtual reality cameras broadcast all surgical scenes at 360 degrees. The virtual space is decorated like a conference venue.

The surgery was broadcast in the smart operating room of Seoul National University (SNU) Bundang Hospital. Participants evaluated that it seemed to be observed in the actual operating room because they could see the surgeon, the surgical nurse, and the environment in the operating room as desired through the 360-degree-8K-3D camera built in the operating room (Figs. 2, 3). The platform is characterized by a virtual environment and a high-quality voice conversation through 3D XR immersive sound technology. Another advantage is that smooth real-time voice support and various screens such as the actual environment can be implemented. The surgical scene is more visible than when the observer enters the operating room and sees it. Participants can also see the surgeon's monitor and how the operating room nurses hand over surgical tools, how the forceps move, and even the sweat that suture the wound. As participants move the mouse, they can see every corner of the operating room from the angle that the observer wants. If they wear a 3D headset, the visible scene changes every time they turn their heads, and the feeling of being in the operating room becomes more significant than the situation without a headset.

**How can it be realized?**

It was possible because SNU Bundang Hospital's smart operating room and metaverse
environment are combined. Metaverse combines Meta, which means virtual and transcendent, and Universe, the world [2]. It is a reproduction of reality in a virtual space. It is easy to understand when anyone thinks of virtual spaces using avatars such as Roblox [3] and Fortnite [4]. SNU Bundang Hospital created a smart operating room in 2019. Six lenses focus on a virtual reality camera that shoots 360 degrees in all directions, a high-resolution camera, and fluorescent imaging equipment that can see lymph nodes in one place in the operating room. Advanced imaging equipment has become critical as surgery to minimize laparotomy and borrow the power of endoscopy increases. Surgeons wear 3D glasses and watch 3 dimensions of high-resolution images of laparoscopic cameras.

An observer can look at it more extensively and precisely than when a surgeon opens the stomach and performs surgery. The operating room camera or lighting has a voice recognition function. A surgeon can operate with both hands and turn off the camera or light directly with one voice. Medical staff may have a remote conversation over the biopsy results during surgery. Suppose the surgeon removes the tissue during surgery and sends it to the pathologist. In that case, the pathologist will display microscopic images on the large screen of the operating room after the biopsy. Watching the video, the surgeon listens to the pathologic findings in real-time and shares opinions. A control room where the observer can look into the smart operating room transparently is attached right next to it, so they can transmit videos or adjust cameras here.

**Importance of a smart surgical room**

After the COVID-19 pandemic, the importance of smart operating rooms has increased. Surgeons from the United States and Europe also came to SNU Bundang Hospital to observe state-of-the-art surgery, but it has become impossible since COVID-19. However, through 360-degree video, they can see it vividly as if they were in an operating room anywhere. There is no need to come to Korea. Dr. Sang-Hoon Ahn, a professor of surgery at SNU Bundang Hospital, said that "Video education using metaverse is more effective than any other educational method available so far." An observer can only see the abdominal cavity through a typical video broadcast, but the 360-degree video shows all the situations in the operating room. For example, in Professor Ahn's case of articulated forceps for laparoscopic surgery, it is difficult to know precisely how to use them only by looking at images of forceps moving in the abdominal cavity. However, through the 360-degree video, if Professor Ahn changes the angle of movement of the wrist, the observers can see how the forceps move inside. They can learn more accurately than direct observation in the operating room [5].
number of people who can enter the operating room is limited. In addition, in the case of
eendoscopic surgery, the monitor angle is tailored to the doctor operating, so even if anyone enters
the operating room, they often cannot see the surgical scene correctly. There is no such drawback
when using the video, so it is used for surgeons, nurses, and medical student education. Dr. So
Hyun Kang, SNU Bundang Hospital fellow, said that such an educational system benefits medical
residents: "Residents and fellows are always busy. I can not run to the operating room to observe while working far
away. It is only seen in medical dramas that medical doctors look down at the surgical scene from above." Even
if residents can not watch the surgical broadcast in real-time, they can study while watching the
recorded video from various angles later.

**Further application of metaverse through tailored education and training**

This demonstration at SNU Bundang Hospital is an example of using metaverse in clinical
education [5]. Among metaverse, this is an example of XR implemented by mixing augmented
reality (AR) and virtual reality (VR). XR refers to all VR technologies ranging from VR to mixed
reality (MR) and AR [6]. With the prolonged COVID-19 situation, the importance of medical
education using smart operating rooms and metaverse is growing. A technical leap is expected, such
as higher camera resolution and delivering the surgeon's touch felt. It is expected to be actively used
in medical education or education for residents and students in the future. The use of metaverse
through tailored education and training in the COVID-19 era will be accelerated even in the post-
COVID-19 period. By actively introducing these cutting-edge technologies into the medical field,
they will contribute to the health of Koreans and people around the world.

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References

Explanation for figures

Fig. 1. Avatars who participated in the virtual conference of the Asian Heart and Thoracic Surgery Society in 2021 (Use of the photo was permitted from the Seoul Nationa University Bundang Hospital).
Fig. 2. Scene of surgery in the smart operating room, Seoul Nationa University Bundang Hospital (Use of the photo was permitted from the SNU Bundang Hospital).

Fig. 3. Avatars who watch the scene of surgery in the smart operating room, SNU Bundang Hospital (Use of the photo was permitted from the Seoul Nationa University Bundang Hospital).