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Training System Trends for Cardiovascular Diseases

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Abstract

Cardiovascular diseases are the primary cause of death globally. In some cases, surgery is needed for treating CVDs, and this needs to be safe, short, and with improved techniques to maintain the patient's quality of life. To operate under these requirements, it is important to develop surgery training systems and have doctors use these systems. We propose that surgery simulation may reduce the risks associated with the complex operations of cardiothoracic surgery and help create a more efficient, thorough, and uniform curriculum for cardiothoracic surgery fellowship. In this paper, we introduce aspects of surgery training systems for education, and the trend for cardiovascular diseases surgery training systems. In addition, the prospect of surgery technical education using augmented reality and mixed reality technology is also argued.

Keywords: Cardiovascular Diseases; Education; Training system; Augmented Reality; Mixed Reality

Introduction

Cardiovascular diseases (CVDs) including heart failure (HF), coronary artery disease (CAD), hypertension, dysrhythmia, and venous thromboembolism, are the primary cause of death globally. An estimated 17.9 million people died from CVDs in 2016, representing 31% of all global deaths, and of these deaths, 85% of these were due to heart attack and stroke [1]. In some cases, surgery is needed for treating CVDs, and the surgery itself needs to be safe, short, with improved techniques to ensure the patient's quality of life. In order to operate such highly technical surgery, it is important to develop training systems that appropriately prepare doctors for surgery. For instance, in Japan, training using simulators has become compulsory in specialties such as cardiovascular surgery, where doctors must complete a fixed amount of training [2,3]. Surgery simulation may reduce the risks associated with the complex operations of cardiothoracic surgery and help create a more efficient, thorough, and uniform curriculum for cardiothoracic surgery fellowship [4]. In this paper, we introduce several surgery training systems for education and discuss the trend for training systems in cardiovascular disease surgery. In addition, the prospect of technical education for surgery using augmented reality and mixed reality technology is also argued.

This paper is organized as follows. Section 2 describes two systems for cardiovascular surgery training systems. One is a training simulator for off-pump coronary artery bypass (OPCAB), and the other is a vascular interventional surgeon training system with cooperation between catheter and guidewire. Section 3 describes future prospects, and Section 4 summarizes this paper.

Systems for Cardiovascular Surgery Training Systems

There are several systems for cardiovascular surgery training systems, and here we focus on two of these.

Training simulator for OPCAB

EBM Inc. developed a training device for coronary artery bypass surgery under heart beating conditions, BEAT (Figure 1), which is a training simulator for OPCAB [5]. A blood vessel model can be applied to BEAT, and doctors can practice vascular anastomosis techniques under a stabilized heart beating motion. EBM Inc. explains that doctors can efficiently master the technique for vascular anastomosis this way. BEAT was developed at Waseda University in 2004, and as of March 2016, 275 machines in nine countries are used for the daily training of doctors [5].

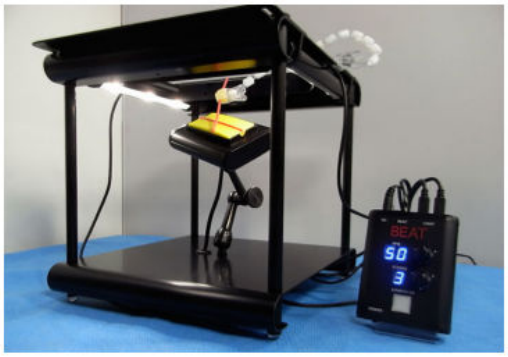

Figure 1: BEAT, a training simulator for off-pump coronary artery bypass (OPCAB).

Vascular interventional surgeon training system

Guo et al. developed the vascular interventional surgeon training system with cooperation between catheter and guidewire [6]. This system is not designed specifically for cardiovascular diseases, although it can be applied to this. This system uses a master

manipulator and virtual reality technology, which aids the operation of the guide wire based on the virtual reality environment. Simultaneously, the operation of the guide wire is controlled by various degrees of freedom, such as the detection and simulation of the collision force. The effect of blood flow on the viscous resistance of the catheter and guidewire is also added. This training system has been demonstrated to help improve training effect.

Future prospects

In addition to the systems introduced above, Augmented Reality (AR) is expected to enable effective education and training for surgery. Use of AR in surgery is said to be a major aim of AR developers as it has potential to decrease operation time and complication rate [7]. There is an increasing interest among surgeons regarding incorporating augmented reality into surgery to improve safety and efficacy of surgical procedures, and many studies shows that the performance of newly devised AR systems are comparable to traditional techniques [8]. Mixed reality (MR) is also expected to become an effective tool. MR holograms as surgical planning tools for congenital heart disease may have a high diagnostic value and contribute to understanding complex morphology [9]. However, AR or MR devices usually weigh several hundred grams and produce plenty of heat, therefore, comfort is an issue with long-term wearing [8]. In addition, AR or MR, as with VR, produces simulator sickness, which presents as nausea, headache, and vertigo or vomiting in the worst scenario. Despite this, AR and MR may become powerful tools capable of revolutionizing the field of surgery through rational use [8]; additionally, there is research on surgery using AR and MR with head mounted display (HMD) [10]. Several HMD devices, such as Hololens2 of Microsoft, Magic Leap One of Magic Leap, Google Glass of Google and so on, would be valuable for introducing effective education and training tools for surgery of cardiovascular diseases.

Conclusion

In this manuscript, two training systems for cardiovascular diseases are introduced. These training systems are effective for surgery education; however, most educators agree that there are important limitations to simulation-based training. In addition, it is said that simulation may never mimic the feel of living human tissue, the complexity of human physiology, or all the psychosocial nuances of real patient care. Although this is true, ongoing and efficient improvement of doctors' surgery skills are needed. As described here, many HMD devices that could be used as effective education for surgery of cardiovascular diseases have been launched. In the near future, these are expected to be able to educate and train doctors and improve their surgery skills.

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