INTEGRATION OF THE MR TECHNOLOGY, ELASTIC PHANTOM AND BLOOD CIRCULATION SYSTEM FOR LIVER TRANSPLANTATION SURGERY SIMULATION: A PILOT STUDY

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Abstract - Liver transplantation (LT) is an important treatment method for liver cancer, liver laceration, and liver cirrhosis. However, the blood vessels are complex in the liver, the success of LT depends on the doctor's experience. This study proposed a set of MR surgical training systems, which builds a virtuality and reality fusion algorithm based on a mesh morphing algorithm method. Projecting the 3D blood vessels onto the surface of an elastic liver phantom, which contains blood vessels, and allowing users to observe 3D information on blood vessels in real-time during LT practice. To verify the feasibility of the system, the study conducted the tests by using a blood circulation simulation system. The experimental results showed there was a positive correlation between cutting-hemorrhage level and blood flow rates. The system has a high degree of realism and is suitable for preoperative practice to improve the quality of surgery.

Keywords - Liver Transplantation (LT), MR Surgical Training System, Mesh Morphing Algorithm Method, Elastic Liver Phantom, Blood Circulation Simulation System.

I. INTRODUCTION

According to WHO statistics, liver malignant tumors are expected to exceed one million people annually all over the world. 90% of the cases are liver cancer, and 10% of the cases are bile duct carcinoma and carcinoma of unknown primary (CUPs). Currently, Liver transplantation (LT), and radio frequency ablation (RFA) are the most commonly used treatment methods with an average five-year survival rate of about 70% after the surgery [1]. However, LT surgery relies on the experience of the doctors, young physicians can only rely on the cadaver-based experience of gross anatomy. There is a real gap with the actual LT. Augmented reality (AR) and MR systems could be used to assist surgeries, such as liver surgery, neurosurgery, and orthopedics surgery [2]. In this study, we proposed a MR surgical training system based the elastic liver phantom and blood circulation simulation system. This system could project the 3D blood vessels onto the surface of liver phantom, allow the young doctors to further understand the structure of 3D blood vessels inside the liver, and provide more realistic and more precise surgical training experience.

II. METHODS AND RESULTS

The system is shown in Figure 1. The system builds a virtuality and reality counterpoint algorithm based on a mesh morphing algorithm. Aligning the 3D blood vessels with the liver phantom and providing depth information of the blood vessels. In order to make the surgical training more realistic, blood flow was guided into the blood vessels through a blood circulation simulation system, fully simulating bleeding effects in the blood vessels of different sizes in the liver. In this study, the root-mean-square error (RMSE) was used to estimate accuracy (< 2mm means fail). After that, record the degree of bleeding during the cutting procedure based on the changes in flow rate settings, the experimental results are shown in Figure 2.

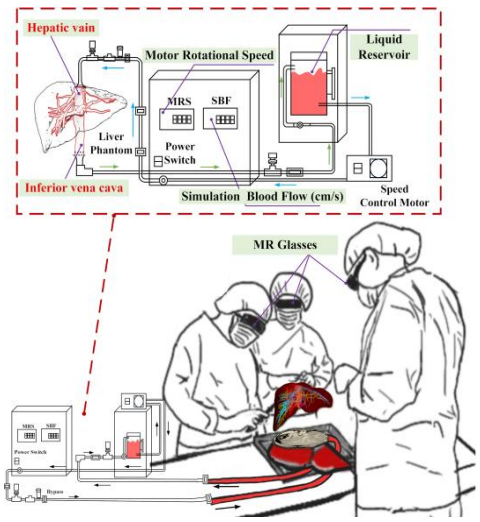


Figure 1. System architecture of system

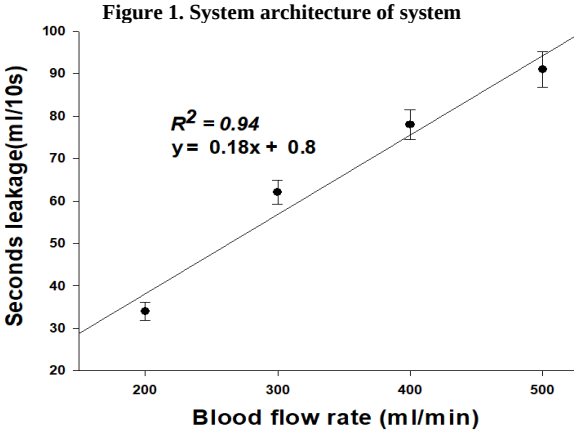


Figure 2. related experimental results between blood flow and blood flow velocity

III. CONCLUSION

The system proposed in this study can fusion 3D blood vessels stably on the surface of liver phantom. In addition, with the blood circulation simulation system, it provides a more realistic and more precise surgical training experience. This system can not only provide clinical preoperative planning, but also serve as a tracking reference for clinical surgical procedures in the future.

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