Symposium 1

Clinical Values of 3D Virtual Liver Surgery System: Focusing on Dr. Liver, a User-Centered Virtual Liver Surgery System

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Virtual surgery refers to a virtual simulation of surgical procedures before performing surgery for practice. Computed tomography imaging technology enables an optimal visualization of the extra- and intra- hepatic vascular branching in a 3D liver mode and provides an individual territorial liver mapping as well as volumetry of corresponding vascular territories. Liver resection can be better planned using the information of a patient's intrahepatic vascular anatomy. Furthermore, the computer-assisted resection planning help the surgeon better assess functional resectability because areas at risk for either devascularization or impaired venous drainage can be identified and precisely calculated preoperatively. This information may have considerable influence on surgical strategy in selected cases, especially with regard to the extent and method of hepatic resection.

A 3D virtual liver surgery planning system provides surgeons with an effective tool for safe and rational surgery by providing not only visual information such as the structure of the liver vasculature and the segments of the liver but also quantitative information such as the volume data of the liver, remnant and/or graft. Most of existing virtual surgery systems such as Rapidia, Voxar 3D, Syngovia, and Osrix do not provide functions specialized to liver surgery planning. These generic virtual surgery systems have a limited utility to surgeons in pre-operative liver surgery planning. For example, the manual or semi-automatic liver extraction using a generic virtual surgery system is quite cumbersome and time demanding (e.g., more than 30 min.) to the user. Virtual surgery systems providing specialized functions for liver surgery planning have been developed and their examples include Synapse Vincent developed by Fujifilm and Visia Liver-Distant Services by MeVis Medical Solutions AG using LiverAnalyzer (not for sale).

My research team has developed a 3D virtual liver surgery system, called Dr. Liver, which provides specialized functions to liver surgery with an intuitive, user-friendly interface so that the surgeon can obtain information necessary for liver surgery planning within a reasonable time. Our system expects an entire processing time of 20 to 30 min. from liver extraction to surgery planning. Dr. Liver consists of seven modules including DICOM loading, standard liver volume estimation, liver extraction, vessel extraction, tumor extraction, liver segmentation, and surgery planning. Dr. Liver utilizes a combination of image processing algorithms such as region growing method, fast marching level set method, and threshold based level set method to extract the liver, vessels, and tumor with efficiency. User-friendly features such as procedural interface, integrated view control button, multiple point selection, segment labeling, error prevention, and audiovisual message have been implemented to Dr. Liver for intuitive, easy interaction. Opinions and recommendations of liver surgeons have been accommodated with importance throughout the whole process of Dr. Liver design and development. The accuracy, efficiency, and usability of Dr. Liver have been examined intermittently with liver surgeons and found satisfactory. Further work such as usability testing in clinical environments, vessel extraction from poor quality CT images, and viewer module on a tablet for clinical effectiveness has been planned. Dr. Liver system has integrated multidisciplinary knowledge of liver surgery, image processing, and ergonomics.

In conclusion, the 3D virtual liver surgery system is useful to surgeon by real-time segmentation and surgical planning which can be used directly in clinical application for decision of the extent and method of hepatic resection. It may also help reduce the surgical risks and potential complications in liver surgery.