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The Function and Application of 3D Visualization in the Treatment of Primary Hepatic Carcinoma

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Primary Hepatic Carcinoma refers to malignant liver tumors. Hepatocellular Carcinoma accounts for more than 90% of primary hepatic carcinomawith its incidence rate ranking the sixth in global tumor incidence and mortality rate ranking the third in tumor-related death in the world. Surgical resection is the preferred treatment for early primary hepatic carcinoma. It includes liver transplantation, partial hepatectomy, laparoscopic hepatectomy, etc. based on Milan criteria, University of California criteria and Hang Zhou criteria. But how the operation is done relies on tumor-evaluation in different stages before the surgery. Medical Imaging is the way to evaluate malignancy degree but is usually 2D. Even though the high-end CT and MR can reconstruct 3D image, clinicians are still provided with 2D image. Therefore, in order to diagnose diseases, surgeons have to reconstruct 2D image into 3D image in their mind according to their experience and liver anatomical structure, causing possible uncertainty and errors in the treatment [1]. It is more so in the following cases: complicated hepatectomy, which requires to resect a larger part of liver tissue, may give rise to postoperative hepatic disorder or even hepatic failure; special surgery site makes it hard to expose the anatomical position and may cause intraoperative bleeding because it is close to major vessels; hepatic blood supply disorder (hepatic congestion, hepatic ischemia) increases difficulty and risk in surgery. All of the above require clinicians to make sufficient preoperative plans, careful intraoperative anatomy and proper postoperative management [2].

The current 3D visualization technology is mainly used in orthopedics, plastic surgery, dental, cerebral surgery, and so on. However, in the field of hepatological, it surgery was still in its infancy. Souzaki et al. [3] has used 3D printing auxiliary liver to implement a case of children liver tumor surgery. Zein et al. [4] semi-transparent liver 3D models has be used in living donor liver transplantation, by postoperatively adjusting model of 3D printing, it can help the key parts of the anatomical position, make more perfect operation plan, and can reduce the operation time and complications. By the use of 3D visualization, the actual anatomic structure of a patient's liver, showing the relationship between the tumor and its neighboring blood vessels and bile ducts, can be obtained and constructed preoperatively [5]. According to some literatures, 3D visualization eliminates the risks of potential blood flow disorder of 20%-40% of remaining liver tissue caused by operations based on 2D CT, and compared to portal veins which supply blood, the drainage disorder of hepatic veins affects the blood flow disorder of liver tissue more [6].

Through preoperative planning and simulated operation, it is possible to observe from any angle the distance between the tumor and the margins after the simulated hepatectomy, as well as the spatial relationship between the tumor and important blood vessels and bile ducts. Repeated simulated operations can avoid hepatic failure induced by lack of liver tissue.

Liver Data from the thin-section CT scans (precontrast, enhanced and lag) are transferred to abdominal MI-3DVS to realize rapid image segmentation/registration and 3D models.

MI-3DVS produces the model of hepatocellular carcinoma, and the relevant 3D images, namely STL documents, are transferred to the rapid prototyping software. Then a 3D printer produces a physical model with resin and metal printing materials. After some handling, the model is finalized. By using a nonrandom study, Fang et al. [7] showed that 3D group in the amount of intraoperative blood transfusion, intraoperative blood loss, incidence of postoperative complications, and postoperative hospitalization days were all less than the conventional group. Moreover, the recovery of liver function main indicators in 3D group is superior to the conventional group, and the two groups had no death in perioperative period. In this study, they divided primary liver cancer patients into the three dimensional visualization technology auxiliary liver resection group and normal liver resection group.

With the help of 3D-printed abdominal organs and 3D model of blood vessels, it is possible to thoroughly analyze pathological changes of living human anatomy, doctors for general surgeries are offered specific morphological data, and reasonable surgical plans and preventions for postoperative complications are also made possible [8-9].

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