Application of VR and 3D printing in liver reconstruction

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As we know, the visualization of the individual vascular and bile duct anatomy of the liver is crucial when hepatectomy or transplantation was executed (1,2). However, an unbridgeable chasm existed in the group of junior surgeons if mere traditional image data was provided. It was abstract and unspecific, requiring enough experience to understand. The number of patients with abdominal tumors are constantly increasing, and the new visualization technique using three-dimensional (3D) images could help surgeons to make preoperative planning in the surgical field (3). This has been a technological innovation for more than two decades that could change the traditional model for preoperative evaluation. Although 3D reconstruction is more preferable to the traditional 2D images, the optimal 3D model is out of consensus, especially in applications of new technologies for virtual reality (VR) and 3D printed models (PR). It is also uncertain whether these new technologies were worthy for further technological innovation.

Here, an interesting study provides the theoretical foundation. Huettl *et al.* first explored 3D PDFs, 3D PR and VR 3D models with regard to hepatic anatomical orientation and personal preferences (4). This was an investigation that involved a population with different levels of clinical experience. Participants needed to specify the tumor location in liver models. The interesting results showed that participants named significantly more correct segments in VR (P=0.040) or PR (P=0.036) compared to PDF model. The tumor assignment was significantly shorter with 3D PR models compared with 3D PDF (P<0.001) or VR application (P<0.001). It meant that a better and partially faster anatomical orientation could be identified in 3D PR models, even in populations with less

clinical experience. More importantly, VR was the most preferred method (n=22, 73.3%) in terms of usability and user experience. It was visualizable and comprehensible. The authors also described potential clinical applications of VR and 3D PR regarding patient information, student education, advanced surgical education and operation planning (5,6).

The technologies of VR and 3D PR are different. Although VR is widely used in education, planning, navigation, rehabilitation and others, the daily clinical usage is deficient because of realistic reasons, such as lacking realism of tasks, abstract graphic design, and the awareness of participants to be in a training environment (7). This is a bottleneck that required a technological breakthrough. Surprisingly, with the development of VR technique, abstract training tasks and procedural operations are available, graphic design and virtual tissue interaction have been improved (8). All of these could help us to increase efficiency for clinical application. In addition, a user-friendly simulation scenario with high immersion and presence created by VR applications that could provide optimal refresh rates, frame rates, display sizes, and display resolutions (9). This would bring a better user experience.

These advantages are more obvious in 3D PR models. It is the most "natural" modality that could be explored without any technical aids. Right now, 3D PR model is the preferred modality in the group of fellows and HPB experts, which is similar to the results of Huettl *et al.* Furthermore, the primary defects for 3D PR models are technical barriers and high costs, which limits the widespread application (10).

In the field of hepatic surgery, the technologies of VR and 3D PR are beneficial to identify the tumor's localization,

vascular structures, and the standard remnant liver volume after hepatectomy (11). However, a long time would be required for these technologies could be extensively used. Firstly, it is unnecessary for senior surgeon because enough experience have been accumulated. Secondly, it is inessential for some solitary, left lateral lobe and tumors without vascular invasion to operate such sophisticated instruments.

In summary, VR and 3D PR models have an immense potential application for preoperative planning and perioperative assessment, especially for clinical and anatomical education. We believed that VR and 3D PR models could provide more convenient in clinical application in the future.

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Footnote

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