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Three-dimensional visualization and virtual reality simulation role in hepatic surgery: further research warranted

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Abstract

Artificial intelligence (AI) is the study of algorithms that enable machines to analyze and execute cognitive activities including problem solving, object and word recognition, reduce the inevitable errors to improve the diagnostic accuracy, and decision-making. Hepatobiliary procedures are technically complex and the use of AI in perioperative management can improve patient outcomes as discussed below. 3D reconstruction of images obtained *via* ultrasound, CT scan or MRI, can help surgeons better visualize the surgical sites with added depth perception. Pre-operative 3D planning is associated with lesser operative time and intraoperative complications. Also, a more accurate assessment is noted, which leads to fewer operative complications. Images can be converted into physical models with 3D printing technology, which can be of educational value to students and trainees. 3D images can be combined to provide 3D visualization, which is used for preoperative navigation, allowing for more precise localization of tumors and vessels. Nevertheless, AI enables surgeons to provide better, personalized care for each patient.

Key Words: Artificial intelligence; 3D printing; Liver Surgery; Virtual Reality; Preoperative Planning; Simulation

Ahmed F, Jahagirdar V, Gudapati S, Mouchli M. Three-dimensional visualization and virtual reality simulation role in hepatic surgery: further research warranted. *World J Gastrointest Surg* 2022; In press

Core Tip: One of the applications of Artificial Intelligence in Hepato-biliary and pancreatic surgery is to generate 3D imaging, models, and virtual reality for preoperative planning. 3D visualization and navigation can facilitate identification of the exact location of tumors and vessels, reducing vascular injury, operative time, and postoperative complications, thereby leading to better patient outcomes. Upcoming surgeons and students can utilize 3D models and VR to gain expertise in the field of HPB surgery and share their experiences with their peers.

TO THE EDITOR

We have read with great interest the paper "Role of Artificial Intelligence in Hepatobiliary and Pancreatic Surgery', published by Bari *et al.* [1] in your well-regarded journal *"World Journal of Gastrointestinal Surgery"*. Concerning the data reported on three-dimensional visualization (3DV) and virtual simulation on hepatic patients, we would like to make a contribution towards the discussion and draw your attention to several interesting aspects from recently published literature.

The role of artificial intelligence in healthcare delivery has become an increasingly important avenue of medical research and practice. Artificial intelligence (AI) is a vast field, which includes machine learning (ML) as a subfield, is steadily being integrated into healthcare settings to provide a more precise and individualized approach [2]. At present, before the surgery to determine treatments, hepatobiliary and pancreatic (HPB) surgeons utilize ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI) which provide two-dimensional (2D) views. Surgeons utilize the shadows, textures, and shades from the 2D displays to extrapolate three-dimensional (3D) information in their brains. This 2D image commonly causes loss of depth perception and exerts more workload on the operating physicians [3]. Three-dimensional visualization (3DV), a new type of computer-assisted imaging technology, exhibits clear and accurate images for post-processing to help surgeons stratify surgical risks and outline their surgical plan for intraoperative navigation [4].

We came across two recent studies that compared 3D and 2D visualization reconstruction techniques in liver diseases. Bari *et al.* [1] referenced in their paper, the research conducted by Fang *et al.* [5] which demonstrated significantly shorter operation time ($P = 0.028$), less hepatic inflow occlusion ($P = 0.029$), and decreased high grade (Clavien Grade III - V) postoperative complications in hepatocellular carcinoma patients using 3D models. Zhang J *et al.* [6] and Zhang S *et al.* [7] also reported similar benefits. Zhang J is the first to conduct research in the Tibet population for hepatic echinococcosis and his results revealed the 3DV technology contributing towards

improved diagnosis and treatment of patients. Moreover, the 3DV technology accurately formulated a preoperative plan with a high compliance rate and reduced surgical time (210 vs. 135; P = <0.05). Also, fewer cases were seen with blood flow blockage (83 vs. 50), reduced blood flow blockage time (30.1 min vs. 18.2 min), reduced volume of intraoperative blood transfusion and hemorrhage ((550 mL vs. 310 mL) and (613 mL vs. 312 mL); P = <0.05)), and a significantly lower incidence of postoperative biliary fistula was noted. A meta-analysis on video-assisted hepatectomy by Zhang S *et al.* [7] indicated significant shorter operating time (mean difference (MD = -34.39; 95%CI: -59.50, -9.28; P = 0.007), less blood loss (MD = -106.55; 95%CI: -183.76, -29.34; P = 0.007), small transfusion volume (MD = -88.25; 95%CI: -141.26, -35.24; P = 0.001), and reduced postoperative complications (odds ratio (OR) = 0.57; 95%CI: 0.35, 0.91) with the utilization of 3D application. Furthermore, 3D video-assisted system is a better option than a 2D system since it provides a simple anatomical image combined with improved depth perception, allowing surgeons to operate precisely and in a shorter time.

Another new tool, the immersive 3D virtual reality (VR), allows for preoperative 3D liver models *via* an immersive VR application. It is not well investigated, so there is limited available literature on this modality. Most obtainable publications on hepatic models are described by means of 3D prints or 3D Portable Document Formats (PDFs) for preoperative planning [8, 9, 10]. To date, we found three current studies comparing 3D PDFs, 3D printed models (PR), and 3DV models in liver surgery.

Boedecker *et al.* [10] engineered a VR application that allows liver resection planning *via* a preoperative 3D liver. The study summarized that the drawbacks of visualization on a 2D screen and surface reflection, which arise from 3D print models, are avoided in the VR technique. VR not only includes almost all the benefits of 3D printing but also allows viewing of the various interactions of overlapping pathologies and hepatic vessels. This is not possible with a 3D print. Furthermore, when it comes to education, 3D models are widely used due to their availability and sustainability [11]. Nascent HPB trainees can utilize the benefits of immersive VR, including the ability to interact with other trainees and mentors who are a long distance away, as supported by

Kenngott et al. [12] in their research, where they describe the benefits of VR application in medical education. However, the disadvantage of using VR is that it is unable to make volume calculations, which is only possible through a 3D PDF format. Also, the haptic interaction with the 3D model and surgeon's own hands is limited to the VR application [10]. This needs further investigations.

Out of all three modalities, the fastest and most cost-efficient tool is 3D PDF [10]. Often the 3D PR models are billed per case. Though the VR application equipment is more expensive than the PR model, VR technology is a better choice since they are only a one-time investment. Additionally, stereolithography (STL) files can be dragged and dropped to create the 3D VR model almost instantly without any delay. Prior to choosing a tool for preoperative surgical planning, the above factors must be reviewed.

Huettl et al. [13] concluded that even though 3D PDF is more cost-effective, the 3D PDFs and 3D VR models have the advantage of providing more precise tumor localization. Comparatively, the majority of surgeons preferred VR application over the other modalities. The study also reported 3D PR as superior for faster tumor localization while 3D PDF and 3D PR showed no difference.

Overall, Bari et al. [1] put in great efforts towards outlining the potential of applying currently available 3D presentation modalities in the perioperative evaluation of those who come in for HPB surgery. Further research is necessary to evaluate the reliability and validity of the results already existing on the 3DV and VR technology. This will help surgeons better understand these modalities, utilize, and design personalized surgical plans for each patient.

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