LETTER TO THE EDITOR

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. Three-dimensional (3D) reconstruction of images obtained via ultrasound, computed tomography scan or magnetic resonance imaging, can help surgeons better visualize the surgical sites with added depth perception. Preoperative 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; Three-dimensional printing; Liver surgery; Virtual reality; Preoperative planning; Simulation

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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 (AI) in healthcare delivery has become an increasingly important avenue of medical research and practice. AI is a vast field, which includes machine learning 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, and magnetic resonance imaging 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].

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 et al[6] and Zhang et al[7] also reported similar benefits. Zhang et al[7] 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 inflow 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 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, 3DV 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[8-10]. To date, we found three current studies comparing 3D PDFs, 3D printed models (PR), and 3D 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

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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 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.

FOOTNOTES

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REFERENCES

1  Bari H, Wadhwani S, Dasari BVM. Role of artificial intelligence in hepatobiliary and pancreatic surgery. World J Gastrointest Surg 2021; 13: 7-18 [PMID: 33552391 DOI: 10.4240/wjgs.v13.i7.7]
2  Schlanger D, Graur F, Popa C, Mois E, Al Hajjar N. The role of artificial intelligence in pancreatic surgery: a systematic review. Updates Surg 2022; 74: 417-429 [PMID: 35237939 DOI: 10.1007/s13304-022-01255-z]
3  Hanna GB, Shimi SM, Cuschieri A. Randomised study of influence of two-dimensional versus three-dimensional imaging on performance of laparoscopic cholecystectomy. Lancet 1998; 351: 248-251 [PMID: 9457094 DOI: 10.1016/S0140-6736(97)00015-7]
4  Rowe SP, Chu LC, Fishman EK. 3D CT cinematic rendering of the spleen: Potential role in problem solving. Diagn Interv Imaging 2019; 100: 477-483 [PMID: 30928470 DOI: 10.1016/j.dii.2019.03.005]
5  Fang CH, Tao HS, Yang J, Fang ZS, Cai W, Liu J, Fan YF. Impact of three-dimensional reconstruction technique in the operation planning of centrally located hepatocellular carcinoma. J Am Coll Surg 2015; 220: 28-37 [PMID: 25456781 DOI: 10.1016/j.jamcollsurg.2014.09.023]
6  Zhang J, Dawa J, Suolang D, Lei Y, Wang J, Basang D. The Application of Preoperative Three-Dimensional Reconstruction Visualization Digital Technology in the Surgical Treatment of Hepatic Echinococcus in Tibet. Front Surg 2021; 8: 715005 [PMID: 34490037 DOI: 10.3389/fsurg.2021.715005]
7  Zhang S, Huang Z, Cai L, Zhang W, Ding H, Zhang L, Chen Y. Three-dimensional versus two-dimensional video-assisted hepatectomy for liver disease: a meta-analysis of clinical data. Wideochir Inne Tech Maloinwazyjne 2021; 16: 1-9 [PMID: 3786111 DOI: 10.5114/witm.2020.100678]
8  Bangeas P, Tsoukas V, Papadopoulos VN, Tsouflias G. Role of innovative 3D printing models in the management of hepatobiliary malignancies. World J Hepatol 2019; 11: 574-585 [PMID: 31388399 DOI: 10.4254/wjh.v11.i7.574]
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9 Yang T, Lin S, Xie Q, Ouyang W, Tan T, Li J, Chen Z, Yang J, Wu H, Pan J, Hu C, Zou Y. Impact of 3D printing technology on the comprehension of surgical liver anatomy. Surg Endosc; 2019; 33: 411-417 [PMID: 29943060 DOI: 10.1007/s00464-018-6508-8]

10 Boedecker C, Huettl F, Saalfeld P, Paschold M, Kneist W, Baumgart J, Preim B, Hansen C, Lang H, Huber T. Using virtual 3D-models in surgical planning: workflow of an immersive virtual reality application in liver surgery. Langenbecks Arch Surg 2021; 406: 911-915 [PMID: 33710462 DOI: 10.1007/s00423-021-02127-7]

11 Pietrabissa A, Marconi S, Negrello E, Mauri V, Peri A, Pugliese L, Marone EM, Auricchio F. An overview on 3D printing for abdominal surgery. Surg Endosc 2020; 34: 1-13 [PMID: 31605218 DOI: 10.1007/s00464-019-07155-5]

12 Kenngott HG, Pfeiffer M, Preuskschas AA, Bettscheider L, Wise PA, Wagner M, Speidel S, Huber M, Nickel F, Mehrabi A, Müller-Stich BP. IMHOTEP: cross-professional evaluation of a three-dimensional virtual reality system for interactive surgical operation planning, tumor board discussion and immersive training for complex liver surgery in a head-mounted display. Surg Endosc 2022; 36: 126-134 [PMID: 33475848 DOI: 10.1007/s00464-020-08246-4]

13 Huettl F, Saalfeld P, Hansen C, Preim B, Poplawski A, Kneist W, Lang H, Huber T. Virtual reality and 3D printing improve preoperative visualization of 3D liver reconstructions-results from a preclinical comparison of presentation modalities and user's preference. Ann Transl Med 2021; 9: 1074 [PMID: 34422986 DOI: 10.21037/atm-21-512]
