

World Journal of *Gastrointestinal Surgery*

World J Gastrointest Surg 2022 July 27; 14(7): 632-730



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Monthly Volume 14 Number 7 July 27, 2022

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The primary aim of *World Journal of Gastrointestinal Surgery* (WJGS, *World J Gastrointest Surg*) is to provide scholars and readers from various fields of gastrointestinal surgery with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, etc.

INDEXING/ABSTRACTING

The WJGS is now abstracted and indexed in Science Citation Index Expanded (SCIE, also known as SciSearch®), Current Contents/Clinical Medicine, Journal Citation Reports/Science Edition, PubMed, PubMed Central, Reference Citation Analysis, China National Knowledge Infrastructure, China Science and Technology Journal Database, and Superstar Journals Database. The 2022 Edition of Journal Citation Reports® cites the 2021 impact factor (IF) for WJGS as 2.505; IF without journal self cites: 2.473; 5-year IF: 3.099; Journal Citation Indicator: 0.49; Ranking: 104 among 211 journals in surgery; Quartile category: Q2; Ranking: 81 among 93 journals in gastroenterology and hepatology; and Quartile category: Q4.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: Rui-Rui Wu; Production Department Director: Xiang Li; Editorial Office Director: Jia-Ru Fan.

NAME OF JOURNAL

World Journal of Gastrointestinal Surgery

ISSN

ISSN 1948-9366 (online)

LAUNCH DATE

November 30, 2009

FREQUENCY

Monthly

EDITORS-IN-CHIEF

Peter Schemmer

EDITORIAL BOARD MEMBERS

<https://www.wjgnet.com/1948-9366/editorialboard.htm>

PUBLICATION DATE

July 27, 2022

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INSTRUCTIONS TO AUTHORS

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PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>



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

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Specialty type: Gastroenterology and hepatology

Provenance and peer review: Invited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): 0
Grade C (Good): C, C, C
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: Dell'Amore A, Italy; Litvin A, Russia; Wang P, China

Received: January 17, 2022

Peer-review started: January 17, 2022

First decision: March 12, 2022

Revised: April 5, 2022

Accepted: June 23, 2022

Article in press: June 23, 2022

Published online: July 27, 2022



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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. 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 pre-operative 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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Core Tip: One of the applications of artificial intelligence in hepato-biliary and pancreatic surgery is to generate three-dimensional (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 virtual reality to gain expertise in the field of hepatobiliary and pancreatic surgery and share their experiences with their peers.

Citation: 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; 14(7): 723-726

URL: <https://www.wjgnet.com/1948-9366/full/v14/i7/723.htm>

DOI: <https://dx.doi.org/10.4240/wjgs.v14.i7.723>

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; $P \leq 0.05$). 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); $P \leq 0.05$], 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, 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[8-10]. 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 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

Author contributions: All authors contributed to the conception, writing, and review of the article and approved the submitted version.

Conflict-of-interest statement: All authors report no relevant conflicts of interest for this article.

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S-Editor: Ma YJ

L-Editor: A

P-Editor: Ma YJ

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