International Journal of Surgery Case Reports 120 (2024) 109886

Contents lists available at ScienceDirect

International Journal of Surgery Case Reports

journal homepage: www.elsevier.com/locate/ijscr

Case report

The impact of 3D reconstruction technology on liver surgery in changing the pathway of surgical maneuvers: A case report

C. Zanframundo *, E. Gjoni, A. Germini, S. Paleino, S. Granieri, C. Cotsoglou

ASST-Brianza, Vimercate Hospital, General Surgery Unit, Via Santi Cosma e Damiano 10, 20871 Vimercate, Italy

ARTICLE INFO

Keywords:
3D technology reconstruction
Liver surgery
Major hepatic surgery
Oncologic surgery
Case report

ABSTRACT

Introduction: This case report illustrates the significant role that 3D technology can play in major hepatic surgery, aiding in the determination of the optimal surgical approach.
Case presentation: We present the case of a patient with metachronous liver metastasis from rectal cancer involving segments 6 and 7, extending to retroperitoneal structures such as the inferior vena cava (IVC) and the right renal vein (RRV).
Discussion: After confirming the feasibility of a right hepatectomy, we opted for a traditional posterior approach, avoiding the hanging maneuver. The 3D rendering was instrumental in this decision, revealing that the mass was in close proximity to the IVC at the 11 o'clock position, a critical area for surgical instruments during the hanging maneuver.
Conclusion: When 2D imaging fails to provide sufficient information, 3D rendering can substantially aid the decision-making process.

1. Introduction

In major hepatic surgery, specific maneuvers can help reduce the risk of bleeding or biliary injuries. Notable techniques include the hanging maneuver, [1], super selective extrahepatic hilar clamping, navigating the six "Gates" based on the anatomical concept of the Laennec capsule [2], the hanging of the common hepatic trunk, and the passage behind the hepato-caval ligament of Makuuchi. Expertise in hepatobiliary (HPB) surgery is crucial for selecting the appropriate technique and determining the surgical approach. Currently, 3D technology is a valuable tool for studying liver anatomy, even for experienced HPB surgeons [3].

Surgeons develop their understanding of liver anatomy through dynamic mental reconstructions based on the three-dimensional reality of the operating theater. Although HPB radiologists are best suited to assess CT scans, the lack of three-dimensionality in 2D imaging can hinder communication between surgeons and radiologists. In this context, 3D imaging can bridge this gap. While scientific reports indicate that 3D rendering cannot replace standard 2D imaging [4], it can help define the most appropriate preoperative strategy. Recent studies have shown that 3D models significantly enhance the understanding of vascular liver anatomy, often leading to changes in surgical approaches [5]. At the ASST-Brianza, Vimercate Hospital, we routinely use 3D rendering for lesions near vital structures or in cases of complex vascular anatomy to better understand the lesion's location and relationship with surrounding structures. This case report demonstrates how 3D imaging aids in selecting the most appropriate technique for major liver resection.

This work complies with the SCARE criteria [6].

2. Case presentation

We present the case of a 65-year-old Caucasian woman with a history of hypertension and rectal adenocarcinoma (staging pT2N1b, grade 2), treated in November 2021 with anterior rectal resection and adjuvant therapy (eight courses of CAPOX). Eleven months later, an abdominal CT scan revealed metachronous metastasis in segments 6 and 7 with thrombosis of the second-order portal branch, in contact with the inferior cava vein (IVC) and right renal vein (RRV). A chest CT scan was negative for neoplasia. A biopsy confirmed the hepatic lesion's intestinal origin. After multidisciplinary team discussions, the patient underwent four courses of chemotherapy with FOLFOX, achieving partial response, and was deemed eligible for right hepatectomy.

Before liver resection, we assessed the risk of postoperative liver failure using the indocyanine green test (R15: 1.6, PDR: 27.7), hepatic

* Corresponding author.
E-mail address: zanframundoclaudia@gmail.com (C. Zanframundo).

https://doi.org/10.1016/j.ijscr.2024.109886
Received 29 January 2024; Received in revised form 3 June 2024; Accepted 4 June 2024
Available online 14 June 2024

shear wave elastography (mean stiffness 4.1 KPa, IQR 1.1), and calculated the future remnant liver volume (27.9 %) [7].

Given the lesion's size and location, we determined that a traditional posterior approach was the best surgical option. Potential RRV and retrohepatic IVC infiltration could hinder the hanging maneuver during right hepatectomy, increasing the risk of damaging the mass or vital vascular structures. The complex anatomical location and potential need for vascular reconstruction prompted us to use a 3D model to understand better the lesion's relationship with surrounding vascular structures. 3D imaging showed that the liver lesion was in close contact with the RRV and IVC at the 11 o'clock position. This critical insight led the lead surgeon to opt for a posterior approach, avoiding the hanging maneuver to prevent the risk of tangential injury to the IVC.

3. Surgical steps

The surgery was performed by two experienced HPB surgeons. First, the hepato-renal ligament was split to confirm the feasibility of separating the mass from the retroperitoneal structures. Once confirmed, the right coronary and triangular ligaments were dissected, isolating the right hepatic vein, and passing a tape posterior to the Makuuchi ligament. The right elements of the hepatic hilum were then isolated, and the right portal vein was clamped to demarcate the Cantlie-Rex line. Parenchymal transection began with the plow technique for the first 4 cm from the Glissonian capsule [8], followed by parenchymal dissection using an ultrasonic device (CUSA®), reaching the hilar plate. The right hepatic pedicle was then dissected, the right portal vein stump was sutured with a running 6/0 prolene suture, and the right hepatic artery and right biliary tract were clipped. The surgery was completed by transecting the hilar plate and the right hepatic vein using a mechanical stapler (EndoGIA®) with a vascular cartridge. To prevent twisting of the IVC and residual portal vein, the remnant liver was fixed to the falciform ligament. The operative time was 5 h and 39 min, with an estimated blood loss of 100 ml. Postoperatively, the patient developed an abdominal collection from a biliary fistula, treated with an endoscopic biliary stent and antibiotics (Clavien-Dindo classification: 3a [9]). The patient was discharged on the 15th postoperative day. Pathological analysis of the surgical specimen confirmed a gastrointestinal tumor with a low grade of dysplasia, diffuse necrosis, and no lymphovascular invasion. Resection margins were negative, 1 cm away from the tumor. The patient is currently under follow-up, with no evidence of disease.

4. Discussion

3D technology has potential applications in various surgical fields, particularly those involving complex vascular anatomy, such as pelvic and head and neck surgery [10,11].

In general surgery, HPB and pancreatic surgery benefit most from 3D technology due to the complex anatomy of these areas [12]. Although 3D reconstructions are not standardized and literature on this topic is still heterogeneous, this technique can be a valuable resource in the preoperative decision-making process [13].

In hepatic surgery, 3D imaging aids in precise lesion localization within the liver parenchyma and in studying vascular anatomical variations that can alter surgical planning [14].

In this case, to preserve as much liver parenchyma as possible [15], our initial plan was a right posterior sectionectomy. However, the presence of macrovascular involvement and thrombosis of the second-order portal branch for segments 6 and 7 led us to plan a right hepatectomy to achieve negative oncological margins. The 3D technology helped us decide to avoid the hanging maneuver due to the mass's proximity to the IVC at the 11 o'clock position, where surgical instruments would pass during this maneuver.

Our intraoperative findings were consistent with the 3D reconstruction, as reported in most literature cases [16].

Despite the large benefits, there are some limitations in using 3D technology, including significant costs. In our case, our institution covered the cost, contracting a bioengineering company to provide the rendering within two days. As the use of this technology becomes more routine, costs are expected to decrease, making it a standard part of preoperative assessment.

Given the liver's complex anatomy, 3D technology reconstruction should be considered for all challenging HPB surgeries, representing the latest tool to improve anatomical accuracy and make complex surgeries safer.

5. Conclusions

Clinical practice should be implemented by the routinely use of 3D imaging. One of the most important uses of 3D reconstruction in HPB surgery is to better understand the relationship between the lesions and the anatomical structures that need to be preserved. When 2D imaging cannot answer to surgeon's questions, 3D rendering can give a substantial contribution to decision-making process.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Ethical approval

The study is exempt from ethnical approval in our institution.

Funding

None.

Author contribution

Case report conception: Cotsoglou C.
Acquisition of data: Zanframundo C.
Literature search: Zanframundo C., Germini A., Paleino S.
Video editing: Cotsoglou C., Gjoni E, Granieri S.
All authors have participated to drafting the manuscript, all authors revised it critically, read and approved the final version of the manuscript.

Guarantor

Cotsoglou C.

Research registration number

None.

Conflict of interest statement

There are no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijscr.2024.109886.

References

[1] J. Coppa, D. CItterio, C. Cotsoglou, et al., Transhepatic anterior approach to the inferior vena cava in large retroperitoneal tumors resected en bloc with the right liver lobe, Surgery 154 (5) (Nov 2013) 1061–1068.

[2] A. Sujioka, Y. Kato, Tanahashi Yl, Systematic extrahepatic Glissonean pedicle isolation for anatomical liver resection based on Laennec's capsule: proposal of a novel comprehensive surgical anatomy of the liver, J. Hepatobiliary Pancreat. Sci. 24 (1) (Jan 2017) 17–23.
[3] C. Cotsoglou, S. Granieri, S. Bassetto, et al., Dynamic surgical anatomy using 3D reconstruction technology in complex hepato-biliary surgery with vascular involvement. Results from an international multicentric survey, HPB (Oxford) 26 (1) (Jan 2024) 83–90.
[4] C. Fang, J. An, A. Bruno, et al., Consensus recommendations of three-dimensional visualization for diagnosis and management of liver diseas, Hepatol. Int. 14 (4) (Jul 2020) 437–453.
[5] A. Ruzzenente, L. Alaimo, S. Conci, et al., Hyper accuracy three-dimensional (HA3DTM) technology for planning complex liver resections: a preliminary single center experience, Updates Surg. 75 (1) (Jan 2023) 105–114.
[6] C. Sohrabi, G. Mathew, N. Maria, et al., The SCARE 2023 guideline: updating consensus surgical CAse REport (SCARE) guidelines, Int. J. Surg. Lond. Engl. 109 (5) (2023) 1136.
[7] S. Granieri, G. Bracchetti, A. Kersik, et al., Preoperative indocyanine green (ICG) clearance test: can we really trust it to predict post hepatectomy liver failure? A systematic review of the literature and meta-analysis of diagnostic test accuracy, Pothodiagosis Photodyn. Ther. 40 (Dec 2022) 103170.
[8] C. Cotsoglou, F. Bruno, L. Lomaglio, et al., The plow technique: an alternative method for the transection of liver parenchyma, J. Italian Surg. Assoc. 42 (3) (Oct 2022) e09.
[9] D. Dindo, N. Demartines, P.A. Clavien, Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey, Ann. Surg. 240 (2) (Aug 2004) 205–213.
[10] C. Dong, I. Beglinger, A.H. Krieg, Personalized 3D-printed guide in malignant bone tumor resection and following reconsruction – 17 cases in pelvic and extremities, Surg. Oncol. 42 (jun 2022) 101733.
[11] Y. Su, F.M. Thieringer, R. Fernandes, et al., Editorial: virtual surgical planning and 3d printing in head and neck tumor resection and reconstruction, Front. Oncol. 12 (Aug 8 2022) 960545.
[12] A. Pietrabissa, S. Marconi, E. Negrello, et al., An overview on 3D printing for abdominal surgery, Surg. Endosc. 34 (1) (Jan 2020) 1–13.
[13] A.M. Bonomi, A. Kersik, G. Bracchetti, et al., 3D reconstruction in complex parenchymal sparing liver surgery, Helyon 9 (3) (Feb 21 2023) e13857.
[14] S. Wujiang, W. Kiangang, G. Jianjun, et al., Utilization of 3D printing technology in hepatopancreatobiliary surgery, J. Zejiang Univ. Sci. B. 25 (2) (Feb 15 2024) 123–134.
[15] D. Moris, S. Ronnekleiv-Kelly, A. Rahnemai-Azar, et al., Parenchymal-sparing versus anatomic liver resection for colorectal liver metastases: a systematic review, J. Gastrointest. Surg. 21 (6) (Jun 2017) 1076–1085.
[16] J.S. Witowsky, J. Coles-Black, T.Z. Zuzk, et al., 3D printing in liver surgery: a systemic review, Telemed. J. E Health 23 (12) (Dec 2017) 943–947.