Preoperative CT Segmentation With 3D Visualization to Predict Superior Mesenteric Vein Reconstruction During Pancreaticoduodenectomy

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Background

Pancreatic cancer is most often diagnosed in a locally advanced stage, where local vessel involvement is more probable. Experienced oncological surgical centers are capable of performing radical local resection with vessel reconstruction; however, this is often an intraoperative decision. Advances in 3D visualization techniques of CT imagery can serve as a crucial preoperative decision-making criterion to identify possible regions of vascular involvement, feasibility of resection, and the extent of potential vessel reconstruction. This is particularly useful given that vascular invasion necessitating reconstruction is itself a negative prognosticator for long term outcomes. Being prepared by seeing the extent of invasion may avoid an operation, instead opting for alternatives such as neoadjuvant chemotherapy

Methods

Computer tomography (CT) dicom files were processed in a medical image analysis and visualization software, 3D Slicer to segment key structures. Anatomical landmarks including the pancreas, superior mesenteric vein (SMV), splenic vein (SV), portal vein (PV), abdominal aorta, and celiac trunk along with its branches were isolated and converted into a 3D mask using a combination of region-based segmentation to define organs and blood vessels and volume rendering. The output of these algorithms (Fig.1) is a surface matrix, or model, that identifies an object or instance to which each pixel belongs using input tags, or seeds. 3D holographic visualization of this model as an interactive, mixed reality object was performed using the Microsoft HoloLens and ApoQlar's VSI HoloMedicine app

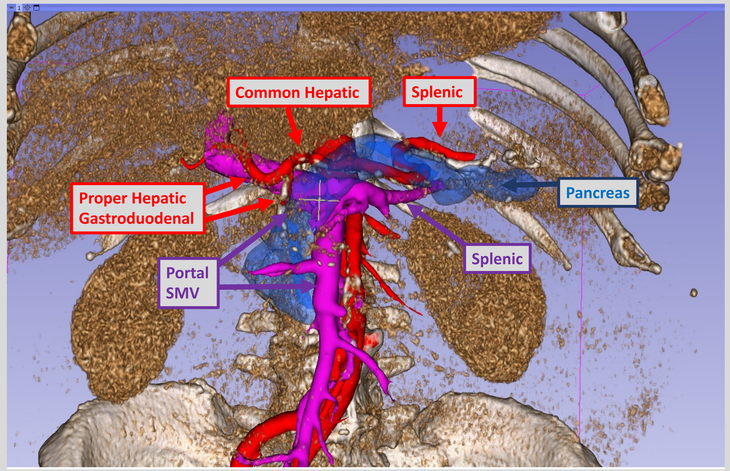


Figure 1. Output of volume rendering and segmentation algorithms showing vascular and anatomic landmarks. Arterial structures in red, venous structures in purple, pancreatic tissue in blue.

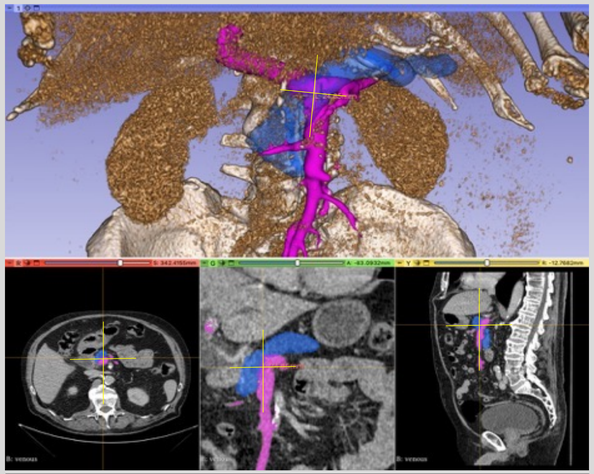


Figure 2. Output identifying a 2.5cm region of potential overlap between Portal, Splenic, and Superior Mesenteric veins requiring intraoperative reconstruction (yellow) crosshairs

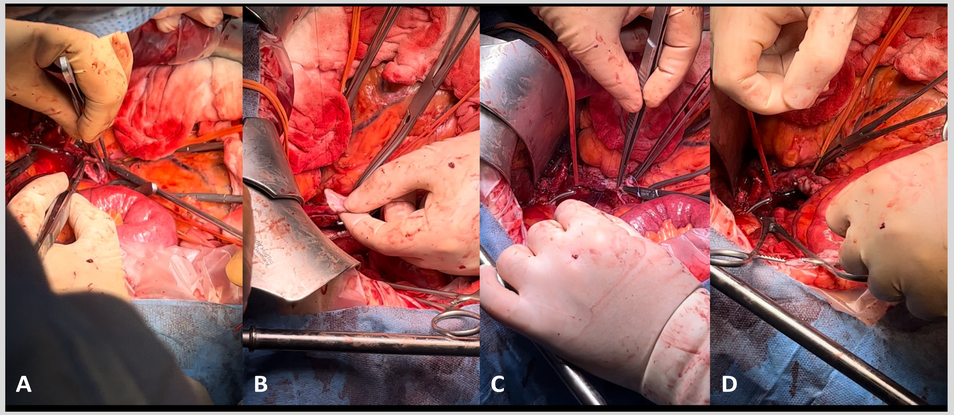


Figure 3. Intraoperative photos showing: (A) lumen of SMV/SV junction after pancreatic head resection corresponding to 2.5cm anticipated defect; (B) blood vessel patch; (C) positioning blood vessel patch over defect; (D) suturing the patch to repair the defect.



Figure 4. Successful vessel wall reconstruction upon revascularization

Case Description

A 74-year-old male with cancer involving the head of the pancreas was scheduled for a pancreaticoduodenectomy. Upon review of the organ segmentation model, a region at the SMV/PV junction measuring approximately 2.5cm was identified as likely requiring intraoperative reconstruction to avert changing the procedure into a prophylactic bypass anastomosis (Fig.2). This was confirmed intraoperatively (Fig. 3), where a patch was successfully applied following vessel dissection and pancreatic head resection (Fig.4). The planned pancreaticoduodenectomy was successfully completed and the patient was discharged on post-operative day 11 following an uncomplicated inpatient stay. Postoperative CT with contrast did not indicate any leakage

Conclusion

Organ and vessel segmentation with subsequent 3D visualization can improve preoperative planning, reduce the incidence of unforeseen intraoperative decision making, and improve clinical outcomes.

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