Intraoperative Mixed Reality Visualization During Robotic Resection of a Hepatic Lesion and its Influence on Patient Experience

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Background

Medical imaging forms the foundation for the decision to operate and is critical to establish how radical a given procedure may be. However, the challenge, especially for younger specialists, remains in interpreting the 2-dimensional greyscale image to form sound clinical judgments. 3-dimensional visualization improves this process by reducing the mental effort required to track structures across slices and adequately view the exact spatial relationship between relevant anatomy. This technology may also improve patient experience by providing a means to better understand a given procedure, and why it is necessary. The Microsoft HoloLens provides a useful intraoperative resource, especially in cases of challenging anatomy because it enables visualization of medical data without blocking the operator's view or compromising the sterile field

Methods

MRI dicom files were processed using 3D Slicer, a medical image analysis and visualization software. Segmentation of key anatomy, i.e., liver, liver mass, portal and hepatic veins, arteries, and gall bladder, were performed and validated by a radiologist. The segmentation model was visualized in mixed reality using the Microsoft HoloLens2. The patient's preoperative anxiety was assessed using the validated Surgical Anxiety Questionnaire before and after the patient was shown the model, with differences, if any, being compared. Intraoperatively the hologram was used to precisely position the patient and the Asensus Senhance surgical robot arms for optimal access. Resection was performed utilizing the Senhance robot in a modified laparoscopic approach.

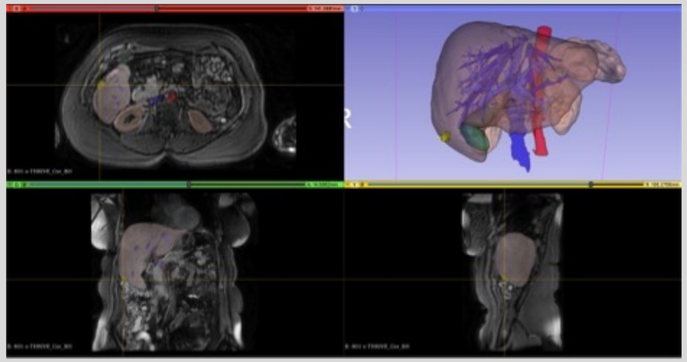


Figure 1. Segmentation of pre-operative MRI scan using 3D Slicer to visualize hepatic lesion (yellow crosshair), hepatic veins along with inferior vena cava (dark blue), portal vein (light blue), liver (brown, translucent), and kidney along with spleen (light brown, solid).

	QUESTION	BEFORE	AFTER	CHANGE
1	I am worried about the anesthesia	4	4	-
2	The anesthesia is constantly on my mind	2	2	-
3	I would like to know as much as possible about the anesthesia	4	4	-
4	**I am worried about the procedure**	5	3	-2
5	The procedure is constantly on my mind	5	5	-
6	**I would like to know as much as possible about the procedure**	4	5	1
7	**I do not understand my condition**	5	3	-2
8	**I feel anxious when thinking about my condition**	5	3	-2
9	**I find it difficult to relate with my condition**	4	2	-2
10	**I am worried about my operation**	5	3	-2
11	**I am worried about possible complications during my operation**	5	4	-1
12	**I understand the radiology scans I was told or shown**	2	5	3
13	**I find my radiology scans relatable**	2	4	2
14	This visualization helped me understand my condition and care plan		5	
15	This visualization made me feel more informed about my condition		5	
16	This visualization made me feel calm		5	
17	This visualization made me feel more engaged with my care plan		5	

Table 1. Patient's questionnaire completed before and after viewing AR visualization using the HoloLens. Change column compares after and before viewing the holographic segmentation model. Items 14-17 were asked only after.



Figure 2. Unobstructed field of view while wearing the HoloLens. Yellow holographic object corresponds to extracapsular extension of the liver mass. (A) Livestream view of HoloLens wearer onto local laptop. (B) Livestream view from the HoloLens wearer with operator examining the hologram preoperatively. (C) HoloLens wearer view intraoperatively outside the surgical field, yellow color denoting FNH, compared to intraoperative view. (D) Surgical robot operator with HoloLens stream. (E) Comparing yellow FNH of holographic segmentation model to real view on robotic surgical monitor.

Case Description

A 52-year-old female presented for the robotic resection of a 2cm capsular/subcapsular focal lesion in the region of liver segments 5 and 6, following several months of abdominal discomfort and postprandial bloating. Preoperative magnetic resonance imaging (MRI) described an ambiguous subcapsular mass with a slight extension beyond the capsule. This was confirmed intraoperatively using both the robotic monitor and the holographic model generated from the MRI visualized on the Microsoft HoloLens. The decision was made to perform a local resection of the lesion with a wide margin using a robotic surgical system aided by intraoperative holographic visualization of a structural segmentation. Preoperative stress levels decreased and desire to learn more about the operation along with general understanding of the medical images increased after being shown the holographic model. The operation was completed as planned and the patient was discharged on post-operative day 4 after an uneventful recovery period.

Conclusion

Augmented Reality visualization of radiological scan segmentations using the HoloLens shows excellent promise in the field of surgery. A surgeon can quickly and easily review a segmentation for surgical planning and later actively use it as an intraoperative reference without leaving the sterile field. A patient may also benefit from decreased anxiety and gain a new understanding of the planned operation

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