

Augmented Reality in a Tumor Resection Model

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Background

The objectives of our study were to evaluate an Augmented Reality system, by surgical resection of a new model of laparoscopic experimental tumors.

Methods

We did a prospective, experimental study on ex vivo porcine kidneys. Alginate was injected ex vivo into the parenchyma (2 to 3 pseudotumors, depending on the kidney size). Alginate easily allowed us to create 4-10mm pseudotumors. The kidneys were then imaged by MRI (T1-weighted) in three planes (axial, sagittal and coronal). We improved the MRI settings to have a 0.4mm resolution, and pseudotumors were easily identified. Augmented Reality (AR) is a technology that allows a surgeon to see sub-surface structures in an endoscopic video. In our technique, three phases are necessary: Phase 1: segmentation phase: using the MRI images, the kidneys and pseudotumors' surface are delimited to construct a 3D mesh model. Phase 2: the intra-operative shape on the kidney is determined. Phase 3: fusion phase: pre-operative and intra-operative models are fused with the laparoscopic view. This blending gives the impression that the kidney is semi-transparent and the surgeon can see the exact location of the tumor inside it. On this 2D images, to improve the depth localization of the tumor the AR software allows one to display in real-time the kidneys' surface meshes in addition to inner tumor meshes. Our software also allows one to display the resection margins defined preoperatively by the surgeon (5mm margins in our model). The kidneys were put into pelvitrainers, and renal pseudotumors were resected laparoscopically. The excised tumors were extracted, and transferred to the laboratory until further analysis. Then resection margins were measured microscopically to evaluate the accuracy of the resection.

Results

In total, we segmented 90 tumors. 30 were used to test the AR software and improve the visualization, and the 60 others were surgically resected. 30 tumors were resected using AR, and 30 without AR. On the MRI images the mean kidneys' size was 74.4mm +/- 5.1, and the mean tumors size was 8.18mm +/- 2.6. Our preliminary results of pathological analysis showed 4% of positive margins in the AR group, and 12% without using AR.

Conclusions

Our AR system facilitates the accurate localization of very small inner tumors. AR in laparosurgery thus seems to enhance the accuracy of surgical resection, even for really small tumors. Crucial information (such as resection margins and vascularization) can be displayed. Therefore, our system could be use in various laparoscopic surgical procedures.