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TITLE
Anatomic Modeling and Visualization of the Kidney and its Associated Major Vessels in Patients with Kidney Cancer

HYPOTHESIS:
Our long-term hypothesis is that improved three-dimensional (3D) visualization of tumor margins and surrounding vital structures adjacent to the tumor within the kidney will allow for safer surgery, less blood loss and reduced complications during robot-assisted laparoscopic partial nephrectomy (RALPN) for kidney tumors.

BACKGROUND/AIMS:
Kidney cancer is the third most commonly occurring genitourinary cancer in adults, with about 273,000 new cases each year worldwide. Of these cases, about 90% are renal cell carcinoma (RCC). Kidney cancer patients who have tumors confined to the kidney are typically treated with surgery (about 30% of RCC patients each year), often with the use of RALPN. This state of the art surgical technique is a minimally invasive approach which employs the daVinci surgical system to remove only the tumor while attempting to preserve the remaining healthy portions of the kidney. RALPN is challenging because of the complex 3D juxtaposition of the critical anatomy within the kidney including abundant blood vessels and the urinary collecting system. Inadvertent injury to these structures can lead to excessive bleeding and transfusion as well as leakage of urine made by the kidney into the abdominal cavity. This may occur as the surgeon is unable to anticipate these structures as the tumor is being excised surgically due to the lack of a 3D road map of the anatomy within the kidney. Between 8 to 10% of laparoscopic procedures result in complication, and our work aims to develop software to reconstruct the 3D anatomy of the kidney, tumor(s) and major vessels and then to effectively present this information to the surgeon in the operating environment.

METHODS:
We obtained CT and MRI image data sets from patients who underwent RALPN for small kidney masses by a single urologic surgeon at UF. We developed software to segment and reconstruct 3D models of the major vessels and urinary collecting system from the patients’ medical images. We developed tools to perform semi-automated segmentation and 3D modeling of the surface of the affected kidney and tumor(s). From these mathematical models, we can generate stereolithography (STL) files for each anatomical structure. These STL files have been imported into a computer-aided design (CAD) program for visualization and manipulation of all critical anatomical parts simultaneously, and have been sent to a 3D printer to generate patient-specific physical models.

RESULTS & CONCLUSIONS
We have developed semi-automated software tools to generate virtual and physical 3D anatomical models of the kidney, tumor, and surrounding arteries, veins, ureters and collecting ducts from conventional 2D MRI and/or CT scans. These models can be exported to commercial CAD software for integration and display of relative proximity of the kidney tumor to vital kidney structures. These tools have been demonstrated on 11 data sets from patients treated with robot-assisted laparoscopic partial nephrectomy at UF. We have also generated 3D printed models for one of our patient data sets. Our ultimate goal is to use these 3D models to aid in planning and performing RALPN with the benefit of reduced procedure time and reduction in complications. Our immediate goals are to streamline the software for routine use, and to have the visualization results evaluated by surgeons in the operating room.