Image-guided laparoscopic cryoablation

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Illustrated workflows in hybrid operating rooms, No. 11
The university hospital of Heidelberg is one of the largest medical centers in Germany. It was founded in 1386. Today it is a fully equipped, maximum care hospital with approximately 2,000 beds and more than 12,000 employees. The hospital is especially renowned for the treatment of cancer. The department of urology has 45 beds and specializes in uro-oncology.

Since 2010 Dr. Dogu Teber is responsible for minimally invasive therapy at the department of urology. He was the first surgeon to use the Artis zeego robotic imaging system for laparoscopic ablation and believes that high-precision imaging in the OR takes urologic surgery to another level.
Clinical Case

The 73-year-old male presented with a tumor in the dorsal midpole of the left kidney suspicious for papillary renal cell carcinoma. The diagnosis was confirmed by intraoperative biopsy and histology as papillary renal cell carcinoma type 2.

In addition, the patient has a history of nephrectomy of the right kidney. Therefore, it was very important to spare as much healthy kidney tissue as possible during the tumor treatment to avoid dialysis. Thus laparoscopic mobilization of the kidney with biopsy and image-guided cryoablation was chosen.
A hybrid operating room combines a traditional OR with a fixed angiographic system enabling high-end imaging during urological procedures. The size of the hybrid operating room is about 50 m² (538 ft²). The room accommodates a control workstation, three ceiling supply units (for anesthesia, perfusion, and endoscopy), two monitor booms mounted next to one of the laminar airflow fields, the C-arm, and the operating table. Two laminar airflow fields are installed based on site-specific requirements.

During the image-guided laparoscopic tumor ablation procedure, the patient is laid left side decubitus on the table with feet pointing toward the Artis zeego. Anesthesia is placed close to the patient’s head on the left.
Instrumententisch-Vorbereitung

Edelstahlbügel als "Abstandshalter"
OK ca. 250 mm ü.FFB

Überwachung
Edelstahlbügel als "Abstandshalter"

HYBRID OP
49,76 m²
Patient positioning

One of the challenges in a hybrid operating room environment is patient positioning. It is important to ensure that C-arm rotation is unobstructed by anesthesia equipment and does not collide with the patient. In kidney surgery the patient is always positioned feet first to allow optimal access by Artis zeego to the patient. The patient’s arms are cushioned with towels.

The C-arm is rotated around the patient before the start of surgery to confirm the position of the patient and to ensure no collision with any surgery equipment. The Artis zeego and the table are fully integrated and coordinated to avoid collisions.

After the patient is in the final position, the patient, the Artis zeego, and the entire table are covered in sterile drapes and surgery begins.

The procedure starts with the placement of ports and the insufflation of CO$_2$ in the abdomen. The CO$_2$ insufflation creates more intraabdominal space for the surgeon to mobilize the kidney and prepare the organ for insertion of ablation needles.
The first step in performing the ablation procedure is pre-operative planning. The planning takes place on a syngo X Workplace based on the preoperative CT dataset. During this step the ideal position and insertion angle of the needles are defined. This provides necessary information to determine how many needles are needed to cover the whole tumor.

The tumor size is 3.8 x 3.5 x 3.1 cm. The needles used in this case for the cryoablation procedure were Galil Medical IceSeed® 1.5. Each needle creates an elliptic ice ball shape with a major axis of 20 mm and minor axis of 11 mm at the temperature of -40° C.

On the image on page 11 the position of one of four needles is shown in projection views. All four needles are shown in the 3D view.
3D acquisition with syngo DynaCT

A syngo DynaCT acquisition is performed in order to obtain the intraoperative location of the kidney. This information is needed in order to display the location of the tumor correctly during the procedure.

During the syngo DynaCT run, ventilation was stopped to avoid respiratory motion artifacts. To avoid radiation for the surgical team the surgeon and all staff stepped out of the hybrid OR. Outside of the room, the Low-dose syngo DynaCT acquisition was started simply by pressing the wireless foot pedal. After this the surgeon and the staff returned to the room. No contrast media injection was used during the acquisition.
Fusion with pre-operative data

After 3D acquisition with syngo DynaCT, the 3D data is automatically transferred to the syngo X Workplace post-processing workstation. Using a filtered backprojection algorithm the projection images are reconstructed into CT-like cross-sectional images with isotropic voxel resolution.

The resulting syngo DynaCT dataset is fused with the preoperative CT dataset based on the manually segmented kidney using a 3D/3D registration algorithm. The 3D/3D fusion is performed semi-automatically using dedicated fusion software on the post-processing workstation.

Prior to the procedure on the preoperative CT dataset, the tumor and the kidney had been manually segmented in 3D and extracted using a polyline marking. syngo 3D/3D Fusion enables the system to position the 3D tumor model in the coordinates of the patient on the table. This allows use of the 3D tumor model for overlay on 2D fluoroscopy in the subsequent steps.
Fusion of CT imaging and syngo DynaCT
2D/3D overlay to visualize the tumor and intraoperatively inserted ablation needles

Once 3D/3D fusion is completed the surgeon can start with needle placement, which is performed under laparoscopic ultrasound guidance. During this procedure it is important to know where needles are positioned in the tumor. Artis zeego shows intraoperatively the location of the tumor and ablation needles using 2D/3D overlay. This is the overlay of the 3D/3D fused image on the live fluoroscopy. The overlay allows to see both the tumor and the needles intraoperatively in real time from different sides.

For needle placement the ultrasound guidance was chosen to speed up intraoperative needle placement. An alternative approach is to use syngo Needle Guidance.
Verification of the exact needle positions with *syngo* DynaCT

*syngo* DynaCT and semi-automatic fusion with preoperative datasets performed after needles are finally placed allows verifying needle position relative to the tumor without inaccuracies caused by respiratory motion. During the Low-dose *syngo* DynaCT run, ventilation was stopped to avoid respiratory motion artifacts. Similar to the steps performed on pages 14-15, *syngo* DynaCT is fused with the preoperative CT dataset based on the manually segmented kidney using the 3D/3D registration algorithm. The surgeon has an opportunity to fine-tune the position of the needles.

Dr. Dogu Teber comments on the advantages of *syngo* DynaCT over laparoscopic ultrasound: “One of the main advantages of a DynaCT is that we can really define not only the tumor but also the risk structures in the preparation to the tumor. Ultrasound has only the opportunity to define dissection zones after you have prepared the tumor. So the DynaCT allows a navigation towards the tumor and the exact measurement of the tumor.”
Cryoablation procedure

After the needle position is finalized the cryoablation procedure starts with a double freeze-and-thaw cycle, which is needed to produce a larger area of ablation with a sufficient margin. Renal cryoablation via laparoscopic access achieved complete tissue ablation without complications. The procedure was uneventful.

For Dr. Dogu Teber cryoablation has advantages over surgical tumor resection resulting in shorter hospital stay, faster patient recovery, more nephron protection, less anesthesia, and less bleeding.
Configuration of the hybrid operating room

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- Artis zeego with Automap functionality
- Artis OR table with wide tabletop
- syngo X Workplace
- syngo DynaCT
- syngo Fusion Package
- syngo 3D Roadmap
- Wireless footswitch
- Three ceiling supply units (for anesthesia, perfusion, and endoscopy)
- Karl Storz OR1™ integrated operating theater
- Two laminar airflow fields
- Radiation protection
- 30 x 40 detector with laser cross light
- Two monitor booms
The Benefits

- High-end 3D imaging improves needle placement accuracy
- Floor-mounted Artis zeego meets all hygiene requirements in the OR
- Pre-operative planning of needle positions
- 2D/3D overlay supports real-time needle guidance
- Precise visualization of the tumor and ablation needles without respiratory motion artifacts

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