Application of emerging technologies to urologic oncology

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CHAPTER 12

FUTURE DIRECTIONS

Improvements in imaging and device engineering have led to the rapid development of advanced, minimally invasive techniques in urologic care. While imaging advances have had a major effect in the areas of diagnosis, computer-assisted surgical planning and robotics had an impact in urology and are likely to provide additional opportunities to urologists in the years to come.

The future of surgery is heading towards more minimally invasive techniques such as single-port and NOTES procedures or non invasive focal treatment using probe ablation technologies.

The need of new technologies will always be needed to overcome limited instrumentation and visualization. In the case of single-port, handheld motorized instruments that overcome limited articulation are under development (Figure 1).

However, a robotic platform such as the da Vinci of the Hansen platform (Figure 2) adapted to single-port or NOTES is awaited.

Image-guided therapy is thought to improve patient care and minimize treatment related morbidity. However, to increase surgical precision and decrease morbidity, more sophisticated imaging and tracking technologies are needed for a better spatial understanding of the targeted anatomy. For instance, we recently showed that accuracy of needle placement during kidney cryoablation fundamental for a successful treatment was enhanced when magnetic (Figure 3) or optical trackers are used.
However, the addition of Robotics, have the potential to improve the precision, accuracy, and reliability of performance in image-guidance interventions by fully digitalizing the procedure, from image to instrument manipulation.

Robots for interventions with needles or other slender probes or instruments can be connected to an imaging modality (CT, MRI, ultrasound, fluoroscopy, etc). Targets and paths are defined in the image on the basis of planning algorithms, and the robot aligns and may insert the needle accordingly. The true potential of needle delivery mechanisms relies on their ability to operate with, be guided by, and use feedback from medical imaging equipment.

Moreover, robots can do complex movements, impossible for humans to perform such as spinning needle to limit tissue and needle deformations during the insertion.

In prostate cancer, targeting and tracking prostate biopsy will be the challenge in the direction of focal therapy of prostate cancer. For instance, a patient with high PSA will undergo DCE-MRI or other imaging modalities, the tumor will be automatically localized on the image view using specialized algorithm. A robotic system using TRUS to track the prostate will get the coordinates of the tumor and set into position and perform the biopsy. If the biopsy is positive, the robotic system will automatically get to the right coordinates for a probe, seeds or nanoshells injection.

The role of the Urologist will be to monitor and confirm the procedure similar to a pilot in his cockpit that made aviation the safest transportation modality. It is very important for the urologist to continue to embrace technological improvements while responsibly and carefully evaluating the benefits for the patient.
Figure 4: A- RVS® system workstation with split screen display. B- Magnetic field generator. C- The magnetic sensor fastened to a sector ultrasound probe D- Cryoprobe

Figure 5: CT-Nav® (Koelis, France) is a stereotactic surgical navigation system used routinely in neurosurgery and orthopedic for surgical navigation that has been adapted for percutaneous urological applications. The system compromises of a tracking sensor, a targeting handle, a stereoscopic infrared camera, and a personal computer. Using a point/area matching and registration protocol, the tracking sensor pre-placed on the patient before the CT scan is automatically recognized in the 3D CT volume data. The infrared camera detects the tracking sensor and localize it three-dimensionally.

Figure 6: The tracking sensor is then used as a reference point. Any movement of the patient is detected by the movement of the tracking sensor allowing the system to readjust the CT volume coordinates in real-time. The targeting handle is also detected and its position is correlated to the tracking sensor, thus allowing the CT-Nav to reconstruct a cross-section CT slice corresponding to the position and angle of the targeting handle. The tracking handle is then used to navigate and guide the needle percutaneously to the targeted tumor.
**Figure 7**: The optimal trajectory is subsequently saved by the CT-Nav® system.

**Figure 8**: Robotic TRUS for targeted biopsies and Focal Therapy

1—Targeted Biopsy

2—Systematic Biopsy for Prostate Cancer Mapping

3—Prostate Cancer Mapping

Focal