

Real-time MR-guided Endourological Upper Urinary Tract Interventions: Feasibility Study

Introduction and Objective: Assessment and implementation of a model for performing endourological diagnostic and interventional procedures using real-time MR pulse sequence tracking and visualisation of an active catheter. The majority of diagnostic or therapeutic endourological procedures in the upper urinary tract (eg. retrograde uretero-pyelography, ureteral stenting) are performed under x-ray guidance. The x-ray fluoroscopy produces instantly (real-time) available positioning information, anatomical information (complete ureter and kidney pelvis) and has good native definition in stone disease. The non-x-ray guided interventions suffer from poor anatomical visualisation or positional information (ultrasound) or from not having a fast enough image acquisition for instant corrections as well as very poor stone detection rates (classical MRI).

Materials and Methods: By using the latest advances in magnetic resonance (MR)-guided endovascular interventions we set out to devise an animal model for solely MR-guided procedures. We used an in-house developed catheter with tip-mounted small radio-frequency coils to rapidly determine the device position (active tracking) in combination with a dedicated real-time pulse sequence with various on-the-fly user selectable MR imaging contrasts. The user interface is able to deliver a real-time visualisation in any projection plane and perform automatic slice selection and orientation. Four healthy domestic female pigs (60kg) under general anesthesia were used, in which cystoscopy offered access to the upper urinary tract. Using in-house developed 5Fr active tracking catheters in clinical 1.5T whole-body MR-system (Siemens Magnetom Symphony) with real-time image display we performed 3D MR-contrast studies of the ureter/renal pelvis, controlled ureteric stent placements up to 12Fr, insertion of 6mm sized calculi with subsequent contrast studies.

Results: At a reaction time of 24msec and a frame rate of three images per second (pulsed fluoroscopy equivalent), the movement of the active catheter could be monitored real-time. With interactive auto-orientation changes, the urinary tract could be accessed by a fully MR-guided x-ray free catheterization in less than 15 minutes.

Conclusions: The MR-guided real time access to the upper urinary tract using active catheters and optimized pulse sequences allowing endourological procedures within the MR-scanner room will challenge the classic fluoroscopy-based approach. With the advent of modern bulk-less MR-scanners and non-magnetic instruments, even MR-guided endoscopic stone therapy lies just around the corner.