iPad-Assisted Percutaneous Access to the Kidney: Initial Experience

Introduction and Objective: Percutaneous access to the kidney is the most important factor to minimize complications and maximize success of percutaneous nephrolithotomy (PCNL). Based on previous experience with marker-based tracking (inside-out), we created a new system for augmented reality navigation using an iPad during percutaneous puncture, of the kidney based on computer tomography (ct).
Materials and Methods: One day before surgery, the patient underwent a thin sliced CT in prone position (similar to PCNL) with coloured radiodense spherical markers fixed around the percutaneous access area. The CT-data are segmented to visualize all important anatomical structures (i.e. ribs, collecting system, stones, renal parenchyma, colon, spleen, liver) in 3D. Before surgery, the markers are re-attached exactly on the skin of the patient in prone position. During the intervention, an iPad is used as a camera to locate the markers and simultaneously as display device to show the enhanced virtual reality of patient's situs. The backfacing camera of the iPad captures images of the access side, compresses and transmits them via WiFi to a server located a room nearby. The server in turn runs the algorithms to analyze the position of the markers and to compute a correct registration of video image and CT. Finally, the server creates the augmented reality enhanced image and sends it back to the iPad. This creates a virtual insight into the patient. During percutaneous puncturing of the kidney, the augmented reality visualization enables the surgeon to adjust puncture site and angle of the needle on to the virtual calix. Digital fluoroscopy was only used to ensure the correct puncture.
Results: We used the novel navigation system in patients (n=10) with complicated nephrolithiasis. The segmented imaging enabled us to select the optimal puncture site and angle without any use of ultrasound and fluoroscopy. Particularly the knowledge of the location of adjacent organs was helpful. This resulted in a one step direct puncturing of the collecting system. Moreover, the augmented reality overlay provided additional information (i.e. stone localization) during endoscopic stone manipulation reducing the need of fluoroscopy.
Conclusion: The use of marker-based tracking proved to be easy and safe to handle. The use of the iPad was advantageous providing good image quality of the virtual reality and space enough for the surgeon to perform the puncture. It may obviate the use of ultrasound for the percuatneous access and reduces the need of fluoroscopy. Future work will focus on the tracking of the needle and the use of stereoscopic tablets.