Get the Needle and Ultrasound Out of the Rectum in Prostate Interventions

Amel Amalou1, Sheng Xu1, R Seltabadi2, N Varble3, M Li4, Baris Turkbey1,2, M Merino1,2, P Choyke1, S Mehraliyan3, Victoria Anderson1, Brad Wood1,2

1Center for Interventional Oncology, Radiology and Imaging Sciences, Clinical Center, 2NCI, NIH, Bethesda MD 20892.

Objectives:

• To develop tools and techniques to optimize ultrasound (US) and registration for use in transperineal (TP) fusion-guided prostate biopsy and ablation, where both needle and ultrasound transducer are outside of the rectum, thus potentially avoiding the infection risk associated with trans-rectal approaches.

Materials and Methods:

Multiple transducers were used for TP US (Philips EPIQ / IU-22), including end fire, curved array, 3D Matrix, & curved array low profile with built-in integrated EM sensor (mCT-2). 3D registration from 2D sweeps were performed. TP biopsies were obtained with freehand & guided navigation to fusion targets. The workflow was simulated in phantoms followed by 10 patients. Indications for TP biopsy / TP US included prior sepsis from TRUS biopsy and absent rectum. An augmented reality (AR) TP system was also developed and studied in phantoms.

Results:

A custom fusion system was deployed and used to build a 3D model from a 2D TP “sweep”, using both custom and standard software and hardware. Multiple US transducers were studied for subjective image quality via a TP window. Standard US interfaced with a custom navigation system and mCT-2 probe was interfaced with a commercial fusion system (PercuNav, Philips). MRI was imported and rotated into place via a manual registration. Phantom studies demonstrated the feasibility of TP US and fusion for prostate biopsy, with the main challenge being matching rotational anatomy in the sagittal plane, as well as left-right orientation. Biopsy results for the initial 10 patients showed similar prostate cancer diagnosis compared to TRUS fusion. In certain cases, clinically valuable information was added or missed. An augmented reality TP biopsy system was also developed (with gyroscopes & cameras), to display internal MRI anatomy on a smartphone, goggles, & on skin surface, to help guide a TP needle.

Conclusions:

Prostate biopsy can be successfully performed with both TP needle and TP ultrasound, which may reduce infectious complications and also be better tolerated. TP approaches (such as TP EM fusion or TP augmented reality) may thus potentially enhance compliance & may provide new options totally outside the rectum.

Transperineal Ultrasound registered to prior triplanar MRI after a 2D EM-tracked sweep

Transperineal Ultrasound MRI Fusion guided transperineal needle placed into MRI-defined target

Background:

• 174,659 new cases of prostate cancer (PCa) in 2019 in USA, responsible for 20.0% of all male cancer and 31,620 deaths
• 1.5 million prostate biopsies performed in US annually
• Traditional prostate biopsies are performed under transrectal ultrasound (TRUS) guidance
• Infectious complications are common after transrectal prostate biopsies (TRBs) occurring in up to 5% of patients despite antibiotic prophylaxis
• Need to reduce infection rates, hospital admissions, and antimicrobial resistance
• Transperineal biopsy has super low infection rates (0.3% in 1 report)
• Patients without rectums require alternate approaches and guidance methods
• Standard “transperineal biopsy” is still guided and monitored by an ultrasound in the rectum
• Getting the needle and the ultrasound both out of the rectum, while maintaining fusion guidance is of high value
• Using standard tools and EM trackers for TP ultrasound tracking results in inaccuracies, due to the 2D to 3D sweep process, which assumes a straight rectal wall and an TRUS orientation
• Thus, new hardware and software are desired for a completely and truly “outside of the rectum” approach

Key Points:

• Getting the needles and the ultrasound out of the rectum is less invasive, less risky for infections, and potentially more comfortable or palatable to the patient, which may increase compliance
• Novel approaches in terms of software and hardware are required, since “off-the-shelf” use of TRUS fusion devices will result in errors
• A custom approach was translated to clinical use, and should encourage similar commercial solutions

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