Introduction: Diffusion weighted imaging (DWI) has been widely used in clinical setting for detecting cancer-related diseases. Single-shot EPI diffusion weighted imaging (EPI-DWI) is a traditional method as a predictive biomarker for assessment of disease aggressiveness\(^3\). However, this technique is burdened by severe distortion as well as low resolution and SNR which hamper accurate diagnosis, for example, for cancer detection in the prostate and urinary bladder wall\(^5\). The interleaved variable density spiral diffusion weighted imaging (VDS-DWI)\(^5\) is a desirable technique with high spatial resolution, reasonable SNR and imaging speed.

Purpose: The purpose of this study is to investigate if VDS-DWI method has the potential application for tumor detection in the prostate and urinary bladder wall.

Methods: A VDS-DWI sequence\(^4\) was implemented on a Philips 3T clinical scanner (Philips, Best, the Netherlands) equipped with a high performance gradient set (60mT/m per gradient axis, slew rate 200mT/m/ms). Pelvic images including the prostate and urinary bladder were acquired from one healthy volunteer and one patient with prostatic hyperplasia (PH) using a 32-channel SENSE Torso/Cardiac coil. These subjects underwent both conventional single-shot EPI-DWI and high resolution VDS-DWI in addition to the traditional standard T2-weighted imaging. Two diffusion imaging sequences were prescribed based on the transverse T2-weighted images to ensure the same structure information among three sequences. They were acquired with different b values: 0, 500, 800 and 800, 1000s/mm\(^2\). For comparison, the EPI-DWI protocols had an in-plane resolution of 2mm and a repetition time of 2000ms and shared the same in-plane FOV of 345\times345mm with VDS-DWI and T2-w images. Other imaging parameters includes TE=68ms, SENSE factor=2,5 and half scan factor=0.698. The VDS-DWI protocols had an higher in-plane resolution of 1.5-1.8mm, a repetition time of 1500-2000ms, 16 interleaves, readout duration for each interleave about 10-12.4ms, one diffusion gradient along the phase encoding direction, \(\alpha=4\) (controlling the sampling density\(^3\)), NSA=6. Two resting slabs were applied to suppress vessel signals which might bring artifacts. Total scan time was about 4-6 minutes. Regions including both the urinary bladder and the entire peripheral zone (PZ) and central gland (CG) of prostate were selected. All subjects provided informed written consent.

Results: Fig.1 shows results from the patient data. We can see that VDS images contain clear boundaries between the entire peripheral zone, junction zone and the central zone, thus provide better contrast and details and high resolution, demonstrate that VDS-DWI has the potential to be used in bladder and prostate disease diagnosis by providing better structural details and high resolution. Further clinical studies are needed to validate this method.

Discussion and Conclusions: In this study, we find that EPI-DWI has severe distortion artifacts for the boundary contours of urinary bladder have deformation for both subjects especially for the fatter subject in the EPI-DWI images, which inevitably interferes with the accurate diagnosis of urinary bladder wall and prostate-related diseases. On the other hand, the VDS-DWI technique can keep the anatomical structure as well as the T2-weighted images (Fig.1). Secondly, less blurring and sharper structure in Fig.2e and Fig.2f indicate that the high-resolution VDS-DWI may have the potential for urinary bladder wall and prostate related disease diagnosis. This study, for the first time, introduces the VDS-DWI into the prostate application. Comparing with the traditional EPI-DWI based method, VDS-DWI has no distortion, relative higher SNR and higher spatial resolution. Our preliminary results, characterized with well-reserved structural details and high resolution, demonstrate that VDS-DWI has the potential to be used in bladder and prostate disease diagnosis by providing better structural details and high resolution. Further clinical studies are needed to validate this method.

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