Prostate cancer screening: The clinical value of diffusion-weighted imaging and dynamic MR imaging

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Introduction: MR imaging (MRI) has been used for the delineation of the extent of cancer, or for posttherapeutic check-up, but the technique has not been applied for the screening of cancer [1-2].   We evaluated the clinical value of diffusion-weighted imaging (DWI) and dynamic MRI in combination with T2-weighted imaging (T2W) for the screening of prostate cancer in patients with elevated PSA levels.

Methods: Eighty-three consecutive male patients with elevated PSA levels (>4.0 ng/ml) who had undergone both an MRI and a subsequent systematic transrectal prostate biopsy were included in this study.   Forty-four of the 83 patients had cancer, and 10 of the 44 patients with cancer underwent radical prostatectomy.   Patients underwent MRI (1.5 T) consisting of axial T2W-FSE (TR/TE=5000/87.9), DWI-EPI with parallel imaging (3600/72.6, b-values= 0 and 1000 s/mm^2), and dynamic MRI (fat-suppressed FSPGR: 130/2.0/90°).   We analyzed three image interpretation protocols: protocol A (T2W-FSE alone), protocol B (T2W-FSE plus DWI), and protocol C (protocol B+dynamic MRI).   All image interpretation sessions were performed on a workstation and the ADC maps were simultaneously displayed to the readers for DWI.   The ability of each protocol for detecting prostate cancer was evaluated by means of ROC analyses using a five-point scale (5: definitely positive; 4: probably positive; 3: possibly positive; 2: probably negative; 1: definitely negative).   In case of patients who underwent radical prostatectomy, histopathological H&E stain from the entire prostate tissue were prepared to measure the ADC of the cancerous tissue, the noncancerous peripheral zone (PZ) tissue, and the noncancerous transition zone (TZ) tissue.

Results: The Az (the area under the ROC curve) values were 0.711, 0.905, and 0.966 for protocols A, B, and C, respectively (Figure 1).   There were significant differences between protocols A and B (p = 0.011), and between protocols A and C (p = 0.0003).   The sensitivity, specificity, and accuracy for the detection of prostate cancer were 73%, 54%, and 64%, respectively, in protocol A; 84%, 85%, and 84%, respectively, in protocol B; and 95%, 74%, and 86%, respectively, in protocol C.   The sensitivity, specificity, and accuracy were significantly different between the three protocols (p = 0.009, p = 0.009, and p = 0.0005, respectively). The sensitivity and accuracy were significantly different between protocols A and C (p = 0.014 and p = 0.003, respectively), and the specificity and accuracy were significantly different between protocols A and B (p = 0.014 and p = 0.003, respectively).   The mean ADC (x 10^{-3} mm^2/s) was 0.93 ± 0.11 (range: 0.89–1.14) for the cancerous tissue, 1.72 ± 0.35 (range: 1.25–2.29) for the noncancerous PZ tissue, and 1.46 ± 0.16 (range: 1.18–1.63) for the noncancerous TZ tissue.   The cancerous tissues showed significantly lower ADC values than those of noncancerous PZ or TZ tissues (p < 0.001).   The minimum ADC pixel value of cancer was below 0.93.

Discussion: Recent developments to improve MRI enabled the use of DWI for the prostate.   Some preliminary studies have indicated that DWI can distinguish prostate cancer tissues from benign tissues because of the differences in the ADC values [3-5].   The use of ADC maps together with DWI would be recommended, because areas with low ADC were more easily recognized on color ADC maps than on DWI alone.   The cut-off value of the mean ADC between cancerous and noncancerous tissues ranged from 1.14 to 1.18 (x 10^{-3} mm^2/s), these data provided some objectivity in the interpretation of the ADC map.   Recently, Shimofusa et al. reported that prostate cancer could be detected more accurately by T2W with DWI as compared with T2W alone [6].   Preliminary studies using dynamic MRI have shown that prostate cancer tissues enhanced earlier than the normal PZ tissues [7].   Although the usefulness of dynamic MRI in depicting prostate cancer remains controversial [7-8], our results indicated some clinical values of dynamic MRI.   Recently, quantitative analyses using the time-intensity curve or the tracer kinetic model have been reported [9-10].   In our protocol, the scan time of dynamic MRI was 22 s and the delay time was 40–180 s, which seemed to be a reasonable imaging window to enable peak enhancement of cancer [9].   Our preliminary study used visual inspection alone for image interpretation and proposed a simple and practical screening method for prostate cancer (Figure 2).   To our knowledge, this is the first prospective study to screen for prostate cancer among patients with elevated PSA levels.   The combination of DWI and dynamic MRI with T2W may facilitate the detection of prostate cancer as compared with T2W alone.   Thus, the combination of T2W, DWI, and dynamic MRI may be a valuable tool for detecting prostate cancer while avoiding an unnecessary biopsy without missing prostate cancer.

References
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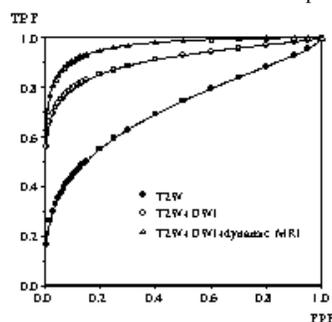Figure 1   The ROC curve of the three protocols.

Figure 2   67 y/o male, prostate cancer (moderately differentiated adenocarcinoma, Gleason's score 3 + 4 = 7)
A case of TZ cancer.   No abnormal finding was observed when T2W was used, and rank 1 was assigned.
However, DWI, ADC maps, and dynamic MRI clearly demonstrate presence of a lesion in the right lobe (arrow).
In protocol B and C, rank 5 was assigned.