Use of endorectal magnetic resonance imaging with dynamic contrast enhanced-MRI and diffusion weighted imaging to detect locally recurrent prostate carcinoma after radical prostatectomy: preliminary results.

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Purpose

Prostate carcinoma (PCa) is one of the most common cancers in males. Clinical screening of PCa, based on combined digital rectal examination (DRE) and prostatic serum antigen (PSA), has increased the detection of early-stage PCa that is curable with surgical resection [1].

After a successful radical prostatectomy (RP), PSA becomes undetectable (<1.0 ng/mL) within one month [2].

Recurrent disease should be considered in presence of any increase of PSA after RP and should be suspected particularly when a trend of rising PSA in three consecutive measurements is present [1,2].

The risk of recurrence after RP is correlated with preoperative PSA level, pathologic stage, Gleason score and surgical margin status.

An increase of PSA level, however, can detect the biochemical recurrence of PCa without providing precise information about the location of relapse, which can be local (i.e. at the side of the RP bed) or systemic (i.e. skeletal or other organs). These two conditions should be clearly differentiated, because they can benefit of different therapies: in the first case, in fact, a local salvage therapy can be attempted (i.e. surgery or radiotherapy); in the second case, a curative systemic therapy can be used (i.e. hormonotherapy) [1,2].

Trans-rectal ultrasound (TRUS) is a simple and minimally invasive tool for evaluating vesico-urethral anastomosis and can be used to guide the biopsy when a local recurrence is suspected. TRUS allows good visualization of the vesico-urethral anastomosis after RP, which is usually surrounded by moderately hyperechoic and homogeneous tissue; in this context local recurrences usually appear as hypoechoic masses [3].

Unfortunately, TRUS can not easily distinguish between fibrous and tumor tissue, even if color/power Doppler imaging or ultrasound contrast agents are used.

Due to its high contrast resolution, Magnetic resonance imaging with endorectal coil (endorectal-MRI), is able to provide an excellent evaluation of the vesico-urethral anastomosis after RP.

The potential role of fast dynamic contrast-enhanced MRI (DCE-MRI) in the detection of hypervascular prostate cancer recurrences after radical surgery, has already been demonstrated in some preliminary studies [4,5]. In this context the role of molecular diffusion techniques (DWI) has not been defined yet, even if some authors have already described the high sensitivity of DWI in detecting recurrent prostate cancer after high-dose-rate brachiterapy [6].
Therefore, the purpose of our study was to present the value of DCE-MRI combined with DWI in detecting local recurrence of PCa after RP, by using clinical and histopathologic findings as the reference standard.
Methods and Materials

1. Study population

From February 2009 to November 2012, 48 consecutive patients suspected of having a local recurrence of PCA, were prospectively evaluated with MRI.

22/48 patients (age 67.86 ± 5.87 years), in whom the presence/absence of local recurrence was established by biopsy or clinical follow-up (C-Choline PET/CT and PSA), were identified.

The following information were collected: PSA values, digital rectal examination (DRE) and TRUS findings closest to the time of MRI.

All patients who had undergone a biopsy within 90 days of MRI were identified. Patients with negative findings at MRI were followed up with C-Choline PET/CT for a maximum of 12 months.

2. MRI protocol

MRI examinations were performed with a 1.5 T whole body scanner and a pelvic phased-array surface coil combined with a disposable prostate endorectal coil.

After local three-plane, morphological study of the post-prostatectomy bed was obtained with Fast Relaxation Fast Spin Echo (FRFSE) T2-weighted sequences in the sagittal, axial and coronal planes. FSE T1-weighted sequence in axial plane was performed.

The DWI acquisition was added to the morphological evaluation and before the injection of contrast medium, in the axial plane, using a spin-echo single-shot echo-planar imaging (SSEPI) sequence, with two b-values (0 and 600 s/mm²) and the following parameters: TE 80 ms, TR 4000 ms, field of view (FOV) 200 x200 mm, slice thickness4 mm, intersection gap0.4 mm, matrix size 256 x 256, number of excitations (Nex) 6, number of slices 15.

Pre-contrast axial FRFSE T2-weighted sequence was used to match the slices of the DWI sequence.

DCE-MRI was obtained using three-dimensional Spoiled Gradient Recalled (SPGR) T1-weighted sequence during the intravenous injection of a paramagnetic contrast agent, at flow rate of 3-4 ml/sec followed by 15 ml of saline solution. Twenty three-dimensional data sets, two before and eighteen after contrast administration, were acquired with 19 seconds temporal resolution and a total duration of 6-8 minutes.
3. Imaging analysis

MR images were assessed by means of consensus between two expert radiologists, who were blinded to all patients’ information other than knowing that each patient had a suspected Pca recurrence.

Vesico-urethral anastomosis was evaluated on T2-, DWI- and DCE-MRI sequences.

On both T2-weighted and DWI sequences, a slightly hyperintense focal area or nodule was considered suspicious of recurrence; hypointense areas or nodules were considered fibrotic tissue.

DCE-MRI images were processed on an independent workstation with a dedicated software. Regions of interest (ROIs) positioned on the suspected areas were used to obtain Time-Intensity (T/I) curves. By using this analysis, color-coded images obtained were superimposed to T2-weighted images. Nodular red pixel clusters or pathological contrast enhancement were defined as a suspicious local recurrence.

The patterns of T/I curves were categorized into three groups (Figure 1): type 1, a rapid initial upslope and a rapid washout; type 2, a rapid initial upslope and a plateau or slow washout; type 3, a rapid or slow initial upslope and a continuous increase.

4. Statistical analysis

We assessed sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of T2-weighted, DCE-MRI and DWI with Receiver Operating Characteristic (ROC) analysis using clinical and histopathologic findings as the standard of reference.
Figure 1. Patterns of I/T curves. (a) type 1, a rapid initial upslope and a rapid washout. (b) type 2, a rapid initial upslope and a plateau or slow washout. (c) type 3, a rapid or slow initial upslope and a continuous increase.

Fig. 1

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Results

On the basis of biopsy and/or clinical follow-up, 11/22 patients had a local recurrence; in this group mean (± SD) PSA level was 1.64 ± 1.25 ng/ml, at the time of MRI.

11/11 patients (100%) had positive MRI findings (Figure 2), in detail: T2-weighted images showed an hyperintense nodule in 8/11 (72.7%); DWI showed an hyperintense nodule in 9/11 (82%) patients.; DCE-MRI showed type 1 T/I curve in 3 (27%), type 2 in 7 (64%) and type 3 in 1 (9%).

In patients without local recurrence, mean PSA level was 1 ± 1.19 ng/ml. MRI was negative in 9/11 (82%) patients (Figures 3, 4), in detail: T2-weighted images showed hypointense tissue in 7/11 (63.6%); DWI showed hypointense tissue in 8/11 (89%) and DCE-MRI showed type 2 T/I curves in 3/11 (27%) and type 3 in 8/11 (72.7%).

ROC analysis showed for each sequence the following values of sensitivity, specificity, NPV and PPV (Figure 5): 72.7%, 63.6%, 70%, 66.7% for T2 sequence; 81.8%, 72.7%, 80%, 75% for DWI sequence; 90.9%, 66.6%, 87.5%, 71.4% for DCE-MRI sequence. Combined evaluation of DWI and DCE-MRI results showed the following values for the same parameters: 100%, 81.8%, 100%, 84.6%.
Figure 2. Local recurrence. (a) axial T2 sequence and (b) axial DWI sequence showed an hyperintense nodule on the left side of RP bed (red arrows). (c) DCE-MRI showed an hypervascular nodule in the same site with type 2 corresponding I/T curve (green curve in d) calculated starting from a ROI positioned on the nodule. CFA= Common femoral artery.

Fig. 2

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Figure 3. True negative patient. (a) axial T2 sequence and (b) axial DWI sequence showed an isointense nodule on the left side of RP bed (red arrows). (c) DCE-MRI showed a type 3 corresponding I/T curve calculated starting from a ROI positioned on the nodule.

Fig. 3

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Figure 4. False positive patient. (a) axial T2 sequence and (b) axial DWI sequence showed an hyperintense nodule on the left side of RP bed (red arrows). (c) DCE-MRI showed an hypervascular nodule in the same site with type 2 corresponding I/T curve (d). The biopsy showed residual prostatic tissue with benign hyperplasia.

Fig. 4

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Figure 5. Graphics of ROC curves. (a) Comparison between ROC curves of T2-, DWI- and DCE-MRI sequences separately. The areas under the curves (AUC) were the following: 0.682 for T2-sequence; 0.773 for DWI-sequence; 0.773 for DCE-MRI. (b) ROC curve of combined DWI+DCE-MRI evaluation; the corresponding AUC was 0.909.

Fig. 5

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Conclusion

Endorectal-MRI is an important tool in the evaluation of post-prostatectomy bed, due to its high contrast resolution which is able to provide an excellent evaluation of the vesicourethral anastomosis.

T2-weighted imaging alone showed an inferior diagnostic performance in detecting areas/nodules of local recurrence compared to DWI and DCE-MRI.

We demonstrated that DCE-MRI, combined with DWI, showed a better diagnostic performance in detecting areas of local recurrence compared to the two techniques evaluated separately.

In addition, we suppose that a characterization of soft tissue in RP bed could be possible by using DCE-MRI; in fact we found a prevalence of type 3 T/I curves (72.%) in patients without local recurrence, while in positive patients type 1 (27%) and type 2 (64%) T/I curves were prevalent. These results suggest that on the one hand type 3 curves could correspond to fibrotic tissue and on the other hand type 1 or type 2 T/I curves could be expression of a local recurrence.

Further studies with larger patients population are necessary to confirm these important observations.
References