Follow-up of parametric maps of the tumoral perfusion in patients with treated bone metastases of prostate cancer.

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Purpose

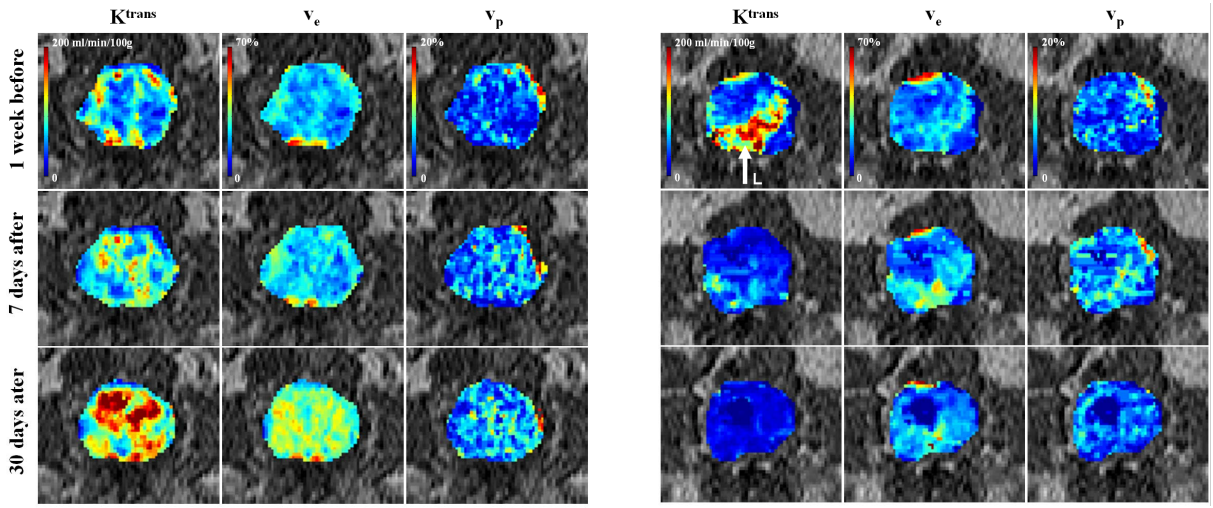
Dynamic contrast-enhanced magnetic resonance imaging with a pharmacokinetic modeling of the data (PK-DCE-MRI) is increasingly used for the non-invasive assessment of normal or neoplasic marrow [1]. However, the heterogeneity of tumors raises difficulties for the clinical interpretation. Building parametric maps of the perfusion enables to take into account this heterogeneity and observe the functional characteristics of the bone marrow, within the lesion but also in its immediate vicinity and in more distant tissues. Thus, the monitoring of the effects of anti-cancer agents in each of these areas during the course of a therapy becomes feasible with the hope to better evaluate the patient response. A prospective study was undertaken to assess this hypothesis.

Methods

The study was performed on 10 PCa patients with known lumbar metastases scheduled to receive hormonotherapy or Taxotere therapy. Patients were imaged on a 1.5T scanner (Gyroscan NT Intera T15; Philips) within one week before, 7 and 30 days after initial treatment. A spoiled turbo-FLASH sequence synchronized to the cardiac cycle was used (a non-slice-selective 90° preparation pulse was incorporated). 200 dynamics were measured. Patients received 8 mL of Gd-DTPA (Magnevist) followed by 20 mL saline flush injected at a rate of 3 mL/s with an automated injector. To convert the signal intensity into ΔR1 relaxation rate which is proportional to contrast agent concentration, a calibration procedure was used [2]. A three-parameter kinetic model [3] and an individual arterial input function were used to fit pixel-based ΔR1 relaxation rate versus time curves. Three parametric maps based on parameters (K^{trans}, v_e, v_p) were reconstructed for each MR examination then compared. Tumor response was evaluated independently by the urologist on the basis of biological and imaging follow-up.

Figure

Parametric maps of the bone marrow perfusion in the transverse plane. Left, a responder treated with hormonotherapy. K^{trans} (depending both on the blood flow and the permeability-surface area product) and v_e (representing the fraction of extravascular volume accessible to the contrast agent) significantly increase between each examination. Right, a responder treated with Taxotere. K^{trans}, v_e and v_p decrease significantly between each examination. The appearance of a central area of necrosis and the progressive disappearance of the hyperperfused area (tagged 'L' and identified as the lesion on the basis of sagittal and axial images obtained before contrast agent injection) can already be observed 7 days after initial treatment.



Results

Only four patients demonstrated disease regression at long term imaging. Among them, two (hormonotherapy and Taxotere therapy respectively) showed a monotonous decrease of the mean PK parameters between consecutive MR examinations as well as a relative homogenization of the bone marrow perfusion during the therapy (Figure, right). The third patient (hormonotherapy) showed an early increase and a late decrease and the fourth one (hormonotherapy) showed a monotonous increase of the mean PK parameters (Figure, left). These latter patients showed a heterogenization of the bone marrow perfusion during the therapy. These different behaviours observed in responders are illustrated by the Figure. We could not find discriminant behaviour between these findings and the observations made in the six non-responders.

Conclusion

The small number of patients did not answer the question of the complex changes observed in the bone marrow perfusion in responders to therapy. PK-DCE-MRI is a sensitive technique that provides useful surrogates for developing adaptive (locally and in time) therapeutic strategies. The clinical usefulness of parametric maps should be clarified in larger series.

References

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