Preliminary results with 3D DCE-MRI curve pattern analysis of treatment response in osteosarcoma

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Introduction: Osteosarcoma (OS) is one of the most common malignant bone tumors of children in the United States. A new treatment protocol in our institute includes multiagent chemotherapy with an anti-angiogenic agent (bevacizumab). DCE-MRI was used for monitoring the treatment response before, during, and after therapy. Kinetic modeling is usually used in DCE-MRI data processing (1); however, this type of processing is very complex requiring choice of pharmacokinetic model, selection of an arterial input function (AIF), and accurate measurement of the intrinsic baseline T_1. Recently, a simple data analysis method called curve pattern analysis (CPA) was proposed without any of the above requirements (2,3). In this abstract, we present preliminary results using the CPA method to assess tumor response to neoadjuvant therapy in children treated for OS.

Methods: Patients in this protocol had newly diagnosed high-grade, biopsy-proven osteosarcoma or malignant fibrous histiocytoma of the bone and had not received any previous chemotherapy or radiation therapy. Bevacizumab was administered three days before the first cycle of chemotherapy (day-3) and on the first day of subsequent cycles. Two blocks of neoadjuvant chemotherapy each consisting of one cycle of cisplatin/doxorubicin and two doses of methotrexate were administered over 10 weeks before definitive surgery.

Serial DCE-MRI examinations for each OS patient were performed at baseline, day-2 (one day after bevacizumab alone), day+1 (3 days after bevacizumab before starting chemotherapy), and day+5 (after starting chemotherapy) during the first cycle, and then at week 5 (after block 1), and week 10 (after block 2 and before definitive surgery). DCE-MRI data were acquired using a fast 3D Cartesian gradient-echo pulse sequence on a 1.5 T Siemens Avanto scanner. The patient was given injections of 0.1 mmol/kg of Gd-DTPA at a rate of 1 ml/s, followed by a saline flush using a power injector synchronized with the MRI scanner. The protocol was as follows: 16 coronal slices with 75% partial Fourier encoding along kz, FOVs kept the same for each patient; slice thickness = 5 mm; TE/TR = 1.24/3.5 ms; receiver bandwidth = 390 Hz/pixel; acquisition matrix = 256 × 192; the total acquisition time was 350 seconds for 50 measurements. Preliminary data were analyzed for the first eight subjects enrolled with OS of the extremity. CPA parameter (β_1, β_2, β_τ, κ) maps for one slice were generated using DCE-MRI data from the first OS patient. The mean values of all CPA parameters for the whole tumor were computed for each exam, and paired t-tests were performed using the baseline measures paired with the latter treatment measures.

Results: Figure 1 shows CPA parameter (β_1, β_2, β_τ, κ) maps from a single slice of the first OS patient whose tumor was in the right proximal tibia. A consistent treatment response is shown in the different parameter maps. The dramatic change started in week 5, and there is less change before day+5. These CPA maps are consistent with K^{trans} maps presented in last ISMRM (4).

Figure 2 shows the bar plots of mean value of CPA parameters for the whole tumor in eight patients versus each time point during therapy. Paired t-tests showed that there was no significant change in the mean values relative to the baseline for any of the four CPA parameters at the first three time points during therapy; and showed a significant change of β_2 and β_τ at the two latter time points in therapy.

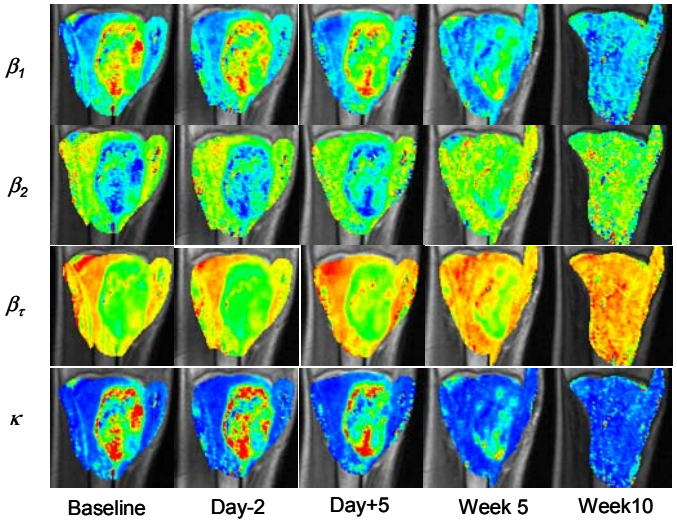

Fig.1. CPA parameters (β_1, β_2, β_τ, κ) maps of one slice from the first patient. Patient missed the day+1 examination. The coloring maps in each row are in the same color scale.

Conclusion: It is feasible to assess the tumor treatment response of chemotherapy and bevacizumab using the CPA method as an alternative quantitative method for kinetic modeling in DCE-MRI studies. Measures of CPA parameters (β_1, β_2, β_τ, κ) provide reliable measures of change in tumors. Further investigation of this CPA method on a larger cohort of patients will be performed.

Reference:

1. Tofts PS, et. al. MRM 1991;17(2):357-367.
2. Guo JY, et. al. JMRI 2009;30(1):177-184.
3. Guo JY, et. al. ISMRM 2009, Hawaii, USA. p 1490.
4. Reddick WE, et. al. ISMRM 2009; Hawaii, USA. p 4181.

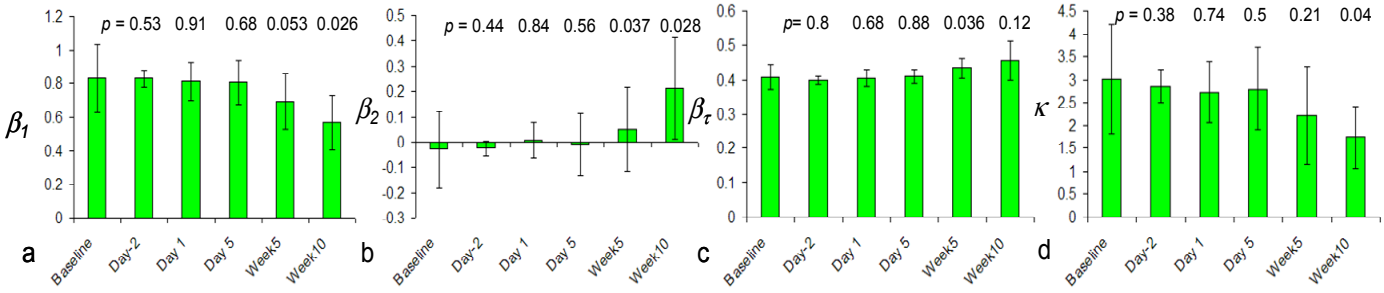

Fig 2. Bar plots of mean values of four CPA parameters (β_1, β_2, β_τ, κ) for six examinations. p-values from paired t-tests are shown above each bar for treatment examinations in comparison with the baseline.