Original Research

Optimizing MRI Scan Time in the Computation of Pharmacokinetic Parameters (K^{trans}) in Breast Cancer Diagnosis

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Purpose: To assess the effects of reduced scan time in dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) of breast for the evaluation of pharmacokinetic parameters (K^{trans}, v_e, and k_{ep}).

Materials and Methods: High temporal resolution DCE-MRI was performed for calculation of pharmacokinetic parameters (K^{trans}, v_e, and k_{ep}) at different timepoints using an in-house developed computation scheme adopting the standard model (SM).

Results: The receiver operating characteristic (ROC) curve analysis revealed an area under the ROC curve (AUC) of 0.994 for K^{trans} at 90 seconds and 0.987 for K^{trans} at 60 seconds with a significant decrease in the AUC for K^{trans} at 30 seconds (0.669). While v_e showed a consistently higher AUC (>0.9) at timepoints ≥40 seconds, the AUC for k_{ep} showed a consistent decline with reduced acquisition times.

Conclusion: Reducing the acquisition time for the K^{trans} and v_e measurement up to 60 seconds yields reasonable accuracy for both and can be incorporated in the routine DCE-MRI protocol for evaluation of enhancing breast lesions.

Key Words: DCE-MRI; pharmacokinetic parameters; K^{trans}; acquisition time
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PATIENT COMFORT, improving throughput (number of examinations per unit machine time) of the machine, and correct diagnosis is a challenge in breast cancer detection. Breast magnetic resonance imaging (MRI) provides good anatomical information of the breast including 3D location of the lesion, but has limitations to characterize the tissue (1,2). Dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) is emerging as an important technique providing pharmacokinetic parameters (K^{trans}, v_e, k_{ep}) as biomarkers for the assessment of cancer detection and monitoring therapy response (3–8). Contrast molecules affect the observed intensity patterns by changing the relaxation times of the tissue in the image that they reach and the difference in behavior called "wash-in wash-out" is used to characterize tissue (9) Typically, contrast agent uptake curves show that malignant tissue is characterized by a sharp rise and overall higher enhancement than benign, normal, or fatty tissue (10–12) because of the qualitative and quantitative change in the microvasculature (neoangiogenesis), which is leaky, while normal and fatty tissues show little contrast agent uptake. These uptake curves have often been fitted using a pharmacokinetic model (a model that mathematically relates to the concentration of contrast agent in the tissue as a function of time) with various physiological parameters of the tissue such as transfer constant K^{trans}, also termed the permeability constant, and an extracellular volume parameter v_e, in an attempt to give a physiologically relevant parameterization of the curve (13–16). Study of these parameters has been proposed as a technique that could identify and characterize tumors into malignant or benign classes (12) DCE-MRI examination requires patient preparation time, setting the patient up on an MRI couch, acquisition time, reconstruction of image data, postprocessing, and analyzing data for reporting. Out of these, longer acquisition times result in patient discomfort and longer analysis time for the clinician affecting overall throughput. Optimizing these timings is an essential step to bring a useful but highly computation-intensive parameter like K^{trans} into the clinical domain. Given the increasing use of DCE-MRI to monitor therapy response, it would be of great interest to estimate k^{trans} with reduced scan time to differentiate progressive or stable disease from partial or complete response.

It is known that the accuracy of computation of the pharmacokinetic parameters is affected by the contrast-to-noise ratio (CNR), temporal resolution, and acquisition time (8,17,18). A compromise has to be

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