

Feasibility of the Usage of the Internal Mammory Artery as an Artery Input Function in Pharmacokinetic Analysis Using the Contrast Enhanced Dynamic MR Study in Breast Tumor

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Background

Dynamic contrast-enhanced MRI has been increasingly used to investigate angiogenesis in breast tumor to provide information on tumor pathophysiology for improved diagnosis and management of breast lesions. Physiologically meaningful parameters such as K_{trans} and k_{ep} related to angiogenesis have been reported to be able to useful for a biomarker of tumor response for anti-angiogenic drug.

In pharmacokinetic analysis of dynamic MRI data, permeability estimation needs an artery input function (AIF) which is very important for measuring more accurate permeability parameters. In breast, aorta has been used as an AIF because the aorta is near the breast. Inhomogeneity of RF power in breast surface coil and the location of the aorta far from the coil in addition to complex blood flow pattern in large aorta, however, may make the signal intensity within aorta to be very weak or variable spatially at precontrast period in a dynamic MR study. Thus, the conversion of dynamic signal intensity time curve into concentration-time curve by using the ratios of postcontrast signal intensity to precontrast ones may have erroneous or variable result of an AIF in the aorta. Also, local artery of the internal mammary artery in breast may reflect true input function due to its position more close to breast tumor compared to the aorta. Therefore, we evaluated the feasibility of the usage of the internal mammary artery as an AIF in pharmacokinetic analysis using a contrast enhanced dynamic MR images in breast tumor.

Materials and Methods:

Dynamic studies were performed on a 1.5 Tesla (GE, USA) using a 3D fast spoiled gradient-echo (SPGR) sequence (TR/TE/flip angle=3.71ms/1.78ms/20°, matrix=256x256, FOV=280mm, slice thickness=2mm) and 8 channel breast coil. A total of 42 phases were acquired with a temporal resolution of 11 seconds, resulting in a total scan time of 7 minutes 42 seconds. Both sides of breast were covered with an axial view. Administration of agent with a rate of 3cc/sec and 0.05mmol/kg were performed through an intravenous injection using an auto-injector. Injection was started when the third dynamic image was acquired to guarantee a well-defined baseline. The signal intensity-time curves were converted to the concentration-time curve from precontrast T1 values. Based on the variable flip angle method, precontrast T1 relaxation times of breast from T1-weighted images with a 3 different flip angles (flip angle=3, 10 and 17) were acquired from each slice before contrast agent administration using the same dynamic sequence.

We used the Tofts model as a kinetic modeling and K_{trans} and k_{ep} were measured utilizing a nonlinear Levenberg-Marquardt least-squares fitting algorithm. All programs including T1 map and permeability map were developed on a platform of IDL (ITT Visual Information Solutions, USA).

As an AIF, we selected an internal mammary artery near the tumor from both sides (Figure 1). Because it was very small in size compared to the aorta, dynamic data at the brightest point of the pixels manually drawn in pixel-based selection was used.

Between Aug 2009 and Oct 2009, twenty patients (mean 51 years; range 35-78 years) with 20 primary breast cancers (18 invasive ductal carcinomas, 1 DCIS, 1 invasive lobular carcinoma) with a mean size of 2.0cm (range 0.3-4.0cm) underwent dynamic contrast-enhanced MR examinations.

Results:

Both sides of the internal mammary artery were clearly shown near chest wall in all patients (Figure 1) and we can obtain the successful concentration-time curves. There was little variation in the concentration time curves within the internal mammary artery. In contrast, there was large

difference in the concentration time curve dependent on the position within the aorta (Figure 2).

All patients showed the good performance in the fitting procedure of the dynamic MR data into the pharmacokinetic model using the internal mammary artery as an AIF (Figure 3). The K_{trans} (0.15-4.0, unit: /min)) and k_{ep} (0.27-4.4, unit:/min) showed the range shown at the other literatures about breast tumor.

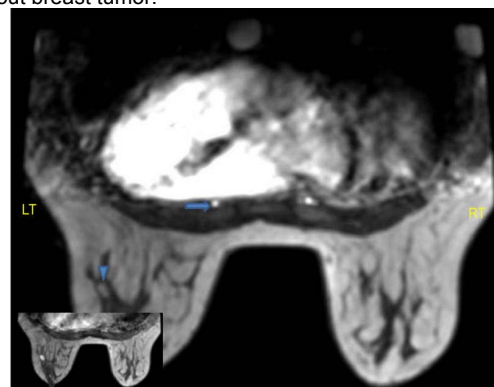


Figure 1. The internal mammary artery (left, arrow) and breast tumor (left, arrow head)

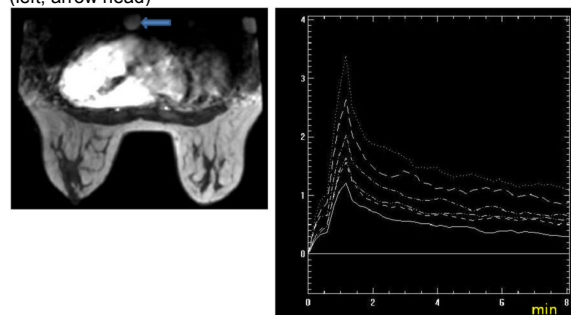


Figure 2. The concentration time curves at several positions within the aorta (left, arrow). The large variation was shown dependent on which pixel was chosen in the aorta (right).

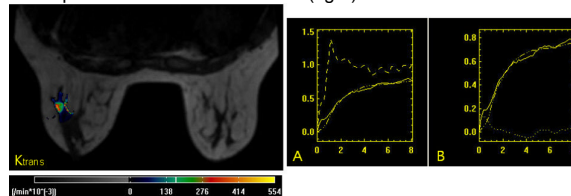


Figure 3. The permeability map in breast tumor and the fitting result of a dynamic MR data by the pharmacokinetic model based on the Tofts model.

Left: K_{trans} image. Right: A) AIF (---), dynamic MR data (—) and the fitted data (— · —) B) Dynamic MR data (—), the fitted data (— · —) and the difference between both data (.....)

Conclusions:

Our study shows that internal mammary artery near chest wall may be used as an appropriate place to get an artery input function in breast tumor. In addition, the internal mammary artery is responsible for sixty percent of the breast blood supply, so it can reflect true artery input function, which may result in more precise estimation of permeability parameters such as K_{trans} and k_{ep} .

References:

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