EVALUATION OF FEMORAL PERFUSION IN A RABBIT OSTEONECROSIS MODEL WITH T2*-WEIGHTED DYNAMIC MRI

Introduction: Magnetic resonance imaging (MRI) is highly sensitive and considered less invasive than other modalities to early diagnosis of non-traumatic osteonecrosis (ON). However, it is generally based on detection of reparative reactions to ON and it is quite difficult to directly detect bone ischemia, which corresponds to initial Stage 0 of the ARCO (Association Research Circulation Osseous) international classification system. Femoral perfusion has been evaluated using T1-weighted dynamic MRI with gadolinium (Gd) contrast agent, so far. However, this method may not always be appropriate for evaluating femoral perfusion in point of a mechanism of contrast enhancement and the pharmacokinetics of Gd contrast agent. On the other hand, T2*-weighted dynamic MRI utilizes a transient decrease of signal intensity during the first pass of Gd contrast agent and is used for evaluating brain perfusion mainly. We applied T2*-weighted dynamic MRI to a rabbit non-traumatic ON model and investigated the possibility of evaluating femoral perfusion and predicting ON occurrence.

Materials and Methods: Sterile heat-inactivated horse serum (10 ml/kg) was injected intravenously to 25 adult male Japanese white rabbits twice with a 3-week interval. First, coronal MR images of each rabbit femur were obtained under general anesthesia using T1-weighted (T1W), T2-weighted (T2W) and fat suppression T1W (FST1W) images with spin echo (SE) sequence. Next, a set of 30 sequential T2*-weighted T2D dynamic MRI images (3.51 seconds/frame) with fast low-angle shot sequence were obtained in intravenous bolus injection of 0.4 mmol Gd-DTPA/kg. After that, Gd-DTPA enhanced T1W (GdT1W) and FST1W (GdFST1W) images with SE sequence were obtained. Serial images were obtained repeatedly for each rabbit as follows: before the first serum injection, 72 hours, 1 week and 3 weeks after the second serum injection, using 1.0 T MRI system. After 72 hours (group A, 7 rabbits), 1 week (group B, 7 rabbits) and 3 weeks (group C, 11 rabbits) MRI, each rabbit was sacrificed and both femora were removed for histological study.

Results: Early microcirculatory injury or necrotic lesion was detected in 50% (10/20 femora with extravasation) at 72 hours, 33% (4/12 necrotic femora) at 1 week and 100% (14/14 necrotic femora) at 3 weeks using non-enhanced (T1W, T2W, FST1W) MRI. Femoral perfusion has been evaluated using T1-weighted dynamic MRI with gadolinium (Gd) contrast agent, so far. However, this method may not always be appropriate for evaluating femoral perfusion in point of a mechanism of contrast enhancement and the pharmacokinetics of Gd contrast agent. On the other hand, T2*-weighted dynamic MRI utilizes a transient decrease of signal intensity during the first pass of Gd contrast agent and is used for evaluating brain perfusion mainly. We applied T2*-weighted dynamic MRI to a rabbit non-traumatic ON model and investigated the possibility of evaluating femoral perfusion and predicting ON occurrence.

Discussion: In the present study of T2*W dynamic MRI, a transient decrease of signal intensity occurred during the first pass of Gd-DTPA in histologically normal femora about 6 seconds after intravenous bolus injection of Gd-DTPA without subsequent decrease. In contrast, the signal intensity in femora with early microcirculatory injury or necrotic lesion showed no transient decrease or a less marked transient decrease. Therefore, it is supposed that a change of transient decrease of signal intensity in femora with lesions reflects a change of tissue perfusion in bone marrow of these femora in this ON model. Furthermore, the transient decrease of signal intensity with T2*W dynamic MRI reflects the artery phase of Gd contrast agent kinetics, not the venous or distribution phase in evaluation of femoral perfusion with T1W dynamic MRI. T2*W dynamic MRI was more sensitive than non-enhanced and contrast-enhanced MRI for detection of early microcirculatory injury during ON development and ON in this ON model, and was able to monitor hemodynamics of the artery phase in the early stage. This method may be clinically useful for evaluating femoral perfusion in artery phase and predicting ON occurrence.

References:

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49th Annual Meeting of the Orthopaedic Research Society
Paper #0152