In-vitro high resolution MR imaging of lymph node at 1.5T: Technique and preliminary observations

D. Koh[1], D. Collins[2], G. Brown[3], M. Leach[2], J. Husband[1]

[1]Royal Marsden Hospital & Institute of Cancer Research, Sutton, United Kingdom, [2]Institute of Cancer Research, Sutton, United Kingdom, [3]Royal Marsden Hospital, Sutton, United Kingdom

Synopsis

The ability to detect nodal metastasis using MR imaging in combination with ultra-small iron oxide particles (USPIO) is influenced by the distribution and magnetic susceptibility effects produced by these particles within nodes. We describe our results of in-vitro high-resolution MR imaging at 1.5T, which enabled us to observe USPIO distribution in a human lymph node. On high-resolution imaging, nodal uptake of USPIO uptake was seen predominantly within the medulla. High regional concentration of USPIO resulted in local magnetic field distortion, which was recognised as areas with strong susceptibility artifacts. Understanding the pattern of USPIO uptake may improve our ability to detect smaller metastases, whilst also leading to an awareness of the limitations of the technique.

Introduction

MR lymphography following administration of USPIO has been investigated as a method to accurately identify lymph node metastasis [1]. In our experience, using a T2*-weighted sequence (such as the 5-echo MEDIC sequence used on the Siemens' Vision system) in clinical imaging is most helpful in distinguishing between malignant and non-malignant nodes [2]. The uptake of USPIO into normal nodes produces susceptibility effects, which typically result in uniformly low nodal signal on T2*-weighted imaging. However, some non-malignant nodes show peripheral high signal instead of uniform low signal [2]. High-resolution imaging can help to relate the nodal distribution of USPIO with its appearance on clinical in-vivo T2*-weighted imaging at 1.5T. Knowledge of the nodal dispersion of USPIO will improve the understanding of the appearance of nodes in clinical imaging and is important for further optimisation of this lymphographic technique.

Purpose

To demonstrate the distribution of USPIO within lymph node by using high-resolution in-vitro MR imaging at 1.5T.

Materials and methods

Two mesorectal nodes obtained from different patients with rectal cancer were interrogated in-vitro using high-resolution MR imaging. One patient did not receive USPIO, but the other underwent MR lymphography 4 days prior to surgery (USPIO administered at dose of 2.6mgFe/Kg body weight). High-resolution imaging was performed using a 1.5T scanner (Siemens' Vision, Erlangen Germany). A spin-echo sequence was used (TE = 35 ms, TR = 620 ms, slice thickness 500μm, field of view 28 mm, matrix = 256*256, in-plane resolution of 109 μm, number of slices = 8, Nex = 8). Images were acquired with fat saturation. The coil used was a home built solenoid with a length of 8cm, 8 turns of Copper foil (2mm wide) and outer diameter 1.6cm. The coil was tuned and matched to 50Ω. The coil and sample were placed with its major axis orthogonal to the static magnetic field and enclosed in a Faraday screen within the magnet bore. The Faraday screen consisted of a rectangular box 29cm long, 23cm in height and 20cm in width. The screening material used was Aluminium foil 4μm thick. The Faraday screen was required because extraneous noise spikes were found to be degrading the image quality. A 3D volume rendering of the 8 slices was also obtained using multiplanar reformatting and maximum intensity projection. Histopathological studies were performed on both nodes.

Results

Both lymph nodes were non-malignant on histopathology. The zonal anatomy of the nodal cortex and medulla could not be identified within the node taken from the patient who had not received USPIO (Figure 1). However, in the node obtained from the patient who had received USPIO, distribution of USPIO was seen as low-signal areas, predominantly within the centre of the node, reflecting uptake in the medulla (Figure 2). Focal areas of strong susceptibility artifacts, discerned as points of high signal proximal to signal voids, were noted in keeping with areas with high USPIO concentration (Figure 2b). These areas were best perceived as low-signal foci on inverted maximum intensity projection of the imaged volume (Figure 2c). The MR appearance correlated with the iron distribution seen using Perl's stain on histology.

Discussion

Using this technique, an in plane resolution of 109 x 109 μm was achieved, allowing visualisation of the USPIO distribution within the node. Imaging artifacts arising from magnetic field distortion, reflecting high focal concentration of USPIO, were observed within the node. To the best of our knowledge, this has not been previously reported at such spatial resolution at 1.5T. High local concentration of USPIO can diminish the sensitivity of MR lymphography since the strong susceptibility effects can obscure adjacent nodal detail. Hence, an understanding of the distribution of USPIO in nodes would aid in the interpretation of clinical imaging in-vivo. In this example, the uptake of USPIO was observed mainly within the nodal medulla. This is consistent with the findings described by Weissleider et al. in rabbit nodes imaged at 9.4T [3]. This medullary distribution may also explain the central low-signal pattern, which has been observed in non-malignant reactive lymph nodes [2].

References

1. Bellin et al. Iron oxide-enhanced MR lymphography: initial experience. Eur J Radiol 2000; 34:257-264
2. D-M Koh et al. MR Imaging of pelvic lymph node in rectal cancer using USPIO: Preliminary observations. Radiology 2002; 225(P):244
3. R Weissleder. Experimental lymph node metastases: enhanced detection with MR lymphography. Radiology 1989; 171:835-9

Acknowledgements

Cancer Research UK Grant C1060/A808/G7643; Pump Priming Grant, Royal College of Radiologist, UK

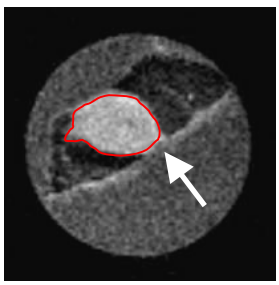

Figure 1. High resolution imaging of a 3 mm normal node without USPIO administration. Note high signal of the node (arrow and outlined) relative to the low signal from the suppressed fat.

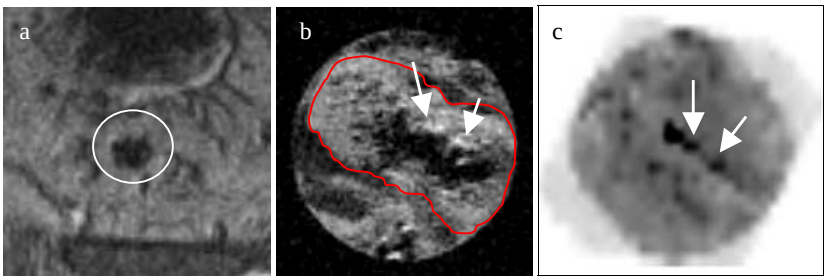

Figure 2. (a) In-vivo MR imaging shows a 7 mm node of near uniform low signal on T2*-weighted imaging (circled) (b) High resolution MR imaging of the node (outlined) shows low signal within the centre of the node, with areas of strong susceptibility artefacts seen as areas of high signal proximal to signal voids (arrows). (3) These are better perceived as low-signal foci on the inverted MIP of the imaged volume.