Whole-body MRI and diffusion-weighted imaging in malignant lymphomas

Poster No.: C-1360
Congress: ECR 2013
Type: Scientific Exhibit
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Keywords: Lymph nodes, Oncology, Mediastinum, CT-Angiography, MR, MR-Diffusion/Perfusion, Chemotherapy, Comparative studies, Diagnostic procedure, Haematologic diseases, Lymphoma
DOI: 10.1594/ecr2013/C-1360

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Purpose

The aim of this study is to compare the performance of whole-body MRI including: the diffusion-weighted (DWIBS) and STIR imaging, and whole body positron emission tomography and computed tomography in patients diagnosed to have lymphoma.


Whole-body MRI may be useful in detecting systemic failures due to it's high relative soft tissues contrast. MRI can be not limited in number and volume of studies due to it's harmless to the patient.

Whereas more traditional radiology methods, such as contrast enhanced CT, scintigraphy, PET, PET-CT are associated with increased radiation exposure and less effective in small focal lesions early detection. So, it is actual to hold whole-body MRI in oncological profile patients for early multifocal lesions diagnosis.
Methods and Materials

Magnetic resonance imaging:
All studies were performed on full "Total imaging matrix "(Tim) MRI systems Siemens MAGNETOM Espree 1.5T, Verio 3.0T and Skyra 3.0T equipped with "Integrated Parallel Acquisition Technique" (iPAT).

MRI study protocol:
The study protocol includes T2-weighted coronal HASTE (Half Fourier single shot Turbo Spin Echo technique) and for overwhelming signal from adipose tissue 3D STIR (Short TI Inversion Recovery) images from the vertex to the proximal third of the leg capturing the whole body in the anterior-posterior direction. Also diffusion-weighted images in transversal plane with b-value 800 were obtained using DWIBS technique (diffusion-weighted imaging with background body signal suppression. Voxel size was 1,4x1,4x5,0 mm, 0,8x0,8x4,0 mm and 1,5x1,5x7,0 mm respectively.

Examination of thoracic and abdominal cavities was respiratory triggered to reduce the movement artifacts. The total time of the study was about 35-45 min. on 1,5T device and about 25-35 min. on 3,0T units (depending on patients constitution and respiratory cycle).

To clarify the process extent and its specificity specialists consultation and complete sighting study of necessary areas by optimal set of complimentary diagnostic methods were performed.

Patient population:
The study included 3 groups of patients, who did not receive any treatment:

1) Patients with Hodgkin's lymphoma - 54 persons including 27 women, 27 men, with average age 41 years (from 18 to 56 years)

2) Patients with other types of lymphoproliferative disease - 22 persons, among them 11 women and 12 men, mean patients age was 44 years (from 18 to 70 years)

3) Patients without a history of cancer pathology - 35 volunteers, including 12 women and 23 men aged 25 to 70 years, with average age 39 years.

All diagnosis in first and second groups were verified histologically.

Patients of the first two groups were also examined in the course of treatment (on average after every two courses of chemotherapy and after radiation therapy (if any was held)).
Images for this section:

**Fig. 4:** Total imaging matrix (Tim) technique

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Results

40 patients of the first two groups were carried out contrast enhanced CT of the chest, abdomen and pelvis at least once - in case of mediastinal form of lymphoma only chest CT was performed in follow-up (in case of absence of vascular involvement in the pathological process suspicion contrast enhancement has not been administered).

Whole-body PET was performed in 20 patients of the first 2 groups.

In case of lesions in only one or more contiguous groups of peripheral lymph nodes, the treatment control was carried out according to the ultrasound and excluded the holding of CT.

Scan area was limited in order to reduce radiation exposure. For remission confirmation whole-body MRI were performed in all cases.

Average number of whole-body MRI studies for one patient was 4 (from 2 to 8).

In first and second groups four basic types of lymphoma lesions were:

1. enlarged lymph nodes
2. package of lymph nodes
3. conglomerate of lymph nodes
4. lymphoid infiltrate

The average number of affected lymph nodes in fist two groups was 7 (from 1 group up to total lymph nodes lesion).

In the first group from 30 to 90 involved nodes, from 1 to 8 diffuse bone lesions, from 1 to 5 lesions in non lymphoid organs and from 2 to 5 focal lesions, as a consequence of the inflammatory-sclerotic processes not related to the lymphoproliferative disease were identified.

In the second group from 20 to 60 specific focal lesions, 1 up to multiple diffuse bone changes, from 2 up to innumerable lesions in non lymphoid organs and from 2 to 3 local changes estimated as consequences of nonspecific inflammatory-sclerotic processes of bones were found.

In several patients of first two groups, who received prolonged courses of chemotherapy (from 6 to 8), post chemotherapy bone marrow infarctions were identified only by MRI. Infarctions were located in long tubular bones - mainly in the femoral bones almost symmetrically on both sides.
In the third group number of detected non-oncologic lesions reached to 5 per person (from chronic somatic illness to severe conditions such as pneumonia). Reactively enlarged lymph nodes were detected in every third patient, most frequently in combination with various sinusitis. In one case disseminated lesion of bone marrow was detected (subsequently histologically proved multiple myeloma).

DWI did not reveal any additional lesions and proved to be not good in mediastinum because of it's high sensitivity to cardiac motion. DWI has shown a low sensitivity in spleen lesions because of natural limitations of diffusion processes in this organ. DWI was helpful in estimation of residual lymphoid tissue - signal intensity decreased signal previously to volume.

Subsequent sighting diagnostic studies in all cases did not contradict with whole-body MRI results.

The results of PET in all cases are not contrary to the whole body MRI. In 3 patients from the first group MRI revealed enlarged and deformed lymph nodes that did not accumulate the radiopharmaceutical in PET (all that lymph nodes normalized after treatment).

Performed CT studies revealed up to 85% lymph node lesions detected with MRI (including 1 patient with intercostal muscles lymph nodes lesion in which CT was absolutely not sensitive).

Local specific bone involvement on CT was differentiated in 5 cases - decomposition of presternum, ribs and destructive lesions of the vertebral bodies in patients with massive mediastinal lymphoma. CT clearly differentiated local reactive changes in the loci of iliac biopsy. Inflammatory and sclerotic changes in cancellous bone CT did not reveal in any case.

Within focal and massive lesions of lung MRI was not inferior to CT in any case. CT was more sensitive in detection of focal lung lesions less than 4,0 mm- that were not differentiated between post inflammatory and specific changes without follow-up.

With whole-body MRI also were suspected few ischemic lesions of cerebral blood flow and one case of specific brain lesions (all confirmed with sighting survey) - that influenced on treatment.

Whole-body MRI clearly detected cases of bile ducts compressions by lymph nodes conglomerates.

Almost every second patient was revealed varying degrees of sinusitis.
Fig. 5: Basic types of nodular lesions: 1. packages of lymph nodes 2. conglomerate of lymph nodes 3. lymphoid infiltration

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Fig. 2: Whole-body STIR images of patient B. (male, 30 y.) Hodgkin's lymphoma with lesion of lymph nodes neck, over- and subclavian, axillary regions, thorax, mediastinum, lung roots, abdominal and retroperitoneal regions. Non-specific focal lesion of right femur. Focal lesion of the L4 vertebral body more corresponds with hemangiomas. Cyst of the right maxillary sinus.

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Fig. 3: Whole-body STIR images of the same patient B. (male, 30 y.) with Hodgkin’s lymphoma after four courses of chemotherapy. The almost complete size and signal normalization of involved nodes. Focal lesion of right femur, cyst of the right maxillary sinus and hemangioma of L4 vertebral body - without any dynamics.

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**Fig. 6:** Patient P., 44 y.o. NHL STIR subtotal lesion of vertebrae, pelvic bones, both the femur and humerus, scapulas, clavicles, ribs, sternu, lymph nodes in the neck, & clavicular regions, root of the right lung, paravertebral & iliac lymph nodes

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**Fig. 7:** Patient P., 44 y.o. NHL DWIBS subtotal lesion of vertebrae, pelvic bones, both the femur and humerus, scapulas, clavicles, ribs, sternu, lymph nodes in the neck, & clavicular regions, root of the right lung, paravertebral & iliac lymph nodes

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**Fig. 8:** HL recurrence In focal and massive lesions of lungs MRI was not inferior to CT in any case.

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Fig. 9: Patient D., 23 y.o., NHL STIR images In focal lesions of lungs and mediastinal lymph nodes lession

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Conclusion

DWI can't be used as an independent method of diagnosis, but it complements conventional MRI in lymphomas patients.

At the same time, we note that to refine the nature of the lesion sighting study, with optimal for the intended type of lesion diagnostic methods, should be hold.

MRI of the whole body can also be used as a screening method in oncology even in patients without cancer history.

Compared with PET MRI advantages are a clear reflection of the anatomical structures, exact location of the lesions and detection of lesions less than the resolution of the PET scanner.

Compared with CE CT whole-body MRI is more sensitive in patients with focal lesions localized in the unaltered surrounding soft tissues and early inflammatory and post treatment infarction changes of bone marrow. Considering the signal characteristics we are able indirectly judge the residual activity of lymphoid tissue in patients in remission.

CT saves it predominance in sensitivity, but not specificity, in small foci in lungs.

Evaluation of true and false positive results were based on the data of follow-up, as the histological verification of all lesions in disseminated process is not possible.

The sensitivity of MRI was up to 96%, specificity of MRI reaches 94% and overall accuracy is up to 94%

Whole-body MRI is a highly sensitive method for detecting focal lesions, including oncology nature ones, with no additional radiation exposure. This is important to support patients during treatment: it is possible to conduct more frequent and complete control of therapy efficiency in patients with various forms of lymphoproliferative disease, to improve and to change tactics and strategies of treatment.

Due to the natural blood contrast whole-body MRI allows to evaluate with sufficient accuracy the relationships between lymphoma tumor and vessels. In some cases this makes it possible to escape contrast enhancement.
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