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Original Article

Whole-body magnetic resonance imaging and FDG-PET/CT for lymphoma staging: Assessment of patient experience

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ABSTRACT

Purpose: To compare patient experience of whole-body MRI and FDG-PET/CT performed for lymphoma staging.
Methods: One-hundred-fifteen patients (59 males, 56 females; 53 Hodgkin, 62 non-Hodgkin; mean age: 43.8 years) with lymphoma underwent whole-body MRI and FDG-PET/CT for staging and filled a questionnaire regarding their experience of the examinations using a 4-point Likert scale (1, very good; 4,very bad). Differences were evaluated using Wilcoxon signed-rank test. Patients were asked to express their preference on both techniques. Preferences were compared on the basis of gender, age, and Ann Arbor stage using the chi-square test. A p-value $\leq .05$ was considered significant.
Results: Most patients found FDG-PET/CT a more burdensome examination than whole-body MRI. Whole-body MRI received a significantly lower score regarding overall satisfaction ($p < .05$), patient experience before ($p < .05$) and after ($p < .05$) scan. No significant difference was found in scan preparation ($p = .207$) and patient experience during scan ($p = .38$). The average Likert scores were <2 in all criteria for both types of scan. 54 patients preferred whole-body MRI, 10 preferred FDG-PET/CT, and 51 had no preference. There was no significant difference in technique preference according to gender ($p = .73$), age ($p = .43$), and stage ($p = 1.00$).
Conclusions: Whole-body MRI and FDG-PET/CT demonstrate high degree of patients' acceptance and tolerance.

1. Introduction

The staging of newly diagnosed lymphoma includes an accurate imaging evaluation of disease location and extent. ^{18}F-fluorodeoxyglucose-positron emission tomography/computed tomography (FDG-PET/CT) and contrast-enhanced CT are currently the modalities of choice for lymphoma staging [1,2]. FDG-PET/CT provides relevant metabolic information and its reliability in response assessment during treatment and end-of-treatment evaluation is now widely demonstrated [1–4]. However, FDG-PET/CT does leave patients exposed to substantial radiation dose and an increased risk of cancer [5]. Previous studies have demonstrated a high rate of secondary malignancies in patients with lymphoma because of chemo- and radiotherapy [6]. Whole-body magnetic resonance imaging (WB-MRI) with diffusion-weighted imaging (DWI) is a radiation free technique that meets the needs of total body imaging [7] and is already applied in most oncologic fields [8–10]. Several studies have proved the high diagnostic accuracy and usefulness of WB-MRI in staging and follow-up of lymphoma patients [11–17]. It is well known that medical examinations may cause a strong psychological burden in oncologic patients [18,19], with severe discomfort and anxiety that can increase the risk of artefacts during radiological procedures [20].

The aim of our study was to compare patient experience of WB-MRI and FDG-PET/CT performed for staging of newly diagnosed lymphoma.

Abbreviations: FDG-PET/CT, ^{18}F-fluorodeoxyglucose-positron emission tomography/computed tomography; WB-MRI, whole-body magnetic resonance imaging; DWI, diffusion-weighted imaging.

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2. Materials and methods

2.1. Patients

This prospective study included patients with newly diagnosed lymphoma who underwent WB-MRI and FDG-PET/CT for disease staging between November 2013 and January 2016.

Inclusion criteria were: age over 14 years, histological proof of lymphoma, WB-MRI and FDG-PET/CT performed before treatment, and performance status values of $\leq$2 according to the Eastern Cooperative Oncology Group (ECOG) scale.

A total of 135 patients were identified. Twenty were excluded because they refused to complete the questionnaire. Thus, our final population was composed of 115 patients (59 males, 56 females; 53 Hodgkin, 62 Non-Hodgkin; mean age 43.8 years, range 15–82) who underwent both WB-MRI and FDG-PET/CT before treatment. Demographic characteristics, lymphoma histology, and Ann Arbor stage of our study population are shown in Table 1. All WB-MRI scans were of diagnostic quality.

Patients were randomly assigned to get the WB-MRI or FDG-PET/CT first. The mean interval time between WB-MRI and FDG-PET/CT studies was 7.3 days (range 4–10). Institutional review board approval was obtained for this study. All patients provided written informed consent after receiving full explanation of the benefits and risks of the procedure either WB-MRI and PET before examination. All procedures performed in this study were in accordance with the Helsinki declaration and its later amendments or comparable ethical standards.

2.2. WB-MRI

All WB-MRI scans were performed at closed 1.5 T MR scanner (Achieva, Philips Healthcare, the Netherlands) without contrast agent administration. The following sequences were used: coronal T1-weighted turbo spin-echo (repetition time, 322 ms; echo time, 18 ms; slice thickness, 6 mm; gap, 1 mm; cranio-caudal coverage, 185.5 cm), coronal short time inversion recovery (repetition time, 1498 ms; echo time, 64 ms; inversion time, 165 ms; slice thickness, 6 mm; gap, 1 mm; cranio-caudal coverage, 185.5 cm), and an axial diffusion-weighted imaging with background body signal suppression (b values = 0 and 800 s/mm^2; repetition time, 3134 ms; echo time, 64 ms; slice thickness, 6 mm; gap, 0 mm; cranio-caudal coverage, 96 cm). We used the built-in body receiver coil. The mean WB-MRI examination time was 35–40 min, including patient positioning.

Table 1
Demographic characteristics, lymphoma histology, and Ann Arbor stage of our study population.

	Hodgkin (53)	Non-Hodgkin (62)
Age		
Mean (range)	31.8 (15–66)	54 (21–86)
Gender		
Male	23	35
Female	30	27
Lymphoma subtype		
Nodular sclerosis	47	
Lymphocite-rich	3	
Mixed cellularity	3	
Diffuse large B-cell		27
Follicular		15
Marginal zone B-cell		7
Mantle cell		7
Lymphoplasmacytic		4
Peripheral T-cell		1
Anaplastic large cell		1
Stage		
I	1	1
II	30	13
III	13	9
IV	9	39

2.3. FDG-PET/CT

FDG-PET/CT scans were performed with two PET/CT scans (Gemini Scan, Philips Medical Solutions and Discovery ST, GE Medical Systems). Before the injection of FDG, the patient blood glucose level was checked and if it was above 200 mg/dl the scan was not performed. The CT images were acquired from the skull base to the proximal thigh and then the PET was obtained. The mean FDG-PET/CT examination time, including the time interval between injection of the radiopharmaceutical and acquisition of PET/CT images, was about one hour and a half.

After a six-hour fasting period, patients were injected with 3.7 MBq/kg body weight of FDG. Blood glucose levels were checked before injection. Following 60 ± 10 min of uptake period. CT was performed from skull base to pelvis by implementing a scout view using 10 mA and 120 kVp scanning parameters, followed by a spiral CT with 80 mA, 140 kVp. After completion of CT, 2D PET emission data (4 min per bed position covering an axial FOV of 15.7 cm with a 3-slice overlap) was obtained. FDG-PET/CT was performed within about 90–100 min, including the period between the injection of FDG and the FDG-PET/CT scan acquisition. CT data was used for attenuation correction. The field of view and pixel size of PET images reconstructed for fusion were 60 cm and 4.7 mm respectively, with a matrix size of 128 by 128.

2.4. Questionnaire

Each patient was asked to fill a questionnaire immediately after the examination. The questionnaire was similar to that used by Adams et al. in a previous study [21] and measured: scan preparation (e.g., insertion of intravenous line); patient experience before the scan (e.g., fear); patient experience during the scan (e.g., fear, discomfort, helplessness); patient experience shortly after the scan (discomfort, emotional distress); overall satisfaction. Evaluation was performed using a 4-point Likert scale (1, very good; 4, very bad). When patients reported a score of 3 or 4, they were asked to explain the reason of their answer. After completing the questionnaires, patients were asked to express their preference on the two techniques.

2.5. Statistical analysis

Data were collected and organized into a statistical database. Differences in experience between WB-MRI and FDG-PET/CT were evaluated using Wilcoxon signed-rank test.

To assess any potential influence of patient-related factors on preference, gender, age ($\leq$25 vs. >25 years), and Ann Arbor stage (early; 1–2, vs. advanced; 3–4) were compared between patients who preferred WB-MRI and those who preferred FDG-PET/CT, using the chi-square (χ^2) test.

A p-value of <.05 was considered statistically significant.

Statistical analysis was performed with software (STATA, version 13.1, StataCorp LP, College Station, Texas, USA).

3. Results

3.1. Patient experience

Most patients found FDG-PET/CT a more burdensome examination than WB-MRI. The mean score for WB-MRI overall satisfaction was significantly higher than that of FDG-PET/CT. WB-MRI

received a significantly lower score for patient experience before the scan and immediately after scan. There was no statistically significant difference in scan preparation and patient experience during the scan. The questions listed on the questionnaire and the questionnaire responses are detailed in Table 2.

Regarding FDG-PET/CT, the reasons of concern and discomfort were:

- During scan preparation, pain and fear for contrast injection (9/115 patients, 7.8%).
- Before the scan, fasting period (4/115 patients, 3.5%) and waiting time (6/115 patients, 5.2%).
- During the scan, fear for radiation exposure and its possible long-term adverse effects (5/115 patients, 4.3%).
- After the scan, the need to limit contact for 24 h with other people (10/115, 8.7%).
- in addition, few patients were little groggy after FDG-PET/CT scan (4/115, 3.5%).

Regarding WB-MRI, claustrophobia was the only source of concern during scan preparation, before and during WB-MRI scan, in six out of 115 patients (5.2%) and two of them required oral sedation to tolerate WB-MRI; none of them stopped the examination.

3.2. Patient preference

Fifty-four (47%) patients preferred WB-MRI, 10 (9%) preferred FDG-PET/CT and 51 (44%) had no preference.

There was not statistically significant difference in imaging modality preference according to gender (p = .73), age (p = .43), and Ann Arbor stage (p = 1.00). Details are shown in Table 3.

Fig. 1 shows a representative case of our study population.

Table 2
The questions listed on the questionnaire and the questionnaire responses.

	WB-MRI	FDG-PET/CT	p-value
Scan preparation: How did you experience the preparation of the scan?	1.49 [1–4]	1.60 [1–4]	.207
Experience before scan: Were you worried before the scan?	1.15 [1–3]	1.58 [1–4]	<.05
Experience during scan: Were you afraid during the examination?	1.47 [1–4]	1.56 [1–4]	.38
Experience after scan: How did you feel directly after the scan?	1.17 [1–2]	1.49 [1–3]	<.05
Overall satisfaction: How did you experience the examination?	1.22 [1–2]	1.38 [1–4]	<.05

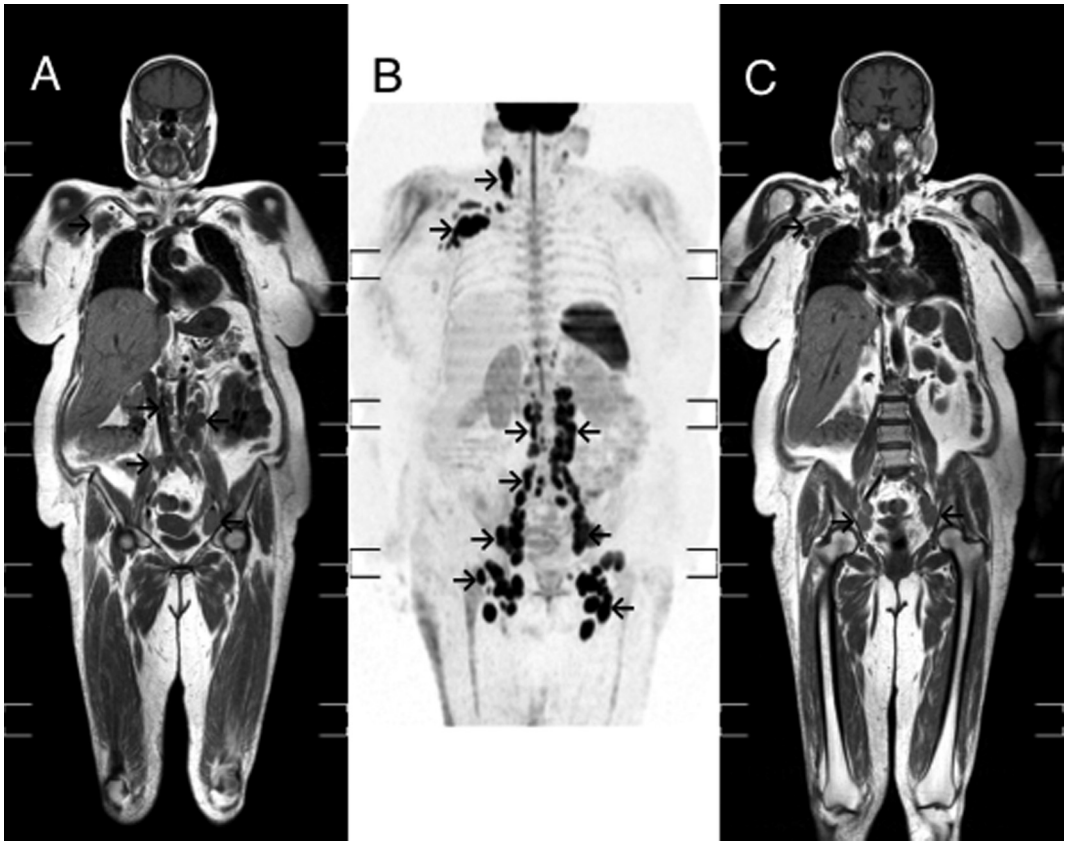

Fig. 1. A 54-year-old woman with Follicular lymphoma. Coronal T1-w (A, C) and coronal MIP grey-scale inverted DWI (B) images show right cervical and axillary, retroperitoneal periaortic, bilateral iliac, and inguinal lymph node involvement (arrows).

Table 3
Comparison between patients who preferred WB-MRI and those who preferred FDG-PET/CT on the basis of gender, age, and Ann Arbor stage.

	Pts who preferred WB-MRI	Pts who preferred PET-CT	p-value
Gender	26 m; 28 f	6 m; 4 f	.73
Age	14 < 25 y; 40 > 25 y	1 < 25 y; 9 > 25 y	.43
Stage	24 early; 30 advanced	4 early; 6 advanced	1.00

m: male; f: female; y: years old.

4. Discussion

This study demonstrated that most patients with newly diagnosed lymphoma found FDG-PET/CT a more burdensome examination than WB-MRI. However, our results showed a low rate of negative experience with average Likert scores being <2 in all criteria for both types of scan; although there may be a statistical difference between the two scans, both techniques appear to have been well tolerated. Regarding FDG-PET/CT, the main sources of discomfort were pain and fear for injection of FDG, fasting period, length of waiting time, high doses of ionizing radiation, and the need to limit contact with other people after the examination. These findings reflect the advantages and strengths of WB-MRI. The absence of ionizing radiations reduces potential long-term adverse effects, while the absence of contrast administration avoids the need of fasting period before scan. Moreover, the increasing awareness and concern in the scientific community regarding the potential gadolinium toxicity have led to suggest caution in the administration of gadolinium-based contrast agents in several fields [22,23]. Furthermore, mean FDG-PET/CT examination time is greater than that of WB-MRI, including the interval time between radiopharmaceutical injection and images acquisition [11,24]. Thus, the lower length of waiting time with WB-MRI might reduce patient anxiety. In a few cases, the main problem during WB-MRI scan was claustrophobia. Two patients required oral sedation before the scan but none of them stopped the examination. In a previous study performed on a large cohort of patients subjected to MR imaging, most of those requiring sedation were having brain MRI [25]. Our WB-MRI protocol without contrast agent administration was relatively fast (35 min); thus, our patients had high possibility to tolerate the WB-MRI scan than with longer protocols. In our study, there were not statistically significant differences in gender, age, and disease stage between patients who preferred WB-MRI and those who preferred FDG-PET/CT. It is extremely important to make the radiological examinations as comfortable as possible, especially if the patient is suffering from oncologic diseases with the subsequent psychological repercussions. In addition, patient anxiety may significantly affect image quality [20]. Moreover, anxiety can lead to changes in blood glucose levels, thus reducing image quality of FDG-PET/CT [19]. Anxiety can also increase pulse rate, respiratory rate, and patient movement leading to artifacts imaging scans [26]. Heart pulsation, breathing, and patient motion cause a miscalculation of apparent diffusion coefficient map on WB-MRI, especially in the mediastinum [27], and an incorrect superimposition of PET and CT data on FDG-PET/CT [28]. To our knowledge, this is the first study comparing patient experience of WB-MRI and FDG-PET/CT. Adams et al. compared patient experience of WB-MRI and CT for staging newly diagnosed lymphoma and found that patients preferred WB-MRI over contrast enhanced CT because of scan preparation [21]. Shortman et al. compared PET/MRI and PET/CT and reported an increased psychological burden of PET/MRI [18]. A limitation of our study is that we investigated only patients with newly diagnosed lymphoma, so other studies should be performed on different samples of patients and during follow-up when patients are more conscious of the procedure of diagnostic modalities.

5. Conclusions

Multiple whole body imaging procedures availability expands diagnostic options. However, focus should not only be placed on diagnostic modalities accuracy but also on patients experience and requirements. WB-MRI and FDG-PET/CT are both imaging techniques with well-established feasibility and reliability in oncologic imaging, which also demonstrate high degree of patients' acceptance and tolerance.

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