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Diagnostic value of whole-body diffusion-weighted magnetic resonance imaging for detection of primary and metastatic malignancies: A meta-analysis

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ABSTRACT

Purpose: To perform a meta-analysis to evaluate the diagnostic performance of whole-body diffusion-weighted magnetic resonance imaging (WB-DWI) technique in detection of primary and metastatic malignancies compared with that of whole-body positron emission tomography/computed tomography (WB-PET/CT).

Materials and methods: Search Pubmed, MEDLINE, EMBASE and Cochrane Library database from January 1984 to July 2013 for studies comparing WB-DWI with WB-PET/CT for detection of primary and metastatic malignancies. Methodological quality was assessed by the quality assessment of diagnostic studies (QUADAS) instrument. Sensitivities, specificities, predictive values, diagnostic odds ratio (DOR) and areas under the summary receiver operator characteristic curve (AUC) were calculated. Potential threshold effect, heterogeneity and publication bias were investigated.

Result: Thirteen eligible studies were included, with a total of 1067 patients. There was no significant threshold effect. WB-DWI had a similar AUC (0.966 (95% CI, 0.940–0.992) versus 0.984 (95% CI, 0.965–0.999)) with WB-PET/CT. No significant difference was detected between AUC of WB-DWI and WB-PET/CT. WB-DWI had a pooled sensitivity of 0.897 (95% CI, 0.876–0.916) and a pooled specificity of 0.954 (95% CI, 0.944–0.962). WB-PET/CT had a pooled sensitivity of 0.895 (95% CI, 0.865–0.920) and a pooled specificity of 0.975 (95% CI, 0.966–0.981). Heterogeneity was found to stem primarily from data type (per lesion versus per patient), MR sequence (DWIBS only and DWIBS with other sequence), and primary lesion type (single type and multiple type). The Deeks's funnel plots suggested the absence of publication bias.

Conclusion: WB-DWI has similar, good diagnostic performance for the detection of primary and metastatic malignancies compared with WB-PET/CT. DWIBS with other MR sequences could further improve the diagnostic performance. More high-quality studies regarding comparison of WB-DWI and WB-PET/CT and combination of them in detecting malignancies are still needed to be conducted.

1. Introduction

In oncology, detection and staging of primary and metastatic malignancies are of importance. Both presence and extent of malignancies are crucial factors for the survival of patients. As tumor spread may involve different anatomical regions, accurate detection of distant malignancies is a fundamental precondition for guiding subsequent staging and optimal management. Whole-body detection and evaluation require combined imaging protocols that are tailored individually to the given disease entity and region of interest. Past clinical practice has shown that fluorine 18 fluorodeoxyglucose positron emission tomography/computed tomography (FDG PET/CT) possesses substantially higher sensitivity and specificity in detection and staging for some malignancies compared with CT or PET alone, although expensive and radioactive ions such as fluorine-18-2-fluoro-2-deoxy-D-glucose are its disadvantages [1]. In recent years, whole-body magnetic resonance imaging (WB-MRI), with its lack of ionizing radiation but high contrast and spatial resolution, has been put forward as another promising whole-body technique for the assessment of distant metastases in patients with malignant tumor [2,3]. Up to date, WB-MRI provides mainly morphological information on tumor spread; however, the lack of functional information has been overcome

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by the introduction of whole-body diffusion-weighted magnetic resonance imaging (WB-DWI) in clinical practice [4]. With the introduction of diffusion-weighted whole-body MRI with background body signal suppression (DWIBS) technique [5], WB-DWI has become clinically feasible. It has been applied to detect primary and metastatic malignancies in patients with suspicious tumors [6–9].

Although the role of WB-DWI has been well assessed in the literature, there remain some controversial results. With DWIBS, tumor sites may be detected throughout the entire body with high contrast resolution; however, exact localization of lesions with DWIBS may be less accurate due to lack of anatomical reference because most normal anatomic structures signal is suppressed. DWIBS provides complementary value to morphological imaging studies. So we performed a meta-analysis to assess the overall diagnostic value of DWIBS as a reliable WB-DWI protocol in detection of primary and metastatic malignancies compared with that of WB-PET/CT, which, to our knowledge, has not previously been studied.

2. Methods

2.1. Publication search

Pubmed, MEDLINE, EMBASE, Cochrane Library database were all searched (Last search was updated on July, 2013). The following terms were used in searching: (DWIBS OR diffusion weighted imaging with background signal suppression OR whole-body diffusion-weighted imaging OR whole-body DWI) and (neoplasm OR malignancy OR tumor OR cancer). All the searched studies were retrieved, and their references were checked as well for other relevant publications. We also review articles to find additional eligible studies.

2.2. Inclusion and exclusion criteria

Studies meeting the following selection criteria were included in this meta-analysis: (1) whole-body DWI or DWIBS and 2-fluoro-2-deoxy-D-glucose (FDG) WB-PET/CT detected or evaluated primary or metastatic lesion in patients of all ages regardless of the location of primary tumors (2) for per-patient or per-lesion statistics, sufficient data were presented to calculate true-positive (TP), false-positive (FP), true-negative (TN) and false-negative (FN) in the original published study, (3) articles were published in English, (4) lesions were confirmed with histopathologic analysis and/or clinical and imaging follow-up, (5) the two imaging modalities (WB-DWI and WB-PET/CT) were performed within 1 month of one another (6) ten or more patients were included. (7) When data or subsets of data were presented in more than one article, the article with the most details or the most recent article was chosen. Studies were excluded based on the following criteria: (1) only WB-PET/CT or WB-DWI was performed. (2) Totals of true positives, false positives, true negatives, and false negatives were not provided.

2.3. Data extraction and quality assessment

Relevant studies were examined by two independent observers with the Quality Assessment of Diagnostic Studies (QUADAS) [10] tool specifically developed for systematic reviews of diagnostic test accuracy. Data extraction including characteristics of the study design, types of primary and metastatic lesion, methodological details for whole-body DWI, and outcome data was performed independently and discrepancies were resolved by discussion by 2 reviewers. The relevant data (TP, FP, TN, FN) were extracted into designed data collection forms.

Table 1
The characteristics of the each study included.

Author	Year	Age	Study design	No. of patients	No. of lesions	Malignancies type	Primary lesion type	Detected lesion type	Data type	MR strength	MR sequence
Manenti1	2011	48–79	Retrospective	45	202	Colo-rectal cancer, lung cancer, Hodgkin lymphoma, multiple myeloma, breast cancer	Multiple type	Multiple type	Per lesion	3T	DWIBS,T1W,T2W,CE-T1W
Manenti2	2011	48–79	Retrospective	45	202	Colo-rectal cancer, lung cancer, Hodgkin lymphoma, multiple myeloma, breast cancer	Multiple type	Multiple type	Per lesion	3T	DWIBS
Stecco	2009	18–80	Prospective	29	1320	Lymphoma, lung cancer, breast cancer, prostate cancer, kidney cancer	Multiple type	Multiple type	Per lesion	1.5T	DWIBS
Sakurai	2013	17–74	Prospective	23	290	Bone metastases from thyroid carcinoma	Single type (thyroid cancer)	Single type	Per lesion	3T	DWIBS, T1W, T2W
Chen1	2010	35–76	Prospective	56	135	Lymph metastases from lung cancer	Single type (lung cancer)	Single type	Per lesion	1.5T	DWIBS
Chen2	2010	35–76	Prospective	56	197	Metastases from lung cancer	Single type (lung cancer)	Multiple type	Per lesion	1.5T	DWIBS
Ohno1	2008	47–85	Prospective	203	ND	Lung cancer, metastasis	Single type (lung cancer)	Multiple type	Per patient	1.5T	DWIBS, T1W, T2W STIR
Ohno2	2008	47–85	Prospective	203	ND	Lung cancer, metastasis	Single type (lung cancer)	Multiple type	Per patient	1.5T	DWIBS
Fischer1	2011	46–74	Prospective	64	374	Lung, liver, malignant lymph	Multiple type	Multiple type	Per patient	1.5T	DWIBS, T2W
Fischer2	2011	46–74	Prospective	64	374	Lung, liver, malignant lymph	Multiple type	Multiple type	Per patient	1.5T	DWIBS
Takenaka1	2009	45–83	Prospective	115	1025	Bone metastases from lung cancer	Single type	Single type	Per patient	1.5T	DWIBS, T1W
Takenaka2	2009	45–83	Prospective	115	1025	Bone metastases from lung cancer	Single type	Single type	Per patient	1.5T	DWIBS
Mosavi	2011	57–80	Prospective	49	ND	Bone metastases from prostate cancer	Single type	Single type	Per patient	1.5T	DWIBS, T1W, STIR

DWIBS: diffusion weighted imaging with background signal suppression.