Skull metastases detecting on arterial spin labeling perfusion

Three case reports and review of literature

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Abstract

Rationale: Detection of skull metastases is as important as detection of brain metastases because early diagnosis of skull metastases is a crucial determinant of treatment. However, the skull can be a blind spot for assessing metastases on routine brain magnetic resonance imaging (MRI). To the best of our knowledge, the finding of skull metastases on arterial spin labeling (ASL) has not been reported. ASL is a specific MRI sequence for evaluating cerebral blood flow using magnetized endogenous inflow blood. This study uses ASL as a routine sequence of brain MRI protocol and describes 3 clinical cases of skull metastases identified by ASL. The study also highlights the clinical usefulness of ASL in detecting skull metastases.

Patient concerns: Three patients with known malignancy underwent brain MRI to evaluate for brain metastases.

Diagnoses: All of the skull metastases were conspicuously depicted on routine ASL images, and the lesions correlated well with other MRI sequences.

Interventions: Three patients received palliative chemotherapy.

Outcomes: Three patients are being followed up regularly at the outpatient department.

Lessons: The routine use of ASL may help to detect lesions in blind spots, such as skull metastases, and to facilitate the evaluation of intracranial pathologies without the use of contrast materials in exceptional situations.

Abbreviations: 18F-FDG PET-CT = 18F-fluorodeoxyglucose positron emission tomography CT, ASL = arterial spin labeling, CBF = cerebral blood flow, CT = computed tomography, FOV = field of view, MRI = magnetic resonance imaging, T1WI = T1-weighted image, T2WI = T2-weighted image.

Keywords: arterial spin labeling, brain magnetic resonance imaging, skull metastases

1. Introduction

The skull is a common site of metastases from systemic malignancies; hence, early diagnosis has an impact on clinical judgment and clinical management.1 In clinical practice, computed tomography (CT) is commonly used for evaluating bony abnormality, though magnetic resonance imaging (MRI) is also used for screening and assessing bone lesions.2 In cases of skull metastases, MRI provides additional information, such as

type, location, multiplicity, and anatomical relationship to the brain and other intracranial structures.3 Even though skull metastases are not rare, the diagnosis is often difficult because they have a wide range of clinical manifestations and radiologic work up is not always available in clinical practice. The detection of skull metastases is not also easy in patients without a known malignancy.

In the literature, there are many studies on skull metastases and their radiological findings. However, there is hardly any report on skull metastases in arterial spin labeling (ASL). ASL is a noninvasive MRI technique used to measure cerebral blood flow (CBF) by inducing the magnetization of inflowing blood.4 Recently, ASL has been applied to various intracranial diseases including neurodegenerative disease, cerebrovascular disease and brain tumors.5 This study presents 3 clinical cases of skull metastases identified on ASL, a routine sequence of brain MRI protocol used at the institution where the study was conducted. This study also provides a brief review of skull metastases and highlights the clinical usefulness of ASL in detecting these metastatic conditions.

1.1. Case report

This was purely an observational case study, and the patient’s management and outcome were unaltered. Therefore, no ethical approval was required for this case report. Written informed consent was obtained from the patient for publication of this case report and accompanying images.
1.2. Case 1

A 62-year-old woman with breast cancer underwent brain MRI evaluation for brain metastases. Brain MRI was performed using a 3T system (Signa Architect; GE Healthcare, Milwaukee, WI) with routine use of synthetic MRI and a 48-channel head coil. ASL was included in the routine brain MRI sequences with the following scan parameters: TR, 4732 ms; TE, 10.3 ms; field of view (FOV), 23 cm; section thickness, 5 mm; NEX, 1; and acquisition time, 1 minute 50 seconds. Pseudocontinuous ASL technique was used with labeling delay of 2 seconds. The brain MRI revealed an enhancing intraaxial mass with perilesional edema in the right frontal lobe (arrowheads in A–C), suggesting brain metastases. In addition, there were 3 enhancing foci in the bilateral parietal bones on enhanced 3D T1WIs, suggestive of bone metastases (arrows in C, H). Two of the 3 enhancing lesions showed subtle bone marrow signal change on T1WIs (arrowheads in B, G) and T2WIs (arrowheads in A, F). However, one enhancing lesion in the left parietal bone (white arrow in H) demonstrated no definite signal change on synthetic T1WI and T2WI (F, G). On ASL, the 3 enhancing bone metastases showed increased CBF (arrows in D, I) and the skull metastases could therefore be easily detected. On 18F-FDG PET-CT, the corresponding bone lesions showed increased metabolic activities (arrows in E, J). ASL = arterial spin labeling, CBF = cerebral blood flow, MRI = magnetic resonance imaging, T1WI = T1-weighted image, T2WI = T2-weighted image.

1.3. Case 2

A 79-year-old woman who had metastatic serous papillary carcinoma in the neck underwent brain MRI for evaluation of brain metastases. There was a focus of increased CBF in the right side clivus on ASL (arrowhead in D). The corresponding lesion showed subtle hypointensity on synthetic T2WI (A), hypointensity on synthetic T1WI (B) and mild enhancement on enhanced 3D T1WI (C). The lesion was considered as bone metastases. Unlike routine sequences including T1WI and T2WI, ASL clearly demonstrated bone metastases by increased CBF. On 18F-FDG PET-CT, the corresponding skull lesions showed increased metabolic activity (Fig. 1E, J). These findings were correlated well with finding from ASL.

1.4. Case 3

A 70-year-old man with lung cancer underwent brain MRI to evaluate for brain metastases. Brain MRI was performed using a 3T system (Ingenia CX; Phillips, Amsterdam, the Netherlands)
MRI can also provide more information regarding metastases, because of the associated excellent soft tissue contrast. Fat suppressed T1WI demonstrates variable enhancement on nonenhanced T1WI with a variable T2 signal intensity. MRI is also useful to detect a direct invasion to adjacent structures, such as dura, brain parenchyma, or cranial nerves. Therefore, meticulous radiological assessment of all sequences of brain MRI is crucial for evaluating obscure skull metastases in patients with known malignancies.

Other methods for diagnosing skull metastases include radionuclide bone scan and 18F-FDG PET-CT. Radionuclide bone scan has great sensitivity in detecting skull metastases, but it is known to be insufficient for purely osteolytic metastases. 18F-FDG PET-CT has comparable diagnostic accuracy of bone metastases to bone scan, and it becomes an important oncological imaging study. However, skull metastases can be missed on 18F-FDG PET-CT because the FOV intentionally excludes the skull vault because of its glucose content.

In the current cases, ASL was used as a routine sequence for brain MRI protocol. The results show that skull metastases have a conspicuous delineation on ASL in all 3 clinical cases. ASL is an MRI sequence that detects CBF using inflow blood as an endogenous tracer. Because ASL is a noninvasive technique that does not require exogenous contrast agent, it is clinically applied in various intracranial diseases, including neurodegenerative diseases, cerebrovascular diseases, vascular malformations, epilepsy, and brain tumors. In previous studies on neoplasms, ASL has been applied to evaluate intraxial tumors and to assess treatment response and has been employed in cases where gadolinium is contraindicated. A review of the literature shows that little previous work has focused on the clinical application of ASL in evaluating skull metastases.

Because of the removal of scalp tissues and background noise by postprocessing of ASL data, the skull does not display specific color on the multisection CBF maps. In the cases examined in this study, this technical background was helpful to detect skull metastases which showed increased CBF on ASL. In case 2, clival metastasis was detected only through ASL during initial radiological evaluation, and it corresponded to signal change in other sequences. These data suggest that the routine use of ASL may help detect skull metastases as well as brain metastases in patients with known malignancies. In addition, ASL also has an inherent advantage over other modalities because of noninvasive and repeatable sequences without gadolinium. Therefore, it can...
be readily performed in patients with renal insufficiency or history of contrast-mediated side effects.

In the current cases, all of the skull metastases were conspicuously depicted on routine ASL images, and the lesions correlated well with other MRI sequences. The findings of this report suggest that the routine use of ASL may help to detect lesions in blind spots, such as skull metastases, and to facilitate the evaluation of intracranial pathologies without the use of contrast materials in exceptional situations.

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