

Doughnut sign of hepatic alveolar echinococcosis on FDG PET/CT

Clinical case report

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Abstract

Rationale: A characteristic metabolic finding of hepatic alveolar echinococcosis (HAE) on positron emission tomography/computed tomography (PET/CT) correlates with morphologic features on CT and magnetic resonance imaging (MRI).

Patient concerns: A young man from an endemic area was admitted to our hospital due to right upper quadrant pain for 2 months.

Diagnosis: CT and MRI revealed a heterogeneous mass with calcification, consisting of central necrosis and peripheral solid inflammatory tissues. Accordingly, FDG PET/CT demonstrated a characteristic metabolic finding of doughnut sign. Combining the above characteristic imaging features with positive serologic findings, the patient was diagnosed as HAE.

Interventions: He then underwent extracorporeal hepatectomy and liver autotransplantation followed by medical treatment of benzimidazoles.

Outcomes: He remained asymptomatic without evidence of recurrence at 2-year follow-up.

Lessons: The characteristic metabolic appearance of HAE on FDG PET/CT, correlated with its morphologic features of CT and MRI, may allow to make accurate diagnoses.

Abbreviations: ¹⁸F-FDG PET/CT = ¹⁸F-fluorodeoxyglucose positron emission tomography/computed tomography, AE = alveolar echinococcosis, CECT = contrast-enhanced CT, CT = computed tomography, HAE = hepatic alveolar echinococcosis, MRI = magnetic resonance imaging.

Keywords: alveolar echinococcosis, CT, liver, MRI, PET/CT

1. Introduction

Alveolar echinococcosis (AE) is caused by infection with the larvae of the *Echinococcus multilocularis* tapeworm. The main endemic regions include parts of central Europe, much of Russia, the Central Asian republics, western China, northwestern Canada, and western Alaska.^[1]

The primary infection of metacestode develops almost exclusively in the liver, and then the larvae can metastasize to other organs including the lung and the brain by direct infiltration or hematogenous dissemination.^[1,2] Despite its parasitic nature,

hepatic AE (HAE) usually behaves like a malignancy that invades and destroys adjacent liver tissues, inducing infiltrating granulomatous and fibrous immune response.^[3] Thus, mixed solid and cystic lesions are common, especially central necrosis of the lesion. In addition, irregular calcifications are often observed. Conventional morphological imaging modalities including ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) that can show these image characteristics, play an important role in the diagnosis, planning of surgical resection and follow-up of HAE.^[4] However, information on parasite metabolic activity cannot be provided by conventional techniques. Currently, ¹⁸F-fluorodeoxyglucose positron emission tomography/computed tomography (¹⁸F-FDG PET/CT) has been regarded as a noninvasive tool for the assessment of HAE viability,^[5,6] of which imaging features mainly depend on the pathologic components of the HAE lesion.^[7] Herein, this case described a characteristic doughnut sign of HAE on PET/CT, which correlated with its contrast-enhanced CT (CECT) and MRI findings.

2. Case report

Because of right upper quadrant pain for 2 months, a 20-year-old man was admitted to our hospital. The initial ultrasonography showed a large mixed-echo mass in the right hepatic lobe. Axial CT image demonstrated an infiltrative tumor-like mass (approximately measuring 16 × 11 cm) with heterogeneous contents including peripheral scattered calcification and central necrosis (Fig. 1A). On the post-contrast arterial phase, no substantial enhancement was observed (Fig. 1B) while the delayed phase

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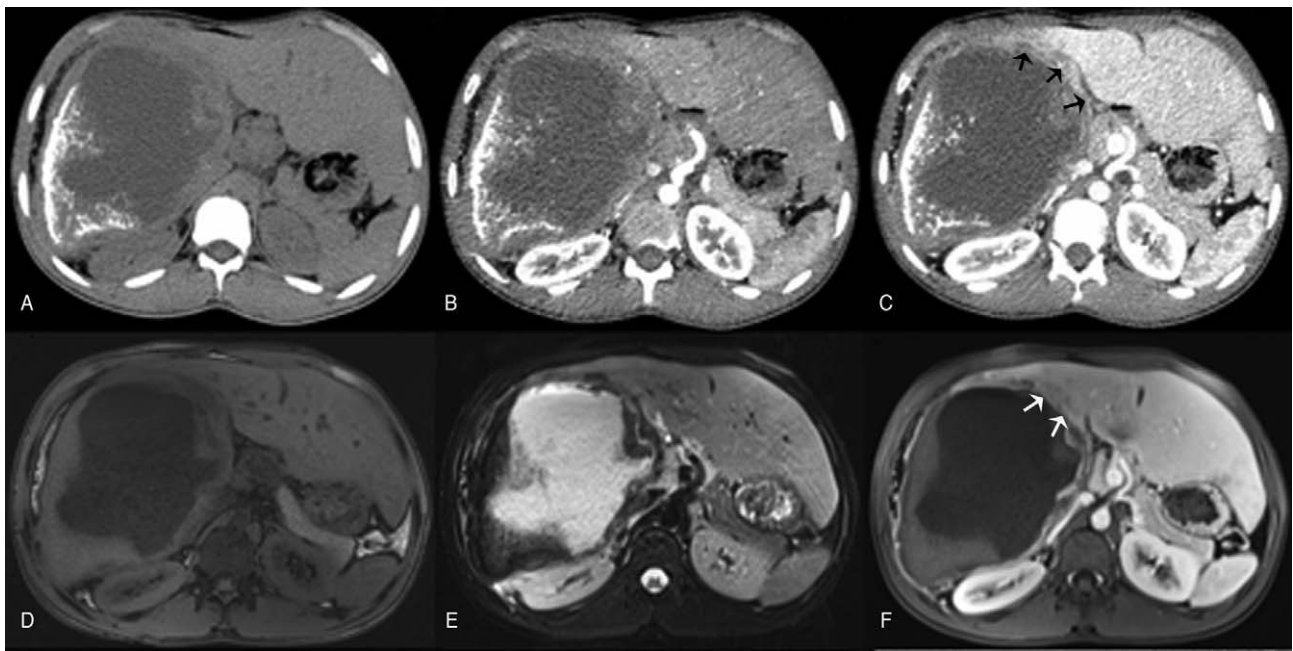


Figure 1. Hepatic alveolar echinococcosis in a young man. (A) Axial unenhanced CT image shows a heterogeneous mass in the right lobe with irregular margin including peripheral hyperattenuated calcification and central hypoattenuated necrosis. (B) Early phase of enhanced CT reveals no significant enhancement in the lesion. (C) Delayed phase of enhanced CT shows faint enhancement of inflammatory components (arrows) surrounding the lesion. (D) The lesion has hypointense or isointense signal on unenhanced T1-weighted image. (E) T2-weighted image reveals central hyperintense necrotic tissues and peripheral hyperintense fibrotic or collagenous components. (F) Contrast-enhanced T1-weighted image shows heterogeneous enhancement at the margin of the mass (arrows). CT = computed tomography.

revealed slightly enhanced components surrounding the lesion (Fig. 1C). Then, he underwent MR examination, and the lesion exhibited low to intermediate signal intensity on T1 weighted image (Fig. 1D) and heterogeneous signal intensity on T1 weighted image (Fig. 1E). High T2 signal intensity corresponded to necrotic tissues while low T2 signal intensity corresponded to surrounding fibrotic or collagenous components, which had heterogeneous enhancement after the injection of contrast agent (Fig. 1F). Approximately 60 minutes after injection of ^{18}F -FDG (310 MBq, 5MBq/kg), PET/CT examination was performed to estimate the metabolic activity of the lesion with a PET/CT modality (Gemini GXL, Philips Corp, the Netherlands). A low-dose CT scan (120kV, 40mA) was performed for attenuation correction followed by the acquisition of PET images in 3

dimensional mode for 2.5 minutes per bed position. On PET and fused PET/CT images, the heterogeneous mass presented with increased FDG uptake on its margin (SUVmax = 8.9) and a large hypometabolic region located centrally, a so-called doughnut sign (Fig. 2A and B).

The serum IgG titer for *Echinococcus granulosus* was also positive. Taking into account the imaging and serologic findings, a probable diagnosis of alveolar echinococcosis was suggested. The patient eventually underwent extracorporeal hepatectomy and liver autotransplantation, and the postoperative pathological analysis showed alveolar echinococcosis vesicles with laminar membranes (Fig. 2C). After surgical resection, he also received medical treatment of benzimidazoles, and until now he remains asymptomatic without evidence of recurrence.

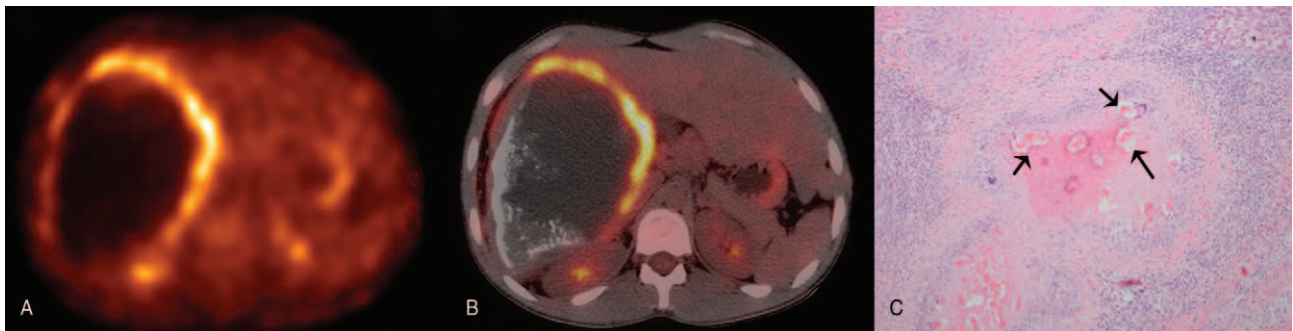


Figure 2. A doughnut sign of hepatic alveolar echinococcosis on FDG PET/CT. (A, B) A characteristic metabolic appearance correlates with morphologic features, including a peripheral hypermetabolic rim due to an inflammatory reaction and a central hypometabolic region due to necrotic components. (C) Photomicrograph (hematoxylin-eosin stain, $\times 100$) shows multiple alveolar echinococcosis vesicles surrounded by laminar membranes (arrows). FDG = fluorodeoxyglucose, PET/CT = positron emission tomography/computed tomography.

The Ethics Committee of West China Hospital of Sichuan University waived the need to obtain informed consent because this study is a retrospective case report.

3. Discussion

Because of the long clinical latency and asymptomatic period, HAE cannot be easily detected in the early clinical stage, with more than one-third of those affected reported to be incidentally detected.^[8] Without timely diagnosis and therapy, the prognosis is dismal with a high fatality rate.^[9] Considering the patient's medical history and clinical findings, the diagnosis is mainly based on the imaging features and serologic results, of which imaging features may depend on the parasite's growth stage and its pathophysiologic change.

In the liver, *E multilocularis* larvae evolve into multiple vesicles containing a germinal layer surrounded by a laminar membrane. Peripheral invasion into the host tissue causes an intense granulomatous response. A strong reactive fibrosis, commonly observed in HAE, compresses and obstructs peripheral biliary ducts or vessels, which leads to atrophic parenchyma with capsular retraction and pronounced enlargement of the lesion.^[10,11] Due to poor vascularization, necrosis frequently develops in the central part of large lesions. In addition, as the lesion heals, calcification develops in the surrounding granulomatous tissues.

Along with the above pathophysiologic changes, our case showed characteristic imaging features. Unenhanced CT revealed hyperattenuating calcifications and hypoattenuating areas corresponding to necrosis and parasitic tissues. The surrounding granulomatous tissues were observed in the delayed phase of CECT. Based on a proposed CT-morphological classification, our case primarily showed widespread cystoid (approximately >8cm) with more solid portions at the edge as well as calcification primarily at the edge.^[12] These characteristic features helped to facilitate the recognition and interpretation of HAE lesions and differentiate it from cholangiocarcinoma, biliary cystadenoma, or hepatic metastases.^[13,14] Although it is not as successful as CT in showing calcification, MRI is the best modality for characterizing the components of parasitic lesions and depicting vascular or biliary involvement.^[15] Central necrotic components and surrounding fibrotic or collagenous tissues are clearly displayed on T2 images. Since HAE lesions consist of cystic and solid components, Kodama et al proposed a MRI classification with 5 classes as follows: multiple small round cysts without a solid component (type 1, 4%), multiple small round cysts with a solid component (type 2, 40%), a solid component surrounding a large and/or irregular cysts with multiple small round cysts (type 3, 46%), a solid component without cysts (type 4, 4%), and a large cyst without a solid component (type 5, 6%).^[15] This classification is a simple and reliable method to compare patients' status between endemic areas and in further in multicenter studies.^[4,7,10] As reported in several previous studies, PET/CT scan of HAE often presented with a peripheral hypermetabolic rim and a central hypometabolic region.^[16–19] Increased FDG uptake at the periphery may be explained by the increased inflammatory response and metabolic activity of the inflammatory cells around the parasitic lesion.^[20,21] FDG PET/CT can reliably evaluate the inflammatory response and can explain the viability of the parasite indirectly, thus, it is the most accepted imaging modality for response assessment and long term follow-up.^[22] In our patient, CECT and MRI findings were compared with PET/CT appearances, and

the presence of granulomatous tissue was suggested to correlate with metabolically active disease.

In conclusion, imaging modalities including CT and MRI provide useful morphologic information for the accurate diagnosis of HAE, typically revealing a heterogeneous mass with central necrosis and peripheral contrast enhancement. Accordingly, FDG PET/CT demonstrates a characteristic metabolic finding of doughnut sign, showing the viability of HAE. Familiarity with these characteristic imaging findings will help to provide an accurate diagnosis.

Author contributions

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Funding acquisition: Anren Kuang.

Visualization: Ying Kou.

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