Abdominal Imaging

Published online: 3 October 2007

Abdom Imaging (2008) 33:133–143
DOI: 10.1007/s00261-007-9331-0

Echinococcosis of the liver

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Abstract

Echinococcosis, also known as hydatid disease, is an infection of larval stage animal tapeworm, *Echinococcus*. The larvae reside in the liver and lungs, producing multiloculated fluid-filled cysts. Imaging findings of Echinococcosis caused by *E. granulosus* are single, unilocular cyst or multiseptated cysts, showing ''wheel-like'', ''rosette-like'' or ''honeycomb-like'' appearances. There may be ''snow-flakes'' sign, reflecting free floating protoscoleces (hydatid-sand) within the cyst cavity. Degenerating cysts show wavy or serpentine bands or floating membranes representing detached or ruptured membranes. Degenerated cysts show heterogeneous, solid-looking pseudotumor that may show ''ball of wool sign''. Dead cysts show calcified cyst wall. Echinococcosis caused by *E. multilocularis* produces multilocular alveolar cysts with exogeneous proliferation, progressively invading the liver parenchyma and other tissues of the body. Imaging findings are ill-defined infiltrating lesions of the liver parenchyma, consisting of multiple small clustered cystic and solid components. On sonography, lesions are heterogeneous with indistinct margins, showing ''hailstorm appearance'' or ''vesicular or alveolar appearance''. CT and MR imaging displays multiple, irregular, ill-defined lesions. Multiple small round cysts with solid components are frequent. Large lesions show ''geographical map'' appearance. Calcifications are very frequent, appearing as peripheral calcification or punctuate scattered calcific foci. Invasion into the bile ducts, portal vein or hepatic vein may occur. Direct spread of infected tissue may result in cysts in the peritoneal cavity, kidneys, adrenal gland or bones.

Key words: Parasites—Echinococcosis—Hydatid disease—Liver disease—Liver cysts—CT—US—MR

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Echinococcosis, also known as hydatid disease, is an infection of humans caused by the larval stage of animal tapeworms, *Echinococcus granulosus, Echinococcus multilocularis*, or *Echinococcus vogeli*. *E. granulosus* produces unilocular cystic lesions, whereas *E. multilocularis* and *E. vogeli* produce multilocular alveolar cysts. Infection of *E. granulosus* is found in Mediterranean countries, the Middle East, eastern Europe, Africa, Argentina, Chile, China, Australia and New Zealand, where livestock is raised in association with dogs [1, 2]. Infection by *E. multilocularis* is widely distributed in the northern hemisphere including the United States, Canada, and central and northern Eurasia including China and Japan [1], and infection by *E. vogeli* in Central and South America.

Echinococcal species have both definitive and intermediate hosts. The definitive and intermediate hosts for *E. granulosus* are dogs and sheep, respectively. For *E. multilocularis*, the definitive and intermediate hosts are foxes and rodents (forest cycle) or less commonly, dogs and cats (rural cycle). The definitive hosts pass eggs in the feces and eggs are ingested by the intermediate hosts. After ingestion, embryos escape from the eggs,

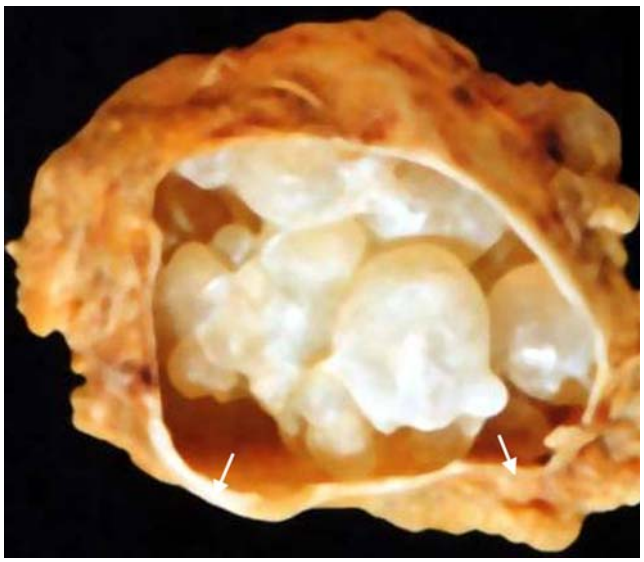

Fig. 1. Gross specimen of echinococcosis showing main cyst wall (*arrows*) consisting of external membrane and germinal layer and multiple daughter cysts. Note whitish transparent membrane of the germinal layer and daughter cyst wall.

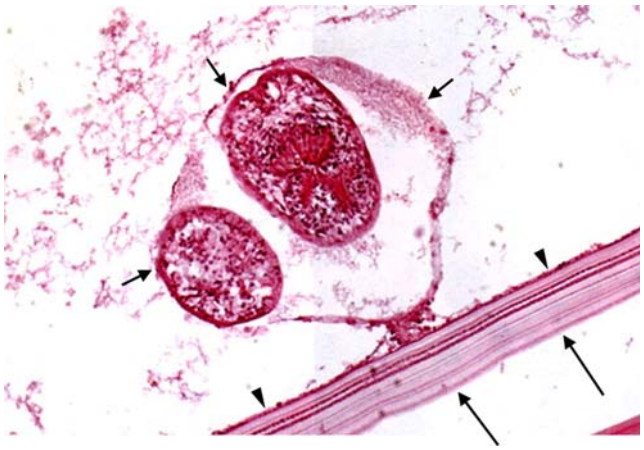

Fig. 2. Photomicrograph shows laminated membrane (*long arrows*) and germinal layer (*arrowheads*). Brood capsule (*short arrows*) arises from the germinal layer containing two protoscoleces.

penetrate the intestinal mucosa, enter the portal circulation, and are carried to various organs [1, 3], most commonly the liver and lungs in which larvae develop into fluid-filled cysts. When a dog or fox ingests raw tissues of sheep or mice containing parasitic cysts, the worm then matures in the small intestine of the definitive hosts. Humans become infected as an intermediate host by ingestion of wild berries, plants or water which is contaminated with eggs of the parasites or by direct contact with the definitive host.

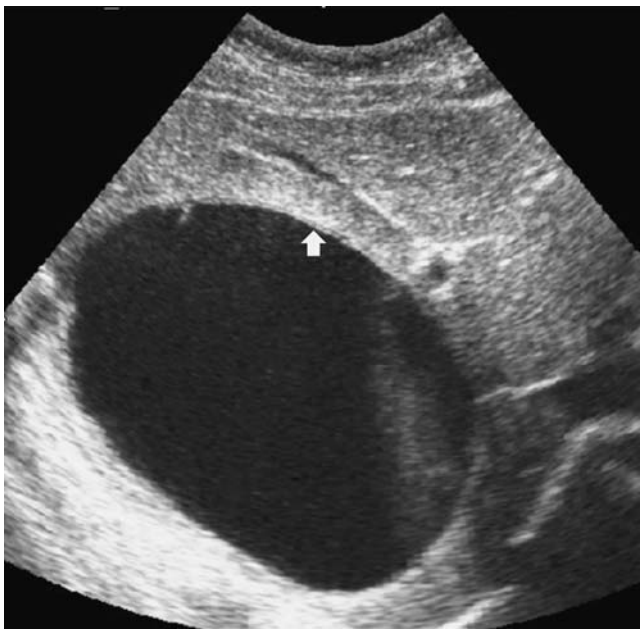

Fig. 3. A 55-year-old man with echinococcosis of liver. Sonography reveals a large anechoic liver cyst with double-line sign (*arrow*) anteriorly.

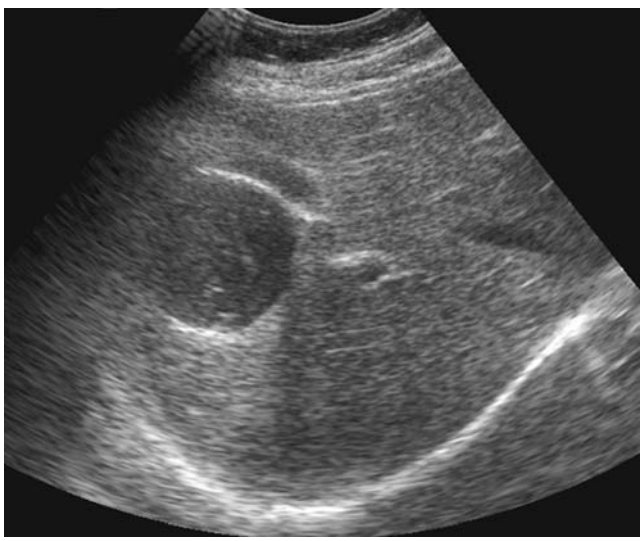

Fig. 4. A 10-year-old girl with echinococcosis. Sonogram shows cyst containing fine echoes ("snow flake sign") representing free-floating protoscoleces.

Clinical manifestations

Patients infected with *E. granulosus* are generally asymptomatic until expanding cysts gradually affect in the liver and elicit pressure symptoms. Cysts may grow for a period of 5–20 years, and may be discovered incidentally on a routine ultrasound or CT examination. Expanding cysts present with abdominal pain or palpa-

Fig. 5. A 50-year-old man with echinococcosis of liver. Sonograms show "honeycomb-like" or "wheel-like" cyst representing multiple daughter cysts.

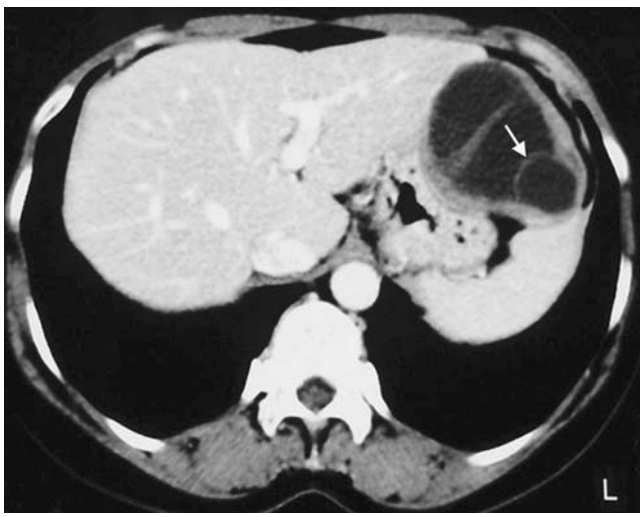

Fig. 6. A 47-year-old woman with echinococcosis of liver. Enhanced CT scan shows hepatic cyst with septum and daughter cyst (*arrow*).

ble mass in the right upper abdomen [2]. Cysts may compress the bile ducts and result in obstructive jaundice. Rupture of a cyst may produce fever, pruritus, eosinophilia or fatal anaphylaxis. Patients infected with *E. multilocularis* usually present with a slowly growing hepatic tumor. The patients complain of abdominal distention and diffuse abdominal pain, and obstructive jaundice may be apparent [2].

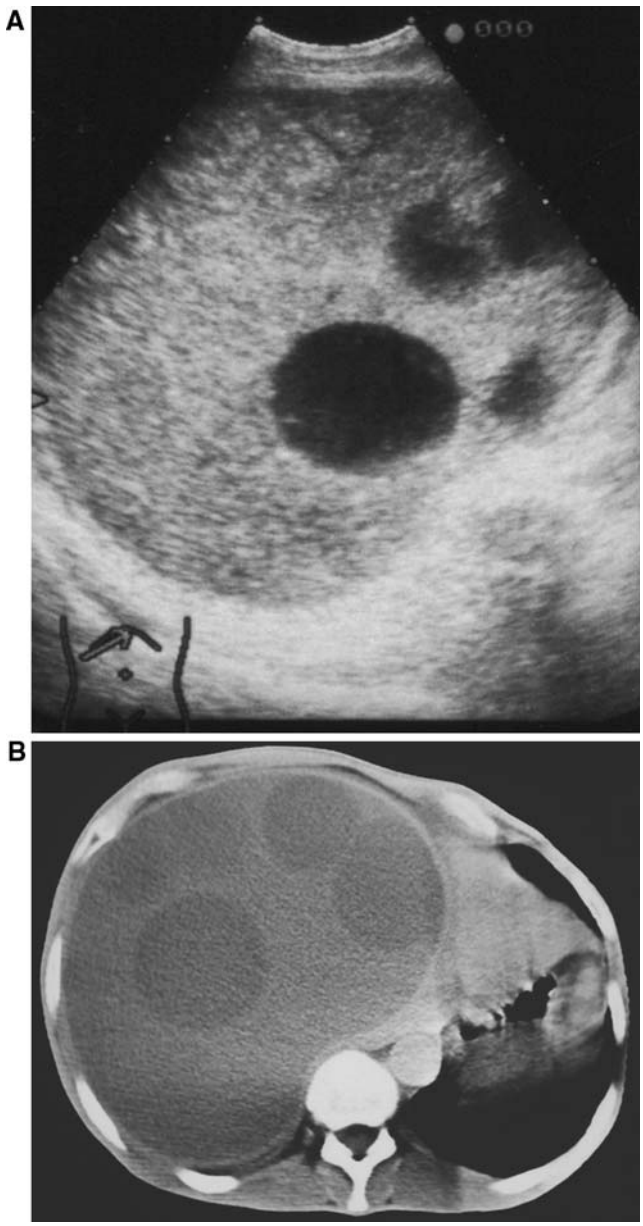

Fig. 7. A 65-year-old man with hydatid cyst with multiple daughter cysts. **A** Sonogram shows a large mother cyst and four daughter cysts. Note echogenic matrix in the mother cyst representing millions of scolices. **B** Enhanced CT image shows a large cyst possessing thick enhancing capsule and four daughter cysts. The content of the mother cyst shows high attenuation due to scolices.

Imaging findings

Pathology of echinococcosis by E. granulosus

When humans ingest dog *Taenia* eggs, embryos escape from eggs, penetrate the intestinal mucosa, enter the portal vein and are carried to the liver and lungs. The larvae develop into fluid-filled unilocular cysts that consist of an external membrane (compressed liver tis-

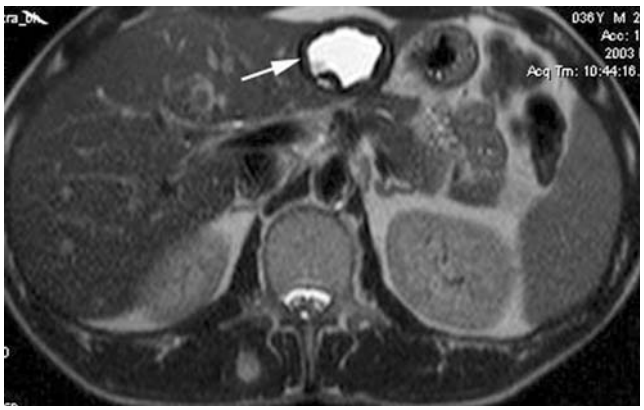

Fig. 8. A 36-year-old man with degenerating hepatic hydatid cyst. T2-weighted axial MR image shows a single cyst possessing hypointense, thick, fibrous capsule (*arrow*). Note thin undulated or wavy membranes within the cyst representing detached, delaminated germinal layers.

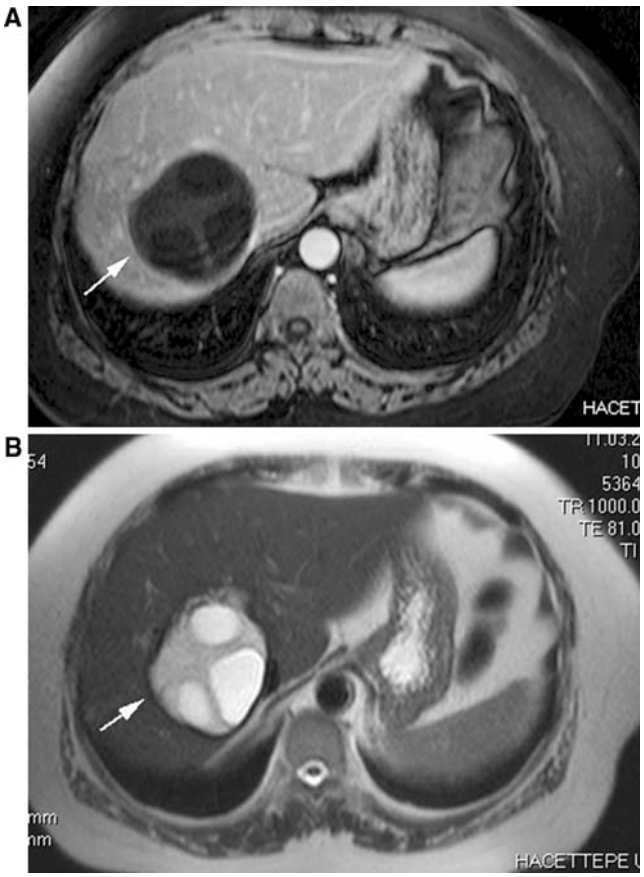

Fig. 9. A 43-year-old man with active hydatid cyst. **A** Postcontrast T1-weighted axial MR image shows a round cystic lesion containing daughter cysts with "cart wheel" appearance. **B** T2-weighted axial MR image shows a cyst containing several daughter cysts showing "rosette-like" appearance.

sue), a middle laminated layer and an inner germinal layer [1, 3] (Fig. 1). Brood capsules (germinating cyst) and daughter cysts develop from the inner aspect of the

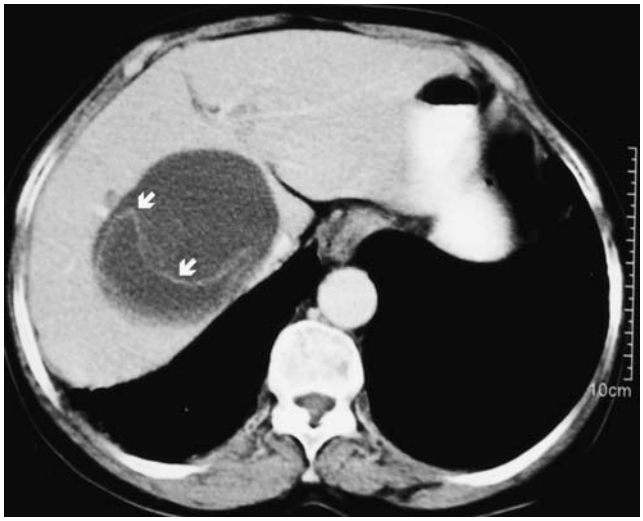

Fig. 10. A 65-year-old woman with liver hydatid cyst in degeneration. Enhanced CT scan shows liver hydatid cyst with detached membranes (*arrows*) indicating degeneration of the germinal layer.

Fig. 11. A 65-year-old man with degenerative hydatid cyst. Sonography reveals a cystic lesion with "ball of wool" sign (*arrows*).

germinal layer (Fig. 2). The cyst expands slowly over years. When the brood capsule ruptures, viable protoscoleces are released as white sediments and float in the cyst, and are called as hydatid sand [1]. By spreading the multitudinous infectious scolices, rupture of the cyst leads to multifocal new cyst formation, exophytic growth, biliary communication [1], and peritoneal seeding [4–7].

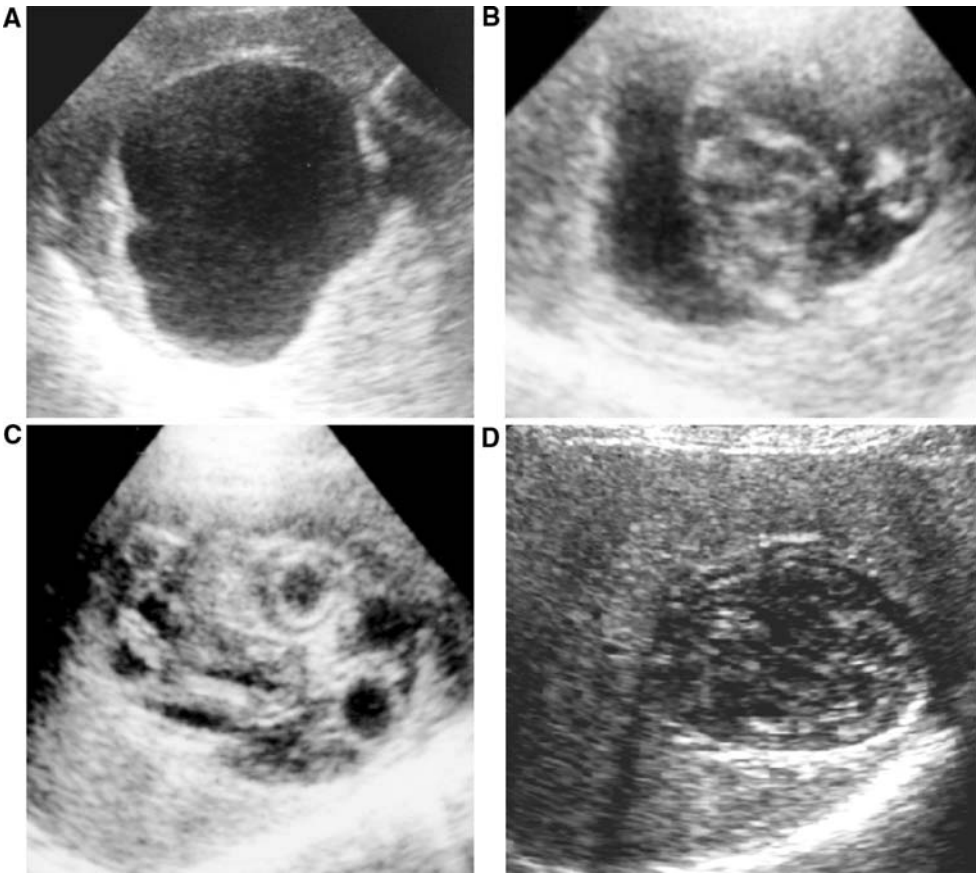

Fig. 12. A 28-year-old man with hydatid cyst showing stages of degeneration after percutaneous treatment. **A** Sonogram shows an ovoid cyst with clear content representing early active stage. **B** Sonogram 1 year after percutaneous treatment shows complex echogenic contents representing detached and degenerative membranes. **C** Sonogram 2 years later shows more complex internal contents and reduction in size of the cyst. **D** Sonogram 10 years after treatment shows nearly solid lesion which is called "pseudotumor appearance".

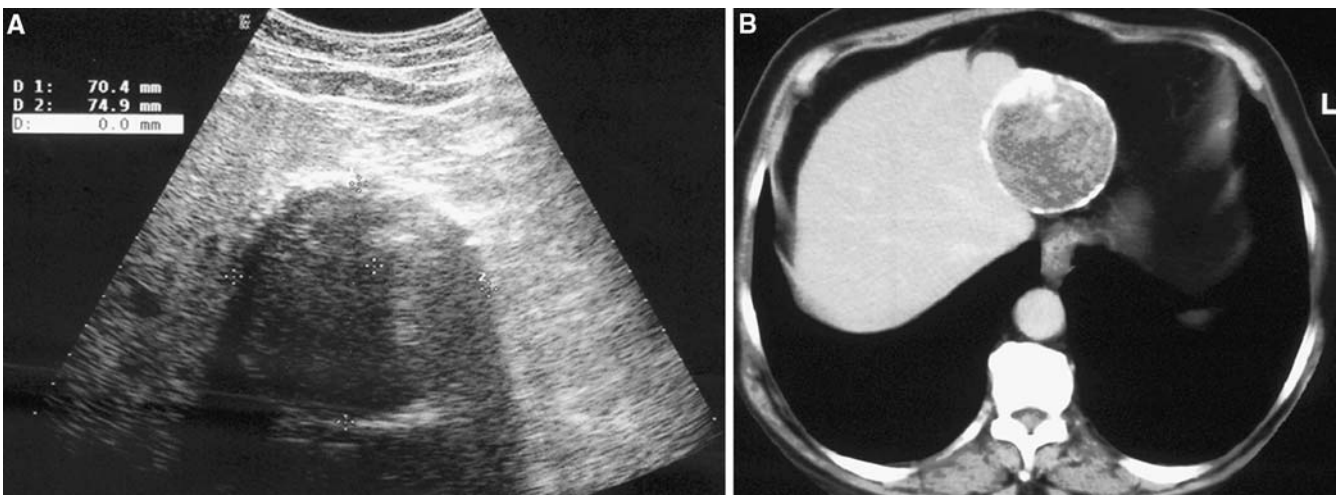

Fig. 13. A 65-year-old man with liver hydatid cyst. **A** Sonogram shows curvilinear echogenic line with posterior acoustic shadowing indicating calcification of the wall. **B** CT scan demonstrates the wall calcification as well as degenerative content of hydatid cyst.

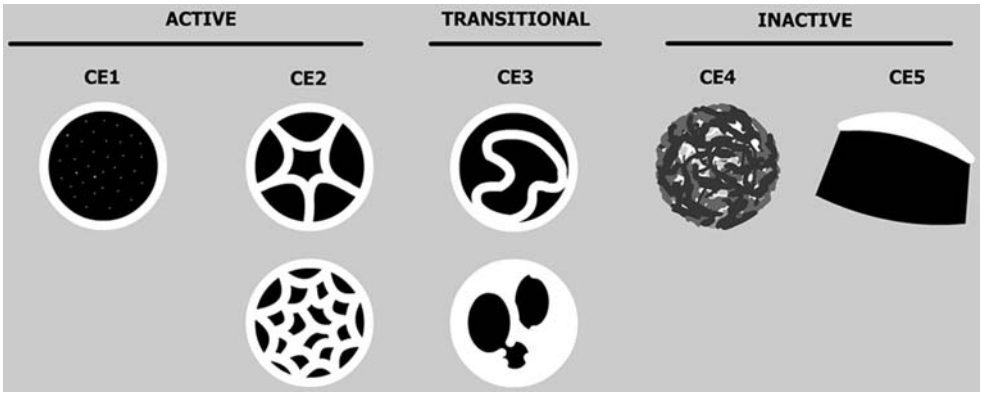

Fig. 14. Diagram illustrating the types of cystic echinococcosis according to classification of WHO Informal Working Group based on sonographic findings relating to the viability of parasite. *CE* cystic echinococcosis (courtesy of Dr. Harum Yildiz, Ankara, Turkey).

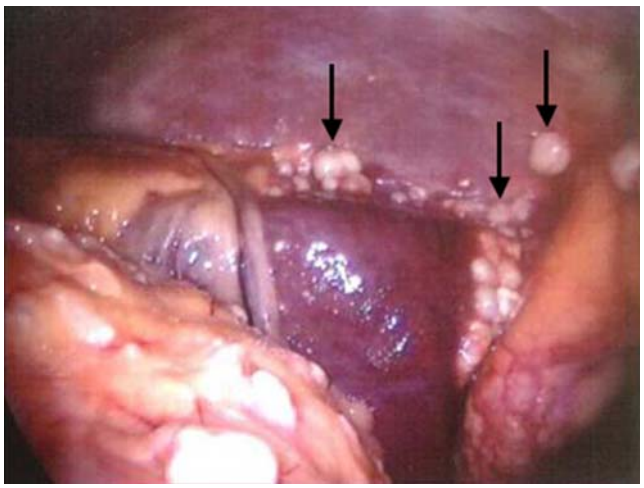

Fig. 15. Laparoscopic photograph of the liver infected with *E. multilocularis*. Note multiple, whitish, small cysts on the surface of the liver representing metatcestateal vesicles, growing progressively by peripheral extension (*arrows*).

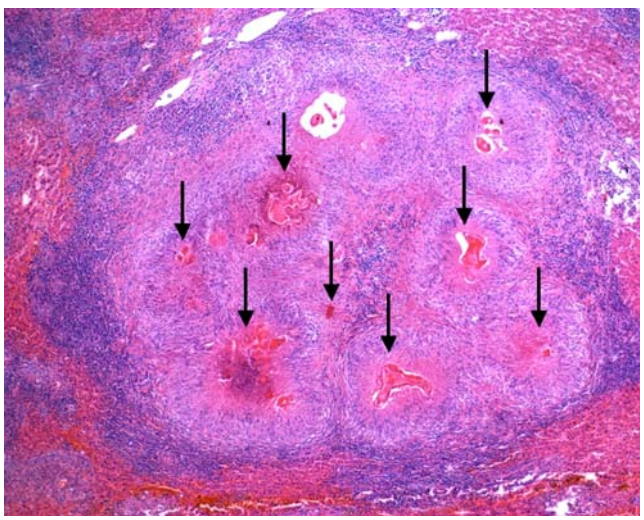

Fig. 16. Microphotograph of the liver infected with *E. multilocularis* showing multiple clustered lesions with central necrosis surrounded by a thin laminated layer (*arrows*) resembling alveoli or honeycomb.

Imaging findings of echinococcosis by E. granulosus

Imaging findings of echinococcosis caused by *E. granulosus* reflect a spectrum depending on the developing and disintegrating stages of the parasitic cyst in the human tissue, ranging from a single unilocular cyst, rupture of brood capsule and release of free protoscoleces, multiple daughter cyst formation, detachment of the endocyst as a disintegrating stage, and then gradually becoming smaller, solidifying, and calcifying [1].

During the early active stages of the disease, hydatid cysts resemble simple cysts on sonogram and CT images. Double-line sign can be seen on sonography representing laminar structure of the cyst wall [1, 7, 8] (Fig. 3). Free-floating protoscoleces (hydatid sand) in the cysts may appear as ''snow flakes'' on sonography by repositioning the patient [1, 7] (Fig. 4).

When the daughter cysts develop and partly or completely fill the mother cyst, the cysts appear as multiseptated (Figs. 5, 6). These daughter cysts may produce ''wheel-like'', ''rosette-like'' or ''honeycomb-like'' structures [1, 3, 7]. Daughter cysts are identified in 75% [3] and sonography is the most sensitive modality for the detection of membranes, septa and hydatid sand [9]. The CT attenuation of daughter cysts is usually lower than the main cyst because of free-floating scolices in the mother cyst [1, 7] (Fig. 7). These single or multiloculated cysts are fertile and contain viable protoscoleces. On MR images, hydatid cyst is characterized by a single cyst, possessing a 4- to 5-mm hypointense rim on both T1- and T2-weighted images, representing the fibrous or calcified pericyst [7, 10, 11] (Fig. 8). The hydatid matrix or hydatid sand representing free scolices appears hypointense on T1-weighted images and markedly hyperintense on T2-weighted images (Fig. 9). Daughter cysts are lower intensity on T1-weighted images than the matrix of the mother cyst [3].

When the viability of the parasite is lost, intracystic pressure is lowered and the endocystic membranes are detached and float freely. Intracystic wavy or serpentine bands (''water-lily sign'') may appear representing dela-

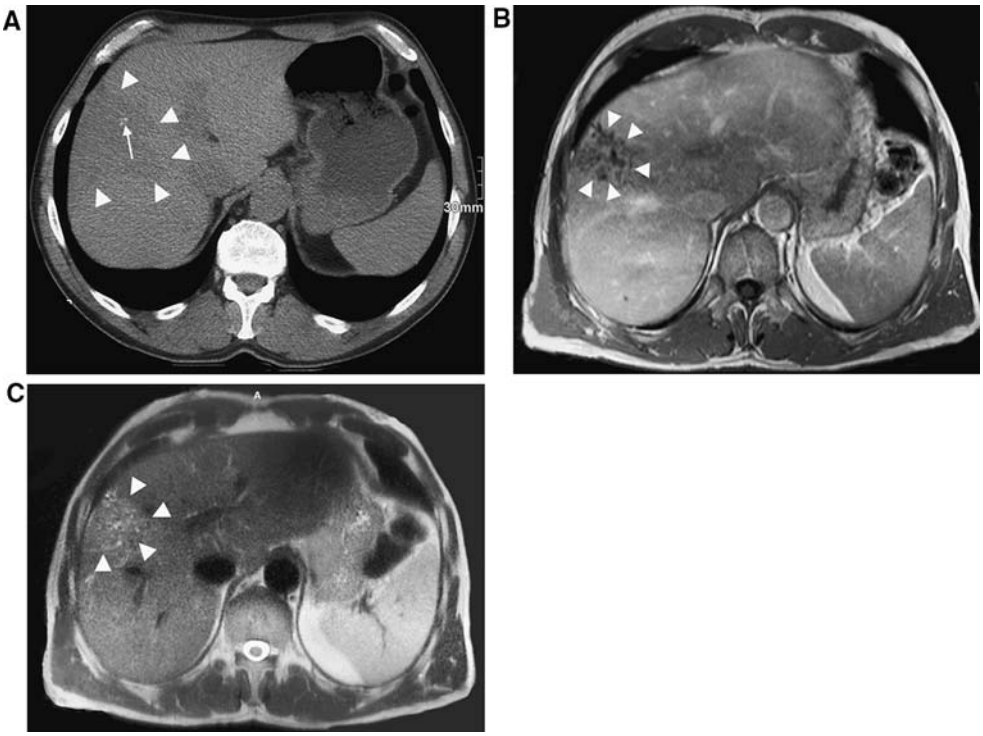

Fig. 17. A 45-year-old man with *E. multilocularis* infection of the liver at early stages. **A** Unenhanced axial CT scan shows a hypodense lesion with irregular and indistinct margins (*arrowheads*). Punctuate calcifications can be seen (*arrow*). **B** Contrast-enhanced T1-weighted MR image depicts a low signal intensity lesion (*arrowheads*). There is no contrast enhancement. **C** Transverse T2-weighted MR image shows clustered small cysts, representing metacestodal vesicles.

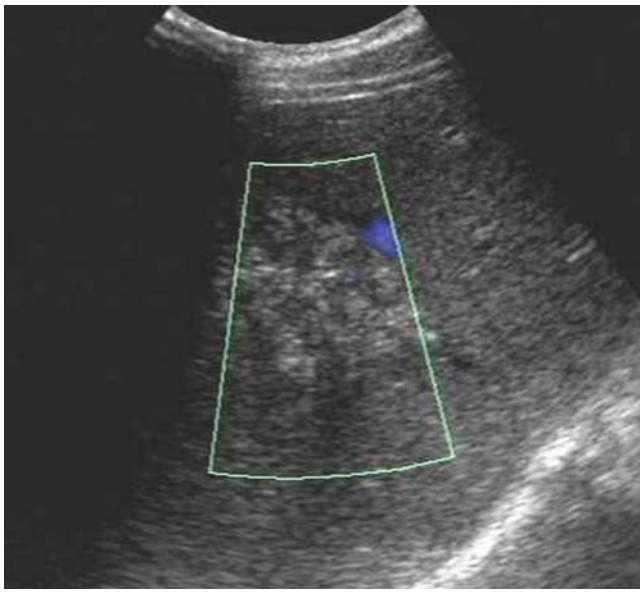

Fig. 18. A 61-year-old man with *E. multilocularis* infection of the liver. Axial sonogram obtained through the right liver shows multiple echogenic nodules with irregular and indistinct margins—the "hailstorm pattern". There was no color signal on color Doppler examination.

minated germinal layer and rupture of membranes [1, 3, 8] (Figs. 8, 10). These cysts represent a transitional stage whereby integrity of the cyst has been compromised. Degenerated cyst consists of heterogeneous, solid-looking pseudotumor that may show a "ball of wool sign" (Fig. 11) as the cystic lesion gradually becomes smaller and solidifies [1] (Fig. 12). Finally, dead cysts are characterized by a thick calcified wall (Fig. 13), with a degree of calcification that varies from partial to complete. Wall calcifications are present in 50% of the cases [3, 7].

The World Health Organization Informal Working Group on Echinococcus has published classification of echinococcosis, which is based on sonographic findings relating to the viability of the hydatid cyst [12] (Fig. 14).

Although surgery is the traditional treatment of hydatid cysts, the surgical results are associated with high rates of mortality, morbidity, postoperative recurrence, and a long period of hospital stay. The results of medical treatment are not satisfactory and are still controversial. In the past few decades, percutaneous treatment is gaining wider acceptance and has become an alternative to surgery in the treatment of liver hydatid cysts [13–16]. The cystic fluid and contents are drained and a scolicidal agent is instilled. As percutaneous treatment is a safe and effective procedure with successful results of low complication rates and short hospital stay, it has become the first choice in the treatment of most cases with liver hydatid cysts.

Pathology of echinococcosis by *E. multilocularis*

Echinococcus multilocularis can affect any organ or tissue in the body, although the liver is the most common site. *E. multilocularis* produces multilocular alveolar cysts (1–10 mm in diameter) that resemble alveoli (Fig. 15) and

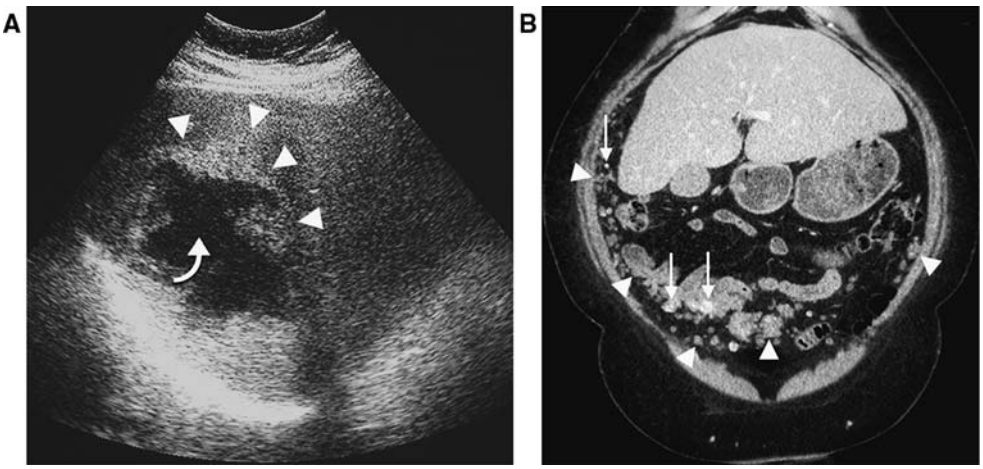

Fig. 19. A 45-year-old woman with metastatic *E. multilocularis* infection. **A** Oblique sonogram through the right liver shows a lesion with central liquefactive necrosis (*curved arrow*). A large hypoechoic region with some internal echoes can be seen. The hyperechoic border (*arrowheads*) of the lesion is irregular and indistinct. Some internal echoes are obvious. **B** Coronal CT reformats shows diffuse cystic infiltration of the omentum by parasitic tissue resulting in a thick, sheetlike mass containing multiple small cysts (*arrowheads*). There are small curvilinear calcifications in some cysts (*arrows*).

Fig. 20. A 26-year-old man with *E. multilocularis* infection of the liver. Contrast-enhanced CT scan shows hypodense central lesion representing necrotic tissue. Necrosis is surrounded by curvilinear calcifications (*arrowheads*). In the periphery of the lesion, small and large irregular hypodense cystic lesions (vital metacestodal vesicles) can be seen (*arrows*). There is slight heterogeneous enhancement at the periphery of the mass.

grow by exogenous proliferation with the cysts progressively invading the host tissue by peripheral extension of the process originating in the germinal layer. The metacestodes (Fig. 16) can proliferate to diameters of 15–20 cm in the human host. In addition, a very strong reactive fibrosis can lead to pronounced enlargement of the lesion [17]. The larva causes invasive and destructive changes in the human host and behaves like a malignant neoplasm. As the lesion heals, it invariably becomes calcified, from a punctuate form, multiple scattered, peripheral, and eventually produces a large homogeneously calcified mass. Clinical course and pathophysiology of *E. vogeli* infection are similar to *E. multilocularis* infection.

Imaging findings of echinococcosis by *E. multilocularis*

Liver involvement by alveolar echinococcosis commonly appears as an ill-defined infiltration of the liver parenchyma (Fig. 17). A hepatic lesion usually consists of several components, roughly divided into cystic and solid components. The cystic components comprise metacestodal vesicles and liquefactive necrosis. The solid components include coagulation necrosis, granuloma and calcifications [18, 19]. While small lesions mainly consist of small clustered cysts (metacestodal vesicles), growing *E. multilocularis* lesions show a great tendency to form central liquefactive necrosis, which may be surrounded by vital metacestodal vesicles. Necrosis is caused by vascular involvement associated with ischemia. There is no or poor enhancement following intravenous injection of contrast material, but contrast enhancement in the juxtalesional hepatic parenchyma is reported [20]. Usually, there is no lymphadenopathy [21].

On sonography, lesions are heterogeneous with indistinct margins and in most cases hyperechoic. Didier et al. [22] described the so-called hailstorm pattern (Fig. 18). Masses also can appear cavitary (Fig. 19A) or cystic to vesicular. Color Doppler sonography shows the absence of vascular flow in the solid components of the lesions; this finding simplifies and clarifies diagnosis in many patients [23].

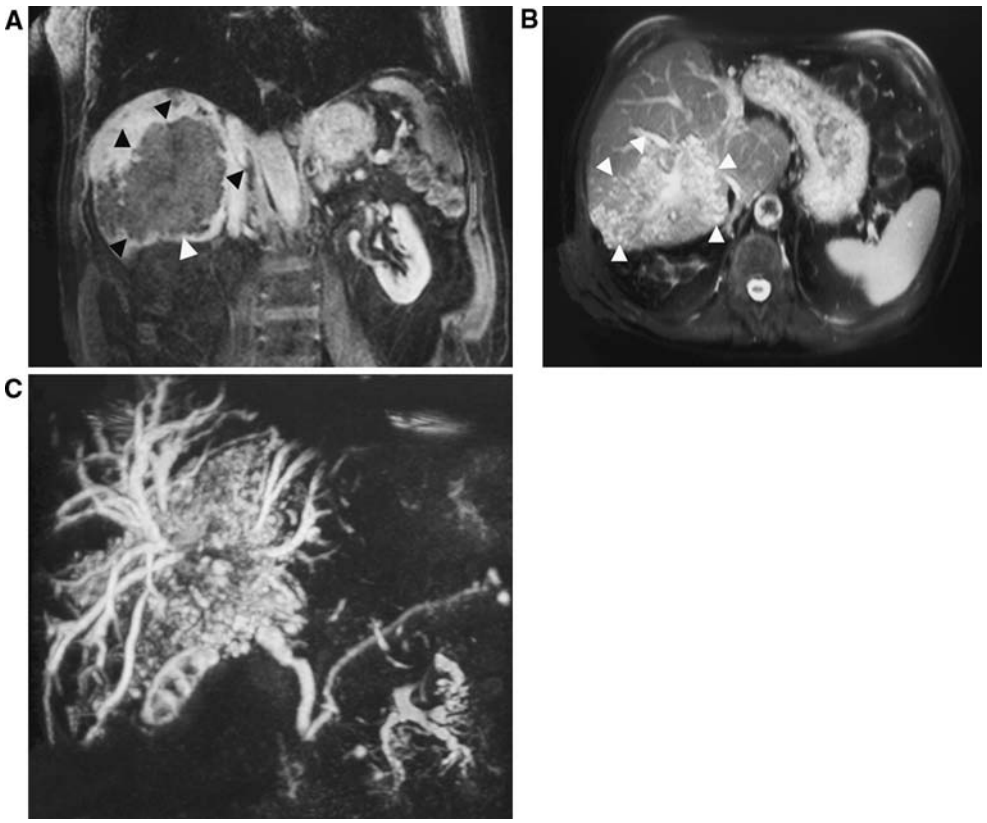

Fig. 21. A 66-year-old man with *E. multilocularis* infection of the liver. **A** Coronal contrast-enhanced T1-weighted fat-saturated image shows a large non-enhancing lesion with low signal intensity (*arrowheads*). The lesion shows a "geographical map" pattern, a characteristic-imaging feature of alveolar echinococcosis. **B** Axial T2-weighted image shows numerous clustered small cysts in the area of the parasitic lesion (*arrowheads*). **C** 3D MR cholangiogram shows numerous clustered small cysts within the liver surrounding and infiltrating the central bile ducts. Small filling-defects represent metacestodal vesicles. Peripheral, segmental and lobar bile ducts are dilated.

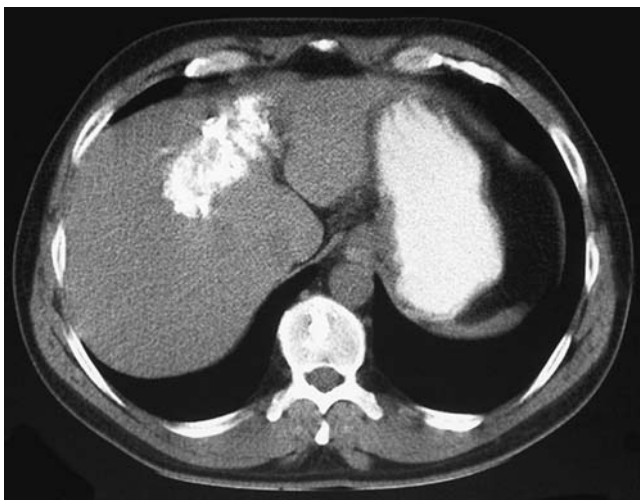

Fig. 22. A 43-year-old man with *E. multilocularis* infection of the liver. Axial-unenhanced CT scan reveals large calcification with irregular margins in the liver, representing nonvital final stage of the disease.

Fig. 23. A 50-year-old man with *E. multilocularis* infection of the liver. Contrast-enhanced CT-scan reveals infiltration of the hepatic hilum (*white arrowheads*) by parasitic tissue. Note infiltration of the portal vein (*open black arrow*) and encasing of the celiac artery (*bold white arrow*). Small calcifications can be seen (*white arrow*). An abscess within the right hepatic lobe was drained percutaneously earlier (*curved arrow*).

CT and MR imaging displays multiple irregular, ill-defined lesions scattered throughout the involved liver tissue [19, 24]. The lesions are hypodense on CT (Figs. 17A, 20) and hypointense in T1-weighted MR images (Figs. 17B, 21A). On T2 weighted images, lesions are hypointense, hyperintense (Figs. 17C, 21B) or isointense. On MR imaging, multiple small round cysts with a solid component or solid component surrounding large

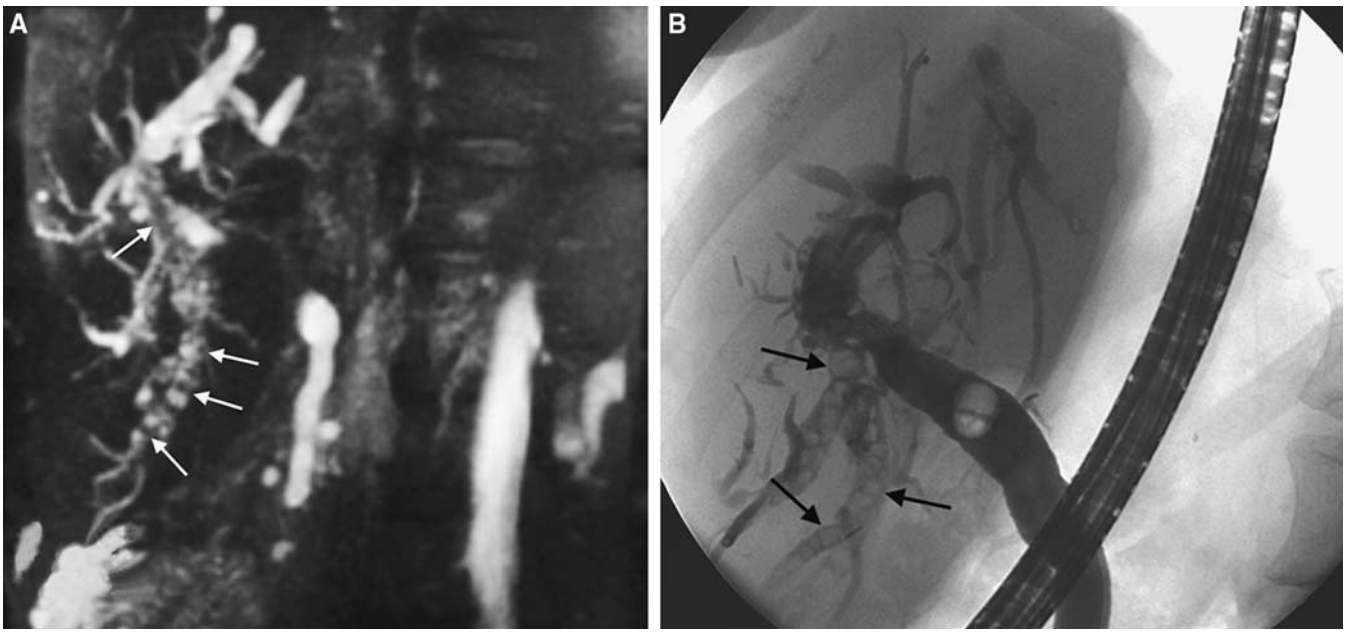

Fig. 24. A 55-year-old man with *E. multilocularis* infection of the liver. **A** 3D MR cholangiogram shows multiple small nodular filling defects (*arrows*) within the dilated bile ducts, representing metacestodal vesicles. **B** Diagnosis of multiple intraductal cysts (*arrows*) is confirmed by endoscopic retrograde cholangiogram. Percutaneous drainage of the bile ducts is performed periodically in this patient.

Fig. 25. A 70-year-old woman with *E. multilocularis* infection of the liver. Enhanced CT scan shows left hepatic lobar atrophy (*curved arrow*) caused by invasion of the hilum. Scattered areas with calcifications (*arrow*) and dilated bile ducts (*arrowheads*) can be seen.

and/or irregular cysts with multiple round cysts are thought to be characteristic of and highly specific for alveolar echinococcosis of the liver [19]. Large lesions often show a ''geographical map'' appearance [23] (Figs. 17, 20, 21). There is poor or no enhancement after bolus administration of contrast material. Calcifications are found in 90% of all infected patients [20]. Peripheral calcifications may be seen within the areas of central necrosis. Multiple punctuate scattered calcifications or a large homogeneous calcified mass may be seen [25] (Fig. 22). In depicting the cystic components of the lesion, T2-weighted MR imaging is superior to CT. CT has a clear superiority over MR imaging in demonstrating calcification, especially in small clusters.

Hilar infiltration is frequent (Fig. 23), resulting in dilatation of the intrahepatic bile ducts and invasion of the portal vein, its branches and the hepatic veins. In addition, abscess formation (Fig. 23) and invasion of the bile ducts (Figs. 21C, 24) may be associated. Lobar atrophy is another characteristic feature [26] (Fig. 25).

Direct spread of echinococcal tissue may result in the involvement of adjacent organs such as the pancreas, right kidney, right adrenal gland, peritoneum or vascular structures [18, 27]. However, these organs as well as all other abdominal organs may be affected by hematogenous metastases as well. On CT, the omentum appears thickened by multiple thin-walled hypodense cysts (Fig. 19B). These cysts can also be found in the minor pelvis.

At present, the method of treatment is controversial. Although medical therapy may stabilize the lesion in some cases, definitive cure can only be obtained by partial hepatectomy of localized masses or by orthotopic transplantation of the liver in advanced cases [28].

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