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Multidisciplinary imaging of liver hydatidosis

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Received: July 2, 2011 Revised: September 2, 2011

Accepted: January 22, 2012

Published online: April 7, 2012

cated in cases in which US is inadequate and has high sensitivity and specificity for calcified hydatid cysts. Magnetic resonance is the best imaging procedure to demonstrate a cystic component and to show a biliary tree involvement. Diagnostic tests such as CT and MRI are mandatory in liver hydatidosis because they allow thorough knowledge regarding lesion size, location, and relations to intrahepatic vascular and biliary structures, providing useful information for effective treatment and decrease in post-operative morbidity. Hydatid disease is classified into four types on the basis of their radiologic appearance.

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Key words: Liver hydatidosis; Hepatic cyst; Daughter cysts; Calcified cyst; Pericyst

Peer reviewer: Paul E Sijens, PhD, Associate Professor, Radiology, UMCG, Hanzeplein 1, 9713GZ Groningen, The Netherlands

Marrone G, Crino' F, Caruso S, Mamone G, Carollo V, Milazzo M, Gruttadauria S, Luca A, Gridelli B. Multidisciplinary imaging of liver hydatidosis. *World J Gastroenterol* 2012; 18(13): 1438-1447 Available from: URL: <http://www.wjgnet.com/1007-9327/full/v18/i13/1438.htm> DOI: <http://dx.doi.org/10.3748/wjg.v18.i13.1438>

Abstract

Liver hydatidosis is a parasitic endemic disease affecting extensive areas in our planet, a significant stigma within medicine to manage because of its incidence, possible complications, and diagnostic involvements. The diagnosis of liver hydatidosis should be as fast as possible because of the relevant complications that may arise with disease progression, involving multiple organs and neighboring structures causing disruption, migration, contamination. The aim of this essay is to illustrate the role of imaging as ultrasonography (US), multi detector row computed tomography, and magnetic resonance imaging (MRI) in the evaluation of liver hydatidosis: the diagnosis, the assessment of extension, the identification of possible complications and the monitoring the response to therapy. US is the screening method of choice. Computed tomography (CT) is indi-

INTRODUCTION

Hydatid disease is a worldwide zoonosis caused by the larval stage of the echinococcus tapeworm, that is endemic in many parts of the world (in European, Middle Eastern, Mediterranean, South American and African countries)^[1-4]. There are two types of Echinococcus infections: Echinococcus granulosus, the more common type, and Echinococcus multilocularis, the less common but more invasive. Hydatid disease is a relevant health problem in underdeveloped areas where veterinary control does not exist. The

most frequent location of hydatid cystic lesions is in the liver (up to 80% of cases), followed by the lung (about 20% of cases), and with a lower reported incidence in any other organ or tissue in the body^[1-4].

Dogs or other carnivores are definitive hosts, whereas sheep or other ruminants are intermediate hosts. Humans are secondarily infected by the ingestion of food or water contaminated by dog feces containing the eggs of the parasite. After the ingestion of the eggs, the freed embryo enters a branch of the portal vein by passing through the duodenal mucosa; most of these embryos become lodged in the hepatic capillaries where they either die or grow into hydatid cysts. Some embryos pass through the hepatic capillaries and become lodged in the lungs and other organs.

The definitive diagnosis of liver echinococcosis requires a combination of imaging, serologic, and immunologic studies^[4].

At biochemical analysis, there is usually eosinophilia, and a serologic test is positive in 25% of patients^[5]. At histopathologic analysis, a hydatid cyst is composed of three layers: the outer pericyst, which corresponds to compressed liver tissue; the endocyst, an inner germinal layer; and the ectocyst, a translucent thin interleaved membrane^[5].

Imaging procedures are essential in diagnosis and evaluation of the extent of liver hydatidosis; ultrasound (US), computed tomography (CT), and magnetic resonance (MR) can depict hydatid disease^[2-4,6].

The imaging method used depends on the involved organ, and the radiologic findings range from purely cystic lesions to a completely solid appearance^[3]. US is the screening method of choice and is also used to monitor efficacy of medical therapy^[2-4,6]. CT is always performed because it has a high sensitivity (94%)^[7]. It is an important preoperative diagnostic tool to determine vascular, biliary or extrahepatic extension, to recognize complications, such as rupture and infections, and therefore to assess respectability^[8-10]. MR is the best imaging procedure to demonstrate a cystic component. It helps to determine vascular or biliary tree involvement, as well as extrahepatic extension^[10,11].

There are many potential complications such as exophytic growth, transdiaphragmatic thoracic involvement, peritoneal seeding, biliary communication, portal vein involvement, abdominal wall invasion and hematogenous dissemination in any anatomic location (lung, kidney, spleen, bone, brain)^[6,10,11].

RADIOLOGIC FINDINGS

Ultrasonographic findings

The ultrasonographic appearance of hydatid cysts may vary, from a simple aspect to a more complex one, in relation to the stage of evolution and maturity^[5-7,10]. US can categorize cysts as solitary univesicular, solitary multivesicular, solid echogenic mass, multiple, either uni- or multivesicular, or collapsed, flattened and calcified^[8].

In the first stage, the hydatid cyst may manifest as a

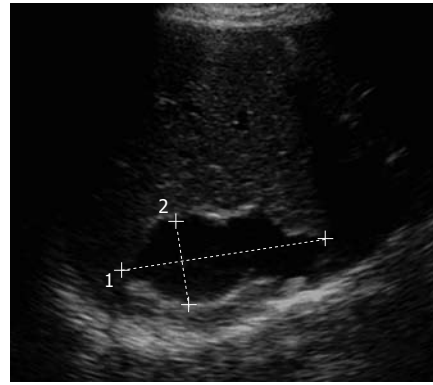


Figure 1 Liver hydatid disease in a 50-year-old man appears as a well-defined anechoic mass without hydatid sand and septa (type I).

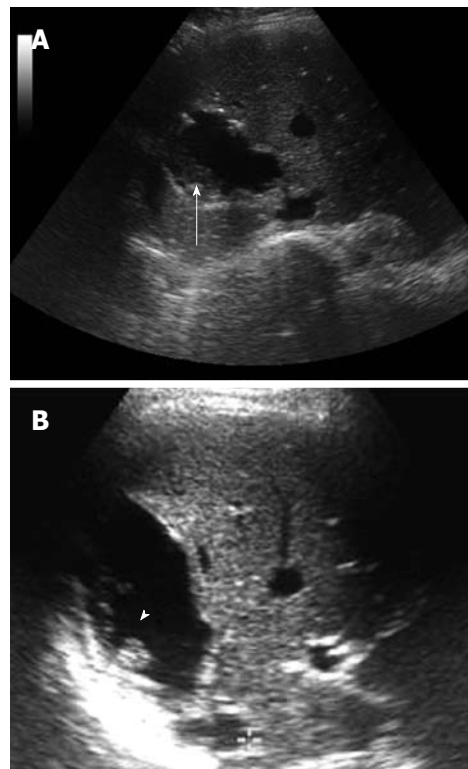


Figure 2 Liver hydatidosis in a 27-year-old female. Ultrasonography images (A, B) show a lesion with mixed echogenicity, with hydatid sand (the arrow) and multiple echogenic foci (the arrowhead).

well-defined anechoic cyst (Figure 1), an anechoic cyst except for hydatid “sand”^[2,6,7]. The more complex aspect is typical of the advanced stages and is related to the presence of multiple internal septa, daughter cysts, multiple echogenic foci and floating membranes inside the cavity (Figures 2 and 3)^[7-9]. Membranes may appear as serpentine linear structures, a finding that is highly specific for hydatid disease^[7,12,13]. The detachment of the membrane inside the cyst is considered the US “water lily sign”^[13-16]. The cyst wall is visible as double echogenic lines separated by a hypoechoic layer (Figure 3)^[16].

Multivesicular cysts manifest as well-defined fluid collections in a honeycomb pattern with multiple septa representing the wall of the daughter cysts. Daughter cysts

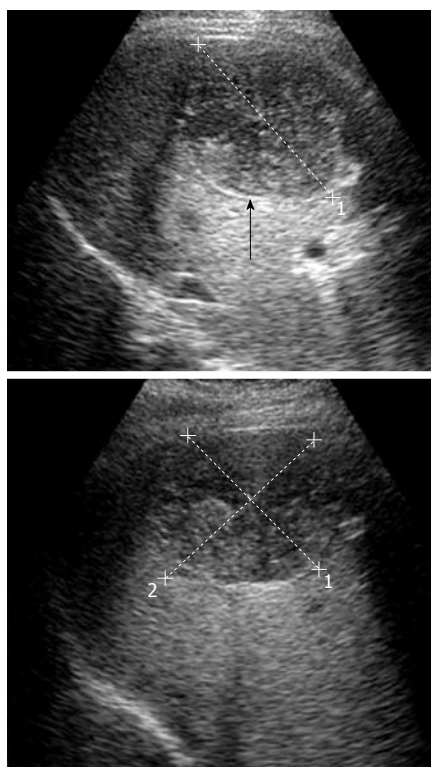


Figure 3 Ultrasonography images of hydatid disease show multiple internal septa and floating membranes inside the cyst. Note the cyst wall is visible as double echogenic lines (see the black arrow).

appear as cysts within a cyst^[7-9]. Altering patient's position may change the position of daughter cysts.

The more complex aspects of hydatid cyst may also mimic solid hepatic masses, and differential diagnosis becomes difficult but fundamental; it is important to look for daughter vesicles or membranes within the lesion that may help in differential diagnosis^[7,8]. Cyst calcification is seen in dead hydatid cysts; US shows a hyperechogenic contour with a cone-shaped acoustic shadow^[13,15,16].

When the cyst wall is heavily calcified, only the anterior portion of the wall is visualized and appears as a thick arch with a posterior concavity. Partial calcification of the cyst does not indicate the death of the parasite, on the contrary densely calcified cysts may be assumed to be inactive^[8,9].

US is considered the preferred investigatory test to monitor efficacy of medical antihydatid therapy because of its low cost^[12,14]. Positive response findings include reduction in cyst size, membrane detachment, progressive increase in cyst echogenicity and mural calcification^[12].

Computed tomography findings

CT is indicated in cases in which US is inadequate due to patient-related difficulties (obesity, excessive intestinal gas, previous surgery^[3,5-7]). CT has high sensitivity and specificity for hepatic hydatid disease^[7]. Intravenous administration of contrast medium is useful to give a vascular map to the surgeon, and when complications (especially infection and communication with the biliary tree) and extra-hepatic diffusion are suspected.

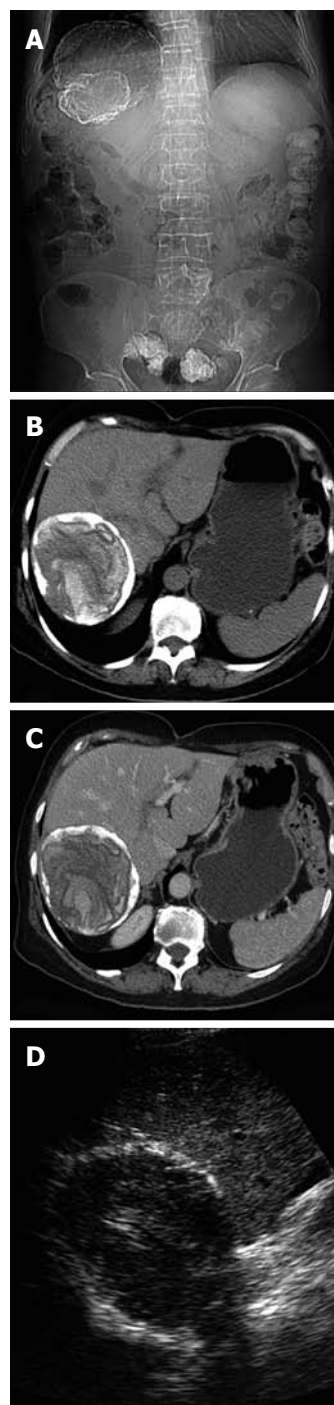


Figure 4 Calcified unilocular hydatid cyst. Digital scout image (A) shows a round, densely calcified lesion supra-elevating the right diaphragm. Computed tomography basal (B) and contrast-enhanced (C) images reveal a hypoattenuating lesion with peripheral wall calcification in the right lobe. Membranes appear as serpentine linear structures. Note the complex ultrasonography aspect of the cyst and the hyperechoic wall (D).

CT may show the same findings as US^[6,7]. Calcification of the cyst wall, internal septa, floating membranes and daughter vesicles are easily detected at CT^[3,5].

A hydatid cyst typically is seen as a round lesion with water attenuation density, surrounded by a calcified ring-like (Figure 4) or highly attenuated wall, representing the pericyst (Figure 5)^[17]. Detachment of the laminated mem-

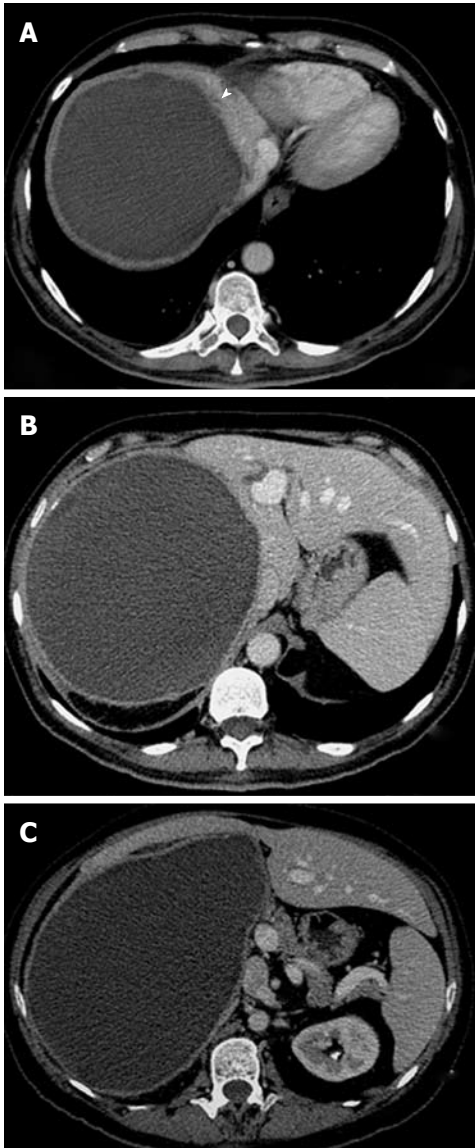


Figure 5 Computed tomography scan shows a huge nonenhancing mass with regular contours and thickened wall representing the pericyst (the white arrowhead) occupying all the right lobe of the liver (type I); either the right portal vein or the right hepatic vein is completely replaced.

branes from the pericyst are visualized as linear areas of increased attenuation within the cyst^[17].

At CT daughter vesicles are visible as round structures located peripherally within the mother cyst; they usually contain fluid with a lower attenuation than that of the fluid of the mother cyst (Figure 6)^[5,7].

Contrast-enhanced CT may show the typical high-attenuation rim representing abscesses surrounding the lesion. Sometimes, patchy areas of contrast-enhanced liver parenchyma are seen in the vicinity of the lesion, representing inflammatory changes^[18].

The dead cysts are totally calcified and at CT they appear as round hyperattenuating areas (Figure 7)^[5,7].

CT also may depict gas or air-fluid levels or fat inside the hydatid cyst, indirect signs of infection and/or communication with the biliary tree (Figures 8 and 9)^[6,10,11].

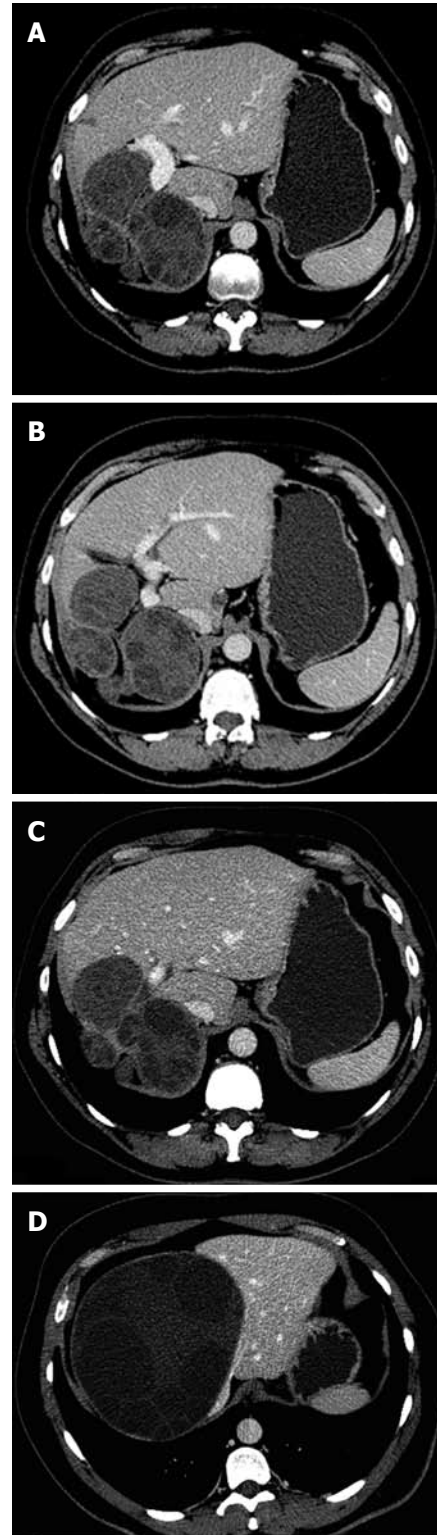


Figure 6 Computed tomography scan (A, B, C, D) shows some unenhanced hypoattenuating masses with well defined borders occupying the right lobe of the liver; multiple round daughter cysts are seen peripherally inside the lesion (type II). Note the "rosette appearance".

CT is the modality of choice to study extra-hepatic diffusion because it allows imaging of the entire abdomen, pelvis and thorax.

Extra-hepatic diffusion may regard peritoneum, the

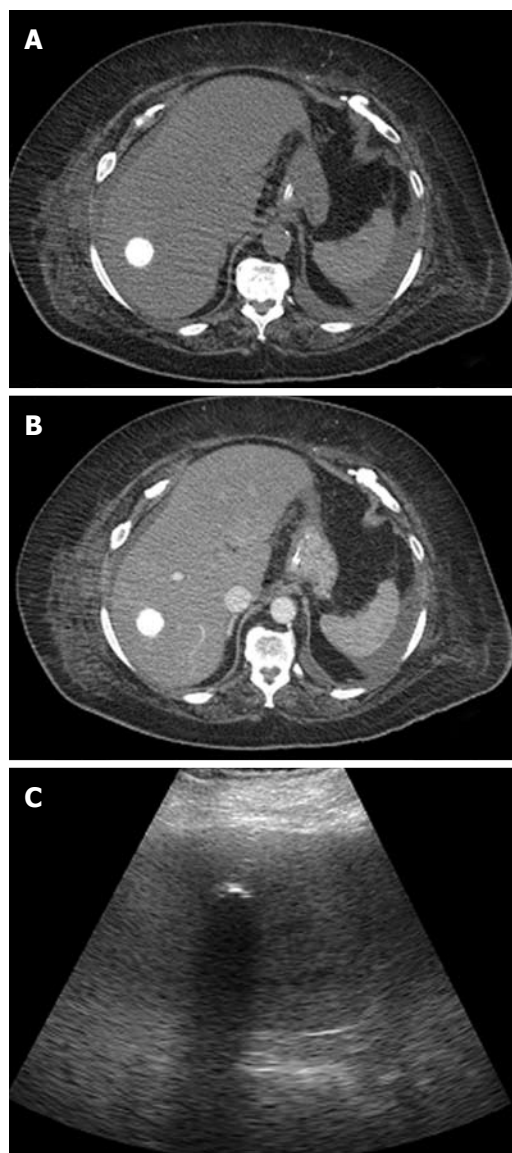


Figure 7 Seventy-three year-old-woman with a dead hydatid cyst. Computed tomography scan basal and enhanced images (A, B) show a totally calcified cyst (type III). At ultrasonography (C) calcified cyst shows strong posterior shadowing.

diaphragm and the thorax cavity, the abdominal wall, the portal system, and the hematogenous dissemination^[4,6,7].

Magnetic resonance findings

MR may be performed to confirm the hypothesis of hepatic hydatidosis and visualize the lesion in different planes. It is the best diagnostic investigation to differentiate the cystic component from the others and to demonstrate a biliary tree involvement^[13].

The hydatid cysts may show variable signal intensities on T1- and T2-weighted images, according to the different components inside the lesion^[13,17,18].

The necrotic and the fluid components are hypointense on T1-weighted images and markedly hyperintense on T2-weighted images^[13,18,19].

When present the daughter cysts are seen as cystic structures attached to the germinal layer that are hypointense relative



Figure 8 Contrast-enhanced upper abdominal computed tomography scan demonstrates a partially calcified hydatid cyst in direct communication with the biliary tree markedly dilated (the bold white arrow). The presence of fat components within the cyst derives from the lipid elements in bile (the thin white arrow) (type IV).



Figure 9 Fifty-five-year-old male with acute abdominal pain, fever and leucocytosis. Contrast-enhanced computed tomography shows intracystic gas in the anterior part of a unilocular partially calcified hydatid cyst, suggesting superinfection; finding confirmed at surgery (type IV).

to the intracystic fluid on T1-weighted images (Figure 10)^[13].

The characteristic sign of hydatid disease is represented by the pericyst that usually appears as a low-signal-intensity rim on T2-weighted images (Figure 10)^[17,19].

In addition, there may be an intermediate-signal-intensity inner ring representing the detachment of the membranes^[19].

After the i.v. injection of gadolinium contrast agent the pericyst may show slight enhancement (Figure 11).

MR is the best diagnostic tool in demonstrating the floating membranes (Figure 12) and irregularities of the rim representing incipient detachment of the membranes (Figure 13)^[17,19,20]. On the other hand MR is less sensitive than CT scan in showing cyst wall calcification.

The “snake sign” is another typical MR imaging feature: it represents collapsed parasitic membranes, secondary to damage or degeneration of the hydatid cyst: these membranes have low signal intensity with all sequences (Figure 13).

Intracystic air-fluid level may be visible on MR, as a possible sign of super-infection (Figure 14)^[16,21].

MR cholangiopancreatography (MRCP) is useful to

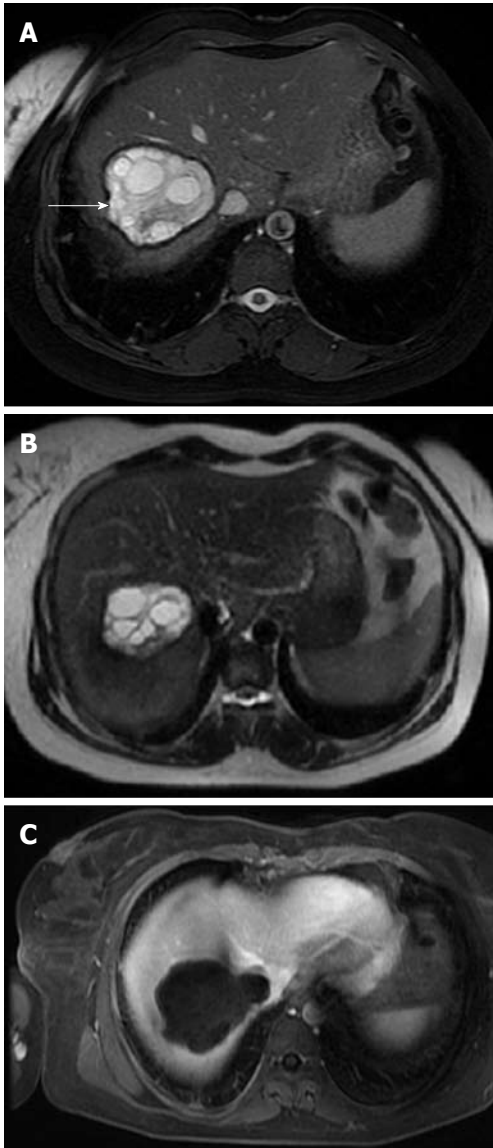


Figure 10 Axial T1-weighted (A) and T2-weighted (B) images show a well defined cystic lesion and the typical peripheral location of the daughter cysts within the mother cyst. Note the marked hypointensity of the pericyst (the white arrow). After contrast administration (C) the cystic lesion does not show contrast enhancement (type II).

study potential involvement of the biliary tree: communication between the cysts and the biliary tree; dilatation of the biliary system secondary to compression of the hydatid cyst^[20,21] (Figure 15).

It is known that routine MRI does not adequately differentiate completely liquid hydatid cysts (type I, see following paragraph) from simple cysts: Inan *et al.*^[22,23] have demonstrated in their study that diffusion-weighted (DW-MRI), a recent MRI technique, can be helpful in the differential diagnosis.

DW-MRI has long been used exclusively in brain imaging due to technical problems and sensitivity to motion artifacts (caused by cardiac motion and respiration); with the advent of faster sequences, DW-MRI has been applied to abdominal imaging^[22,23].

Using DW MRI with a high b factor (1000 s/mm²) the

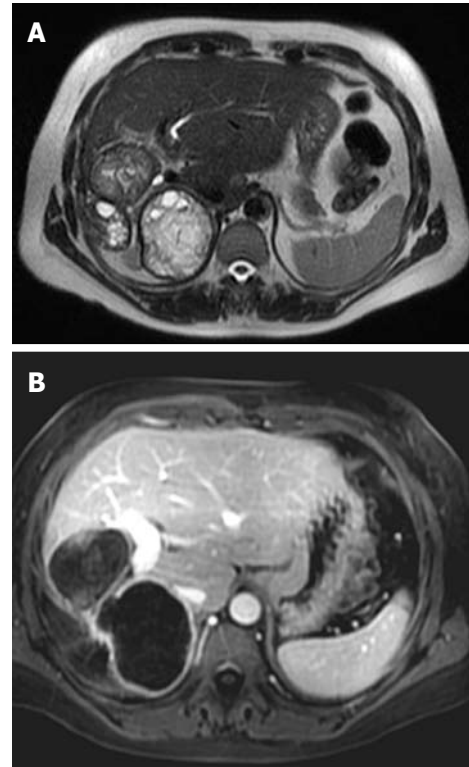


Figure 11 Axial T2-weighted and post-contrast images show the exophytic growth of hydatid cyst (type II) (A). After the injection of contrast media the septa and cyst wall enhance (B). Note the proximity of the cyst to the diaphragm which facilitates transdiaphragmatic thoracic involvement and to main portal vein.

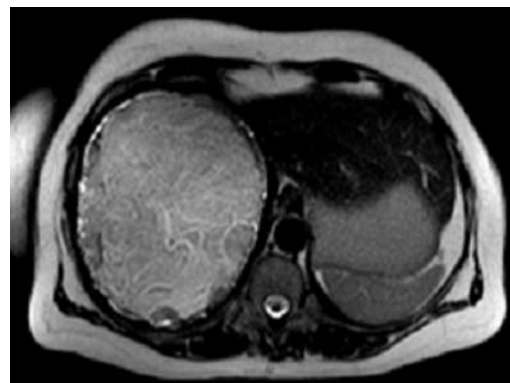


Figure 12 35-year-old woman living in an endemic region. Axial T2-weighted magnetic resonance image show the hydatid cyst that occupies almost the entire right lobe of the liver with thickened pericyst and multiple floating membranes inside the lesion (type II).

hydatid cysts are hyperintense, whereas none of the simple cysts show significant hyperintensity (Figure 16)^[22-24].

In addition, using DW MRI it is possible to calculate a parameter, called the apparent diffusion coefficients (ADCs), that measures the difference in cellular density of hepatic lesions^[22-24].

This quantitative parameter can be used to differentiate hydatid cysts from simple cysts. The difference between the ADCs of the hydatid cysts and those of simple cysts can be attributed to the difference in cyst contents^[22-24].

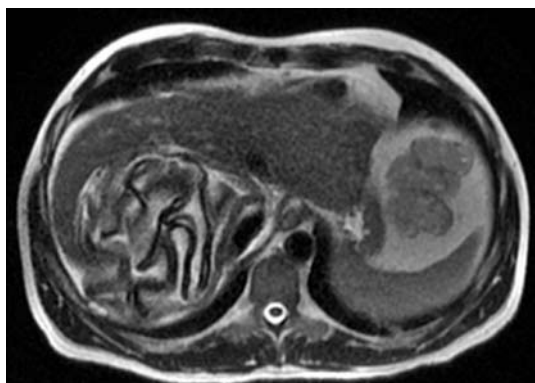


Figure 13 The detachment of the pericyst and the collapsed membranes inside the cyst due to damage or degeneration may give the hydatid cyst a serpentine linear aspect; this is the “snake sign”.

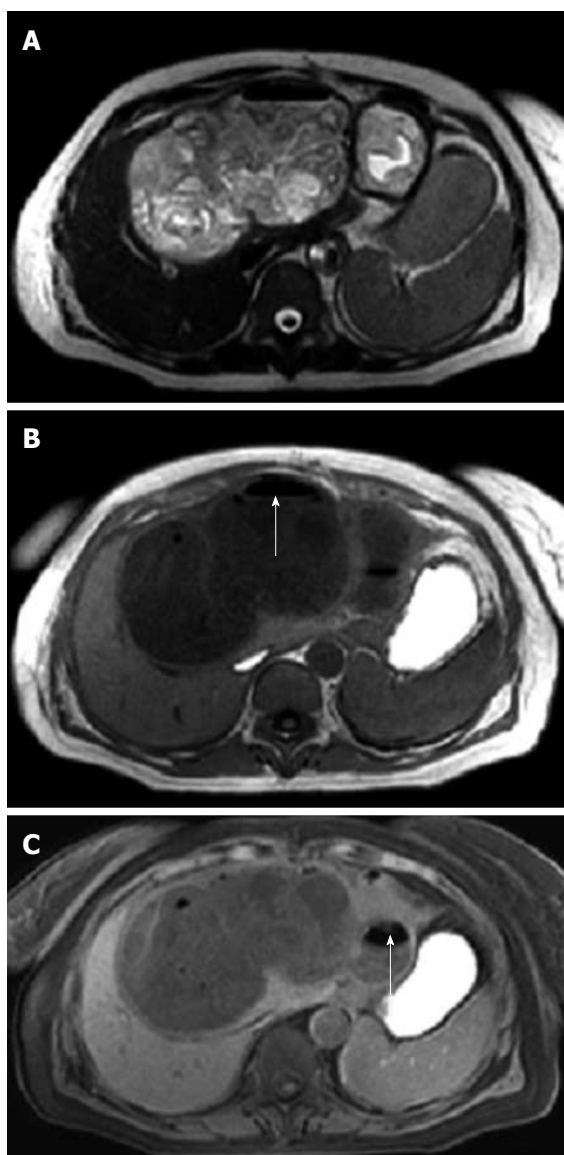


Figure 14 Axial T2-weighted (A) and T1-weighted (B, C) magnetic resonance images demonstrate a round, cystic lesion in the left hepatic lobe, with thickened pericyst, small daughter cysts, floating membranes and an air-fluid level within the cyst (white arrow). The diagnosis is an infected hydatid cyst (type IV).

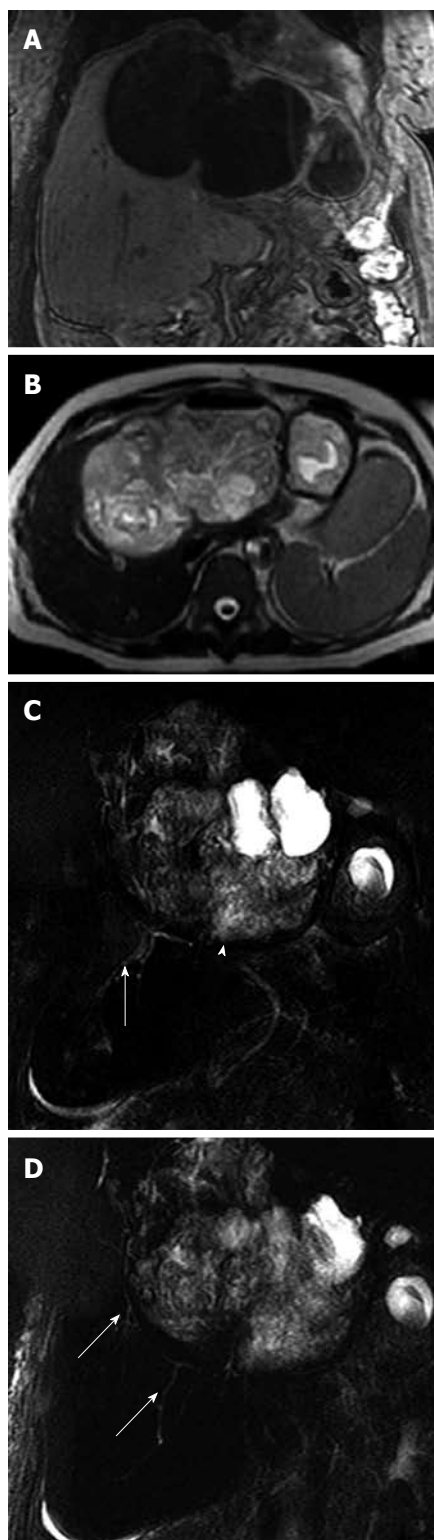


Figure 15 T1 coronal image and T2 axial image show a huge and multi-locular hydatid cyst occupying the entire left lobe, partially the right lobe (A, B) and protruding into the hepatic hilum. Magnetic resonance cholangiopancreatography (MRCP) sequences show the compression of the common bile duct at the confluence and of the right hepatic duct (the white arrowhead) and the consequent intrahepatic biliary tree dilatation (the white arrows) (C, D).

Because the hydatid cyst contains viscous hydatid sand that consists of scolices, sodium chloride, proteins, glucose, ions, lipids, and polysaccharides, the ADC of the hydatid

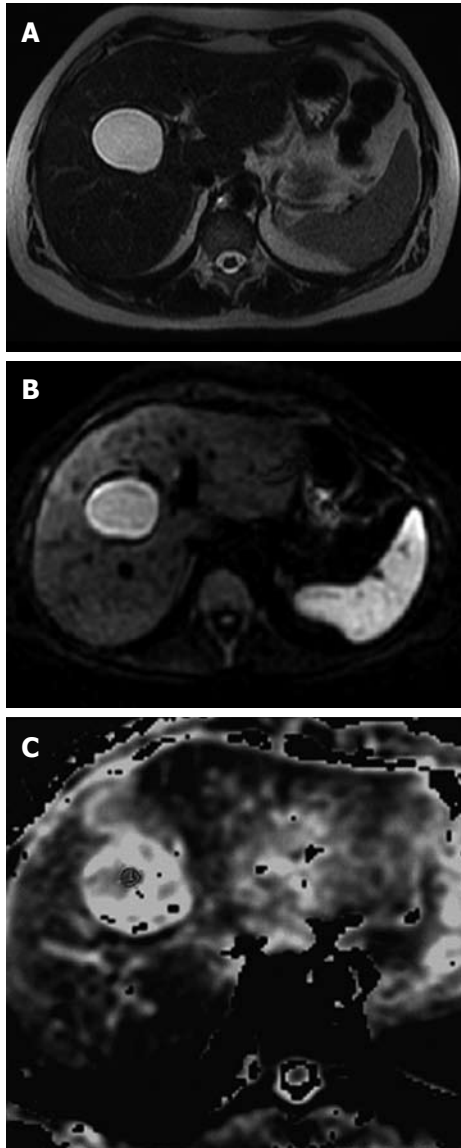


Figure 16 A type I hydatid cyst. A: Axial T2 weighted magnetic resonance image depicts a round cystic mass in the anterior segment of the right lobe, with no septa or solid portions; B: On the diffusion-weighted image the lesion exhibits high signal intensity ($b = 1000$); C: On apparent diffusion coefficient map, apparent diffusion coefficient value is 2.4×10^{-3} .

cyst is decreased; on the contrary the simple cyst has lower viscosity, hence the higher viscosity. In Inan's series the mean ADCs of the hydatid cysts was significantly lower ($2.5 \times 10^{-3} \pm 0.9$) than that of the simple cysts ($3.5 \times 10^{-3} \pm 0.5$) (Figure 16)^[22-24].

In patients affected by hepatic hydatidosis, contrast enhanced magnetic resonance angiography may be useful in detecting hepatic venous outflow obstruction or thrombosis or invasion^[25]; in these patients, pulmonary embolism may be a possible complication (Figure 17)^[26].

CLASSIFICATION OF HYDATID DISEASE ON THE BASIS OF IMAGING

Hydatid disease is classified into four types on the basis

of their radiologic appearance^[27]:

Type I : Simple cyst with non internal architecture

Hydatidosis appear at US as a well-defined anechoic mass with or without hydatid sand and septa. Unilocular cysts are considered to be an initial stage in the development of the parasite^[28]. A solitary type I cyst may be difficult to distinguish from a simple epithelial cyst^[8].

At CT, a type I appears as a well-defined water-attenuation mass; after injection of contrast material the septa and cyst wall enhance, a finding that helps differentiate type I from a simple liver cyst^[13,19]. MR images are also similar to those of a simple liver cyst, including hypointensity on T1-weighted images and marked hyperintensity on T2-weighted images; a low signal intensity rim ("rim sign")^[19,20], which is more evident on T2-weighted images, has been described as typical of hydatidosis, and it can be used to differentiate hydatid cysts from simple cysts; this finding represents the pericyst.

Recently the emerging role of DW MRI may play a decisive role in the differential diagnosis of hydatid liver disease and simple cysts^[22-24] (Figures 1, 5 and 16).

Type II : Cyst with daughter cysts and matrix

Daughter cysts are inside the mother cyst, usually arranged at the periphery^[15,18]. Floating membranes or vesicles can be also seen in the cyst. Multiple daughter cysts are enclosed together looking like an echogenic solid lesion. (Figures 6, 10, 11 and 12)

Type II may manifest as a well-defined fluid collection in a honeycomb pattern with multiple septa representing the walls of the daughter cysts, creating a "rosette" appearance^[15]. Peripheral calcification may occur and involves the pericyst; it is easily detected in CT images as a curvilinear or ring-like structure. CT can distinguish the mother cyst: the average density attenuation of the mother cyst is higher than that of daughter cysts. At MR imaging, daughter cysts may appear hypointense or isointense relative to the maternal matrix on T1 and T2-weighted images^[19,20].

Type III : Calcified cyst

Type III lesions are dead cysts with total calcification. At US calcified cysts show strong posterior shadowing, at CT they appear as round hyperattenuating areas, at MR they appear as hypointense areas (Figure 7).

Type IV

Hydatid complications include rupture and superinfection and may be seen in both type I and type II. CT and MRI play a key role in recognizing the complications such as rupture and infection of cysts associated with hydatid disease.

Ruptures may occur in 50% of cases^[6,9,11]; cyst rupture is mainly due to the degeneration of parasitic membranes. Cyst rupture is usually due to the degeneration of parasitic membranes, as a result of age, or a host defense mechanism^[6,9,11]. The rupture may be contained, commu-

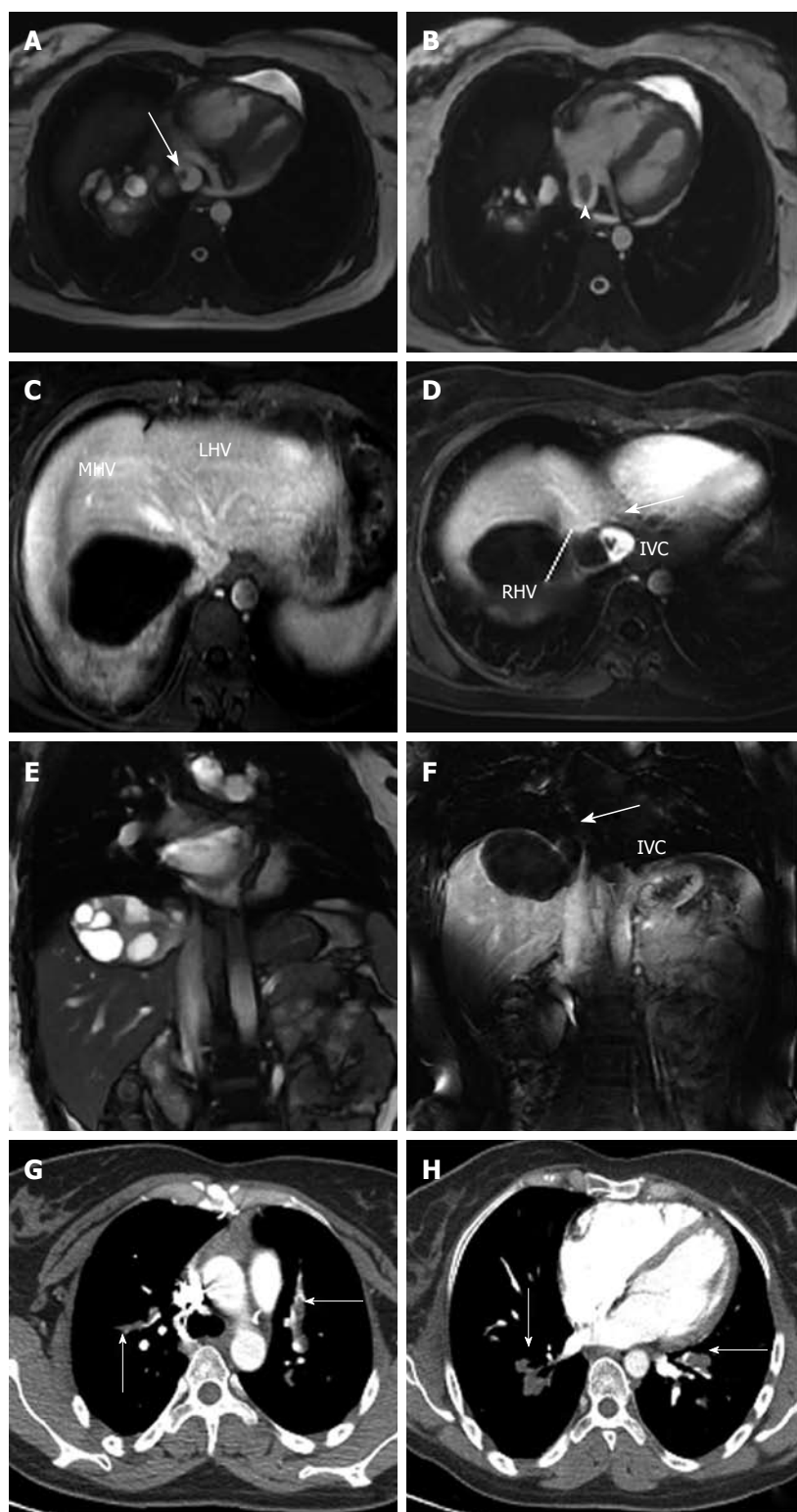


Figure 17 Hepatic hydatidosis in a 30-year-old woman who presented with short of breath, fatigue and edema to the lower limbs. Magnetic resonance (MR) steady-state-free-precession sequences (A, B, E) and MR angiography (C, D, F) images showed the hydatid cyst invading the right hepatic vein (RHV), protruding in the inferior vein cava (IVC) (the bold white arrow) and in the right atrium (the white arrowhead). The mid hepatic vein (MHV) and the left hepatic vein (LHV) were normally patent (C). The multidetector computed tomography-angiography revealed diffuse pulmonary parasitic embolism (the thin white arrows) (G, H).

nicating or direct.

Fissures in the cyst wall can be visualized at both CT and MR imaging. Perforation to the biliary tree has been reported in up to 90% of hydatid cysts^[7,10,11]. Hydatid cysts

may also rupture into pleural and peritoneal cavities. Up to 25% of ruptured cysts may become infected^[10,11]. Signs of cyst infection include air-fluid or fluid-fluid levels^[9,11] (Figures 8, 9 and 14).

CONCLUSION

Imaging plays a primary role in liver hydatidosis. It is used for diagnosis, for assessment of extension, for identification of possible complications, for classification and for monitoring the response to therapy. US, MDCT and MR have different roles depending on accuracy in depicting the different goals.

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S- Editor Shi ZF L- Editor O'Neill M E- Editor Zhang DN