20 Parasitic Hepatic Cysts and Pyogenic Hepatic Abscess

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- *The most common parasitic hepatic disease that can need surgical treatment is the hydatid cyst, caused by Echinococcus granulosus. Other echinococcosis (alveolar and polycystic) are less frequent.*
- *Hydatid cysts may be multiple and can measure up to 20-50 cm in diameter. Most of them develop in the right lobe of the liver. Commonly, symptoms result from mass effect or cystic complications, such as rupture (into biliary tract, peritoneal cavity, hollow viscera, and lungs) or infection. Diagnosis is suggested especially by radiological findings.*
- *Surgical treatment can be conservative (comprising sterilization of the cyst and treatment of the residual cavity) or radical (including pericystectomy and anatomical liver resections).*
- *Pyogenic liver abscess represents a life-threatening bacterial infection of the liver. Surgical treatment is indicated in case of failure of conservative therapy (antibiotics combined or not with percutaneous drainage), which occurs mainly in multiloculated abscesses and those with biliary communications.*

INTRODUCTION

The liver, the largest gland in the body, seems to be very attractive for many parasites. They either inhabit the organ, or pass through during their normal development without damaging the organ, or may be carried to it leading to its destruction. People in developing countries and tropical areas are commonly exposed to these parasites.[1,2] Because of traveling, immigration and the HIV/AIDS pandemic, parasitic disease can be found anywhere and may even affect inhabitants of developed countries. To combat this worldwide diffusion, some attempts to develop vaccines against these pathogens have been made, but have been hampered by the difficulty inherent to cultivating parasites in vitro, the complexity of their multicellular organization and/or multistage development, and their impressive antigenic variability. Luckily, anti-parasitic drugs treat most parasitic liver diseases. In advanced stages of disease, other therapeutic methods are required to suppress parasites or to manage their complications, as represented by percutaneous, endoscopic, or surgical approaches. Even liver transplantation can be needed for the treatment of advanced cases in which the remnant liver is not large enough to assume normal metabolic activity.

Pyogenic hepatic abscesses are relatively rare and most often polymicrobial. Bacteria may reach the liver through the portal vein, arterial blood, biliary tract, or even direct contact. The development of modern radiology techniques has facilitated diagnosis and management. However, surgical approach still plays a role in the management of selected cases not amenable to treatment through the combination of percutaneous drainage and antibiotic therapy, the standard treatment for this disease.

In this chapter, we will discuss the three main parasitic infestations requiring liver resection (hydatid disease, alveolar echinococcosis and polycystic echinococcosis). Nonetheless, this chapter will cover the surgical approach to treating pyogenic hepatic abscesses.

CYSTIC HYDATID DISEASE OR CYSTIC ECHINOCOCCOSIS

ETIOLOGY, PATHOLOGY AND NATURAL HISTORY

Cystic hydatid disease (CHD) is caused by the development of the larval form of *Echinococcus granulosus*, a parasite spread almost all over the world. It is a tapeworm (2-7 mm in length) that resides and grows in the small bowel of dogs and other canines (definitive hosts). It produces eggs that pass through the stool and infect pastures. When ingested by intermediate hosts (mainly sheep and cattle), eggs hatch into oncosphere larva in the duodenum. The larva crosses the intestinal wall and, via the portal system, migrates to the liver, where it grows into a cyst. The definitive hosts are infected by consumption of cyst-containing viscera of slaughtered animals (**Figure 1**).[3–6]

Humans (accidental intermediate hosts) become infected through the ingestion of tapeworm eggs excreted in the feces of infected dogs, either by direct contact with the animal or by consumption of unboiled or unwashed contaminated vegetables (**Figure 1**). In the duodenum, eggs release larvae that go through the intestinal wall and migrate to the liver via the portal system. Reaching the liver, larvae may die or develop into hydatid cysts within months to years. Thus, the liver is the most frequently infected organ in humans (50-77% of cases).[7–9] The hepatic parenchyma is a physical barrier that prevents the spreading of parasites to the whole body. However, in some cases, larvae may pass through the liver, continue their course, and settle in the capillaries of the lungs (17-25% of cases),[10–12] or even reach the systemic circulation and potentially lodge in any part of the body — muscle (5%), peritoneum (4%), mediastinum (3.5%), bones (3%), heart (2%), kidneys (2%), spleen (1%), central nervous system (1%), thyroid (1%), or the adrenals, pleura, bladder, ovaries, or scrotum (<1% each location).[13–26]

Once in the human liver, the parasite's natural course is variable and cysts generally grow slowly (1 mm to 5 mm per year), but they can grow faster (up to 160 mm per year) and can reach very large sizes before they become clinically evident. Cysts can reach 25-50 cm and contain several smaller cysts ("daughter cysts") inside a large cyst ("mother cyst"). On the other hand, cysts can regress and/or become infertile.

CHD is endemic in many areas around the world, mainly in Mediterranean countries such as Morocco, Tunisia, Greece and Turkey, in addition to other regions where sheep and cattle are raised, such as the Middle East, the southern part of South America, Australia, New Zealand, and southern countries of Africa.[27–29]

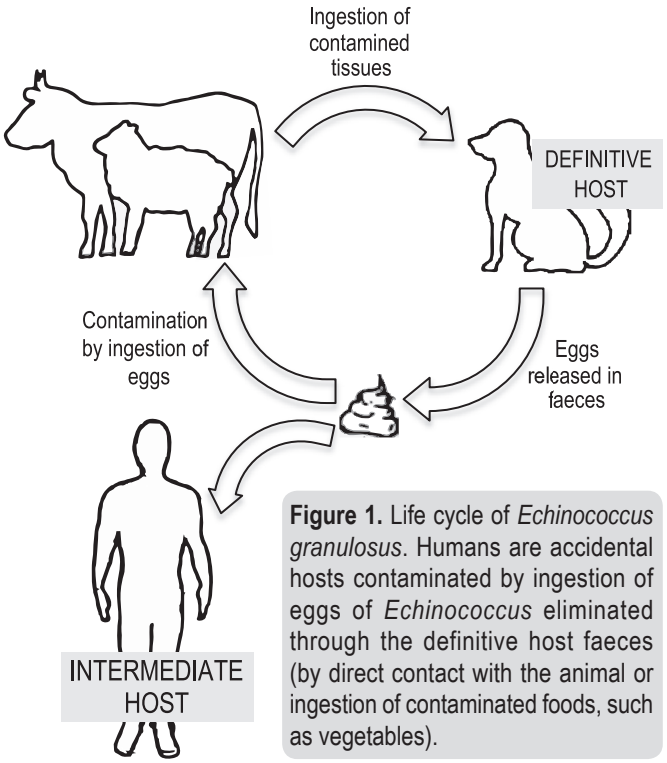

Figure 1. Life cycle of *Echinococcus granulosus*. Humans are accidental hosts contaminated by ingestion of eggs of *Echinococcus* eliminated through the definitive host faeces (by direct contact with the animal or ingestion of contaminated foods, such as vegetables).

In recent decades, echinococcosis incidence decreased owing to improvements in both agricultural and medical habits that followed the economic growth of these countries.[30] The incidence of hepatic hydatid disease in endemic areas ranges from 1-220 cases per 100,000 inhabitants.[7,31–34]

Histologically, hepatic CHD is composed of two main layers (**Figure 2)**:

i) the **pericyst** (or adventitia), composed of host compressed hepatic cells that form a dense fibrous zone secondary to a reaction to the parasite, and
ii) the **parasite-derived endocyst**, which has an outer laminated layer (called the laminated membrane, and formerly called the ectocyst) and an inner germinal layer (called the germinal membrane, and formerly called the endocyst).

The laminated membrane is an acellular elastic layer that allows the passage of nutrients into the cyst.

The single-celled germinal membrane secretes a clear colorless fluid, with a neutral pH, that can contain scolices and is strongly antigenic. Indeed, it can cause anaphylaxis if it makes contact with the circulation of the host. The germinal membrane is responsible for the formation of the laminated membrane, and gives rise to the brood capsules and daughter cysts, both containing scolices (**Figure 3**). Brood capsules are initially attached by a pedicle to the germinal layer, but they may detach from it and grow into daughter cysts. Occasionally, daughter cysts can grow up through the laminated

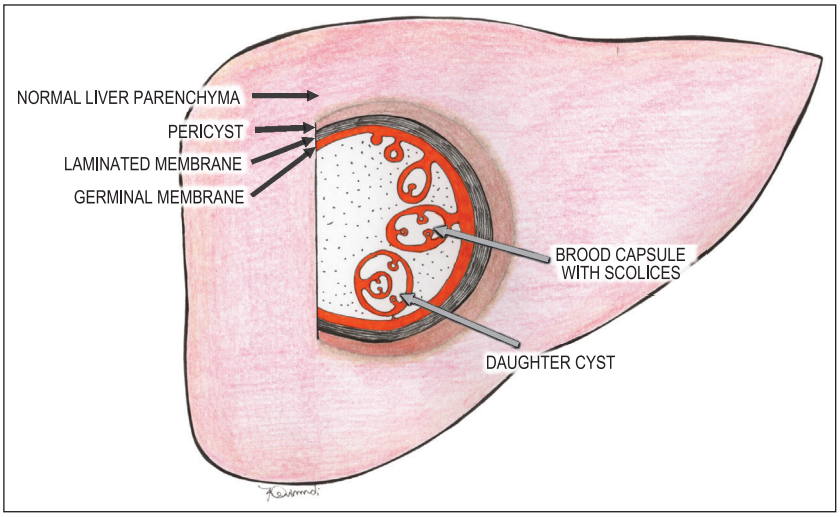

Figure 2. Schematic representation of a viable uncomplicated liver hydatid cyst. Thickened surrounding liver parenchyma forms the pericyst layer. Germinal membrane produces brood capsules and daughter cysts (development of daughter cyst is represented in the cyst in a clockwise sense).

membrane towards the external side of the original cyst, leading to the development of satellite cysts (exogenous daughter cysts). The so-called hydatid sand corresponds to scolices and remnants of membrane from ruptured daughter cysts.

Following the growing phase, hydatid cysts can involute as a consequence of scolices and overproduction of daughter cysts. In this phase the cystic fluid is replaced by scolices and membranes, and the reaction of the host can lead to a progressive calcification around the cyst. Indeed, completely calcified cysts are usually considered "dead cysts", despite the rare presence of fertile daughter cysts. Multiple small single cysts may form clusters resulting in a polycystic or multivesicular appearance, which has to be distinguished from alveolar and polycystic echinococcosis.

SYMPTOMS

Uncomplicated hydatid cysts are usually asymptomatic (50% of cases) and they may be diagnosed incidentally during imaging studies for other reasons.[35] The liver is the most affected organ (up to 70%) and frequently (65% of cases) the hydatid cyst is unique and localized in the right hepatic lobe. Multiple hepatic cysts occur in 20-40% of cases.

Symptoms due to hepatic CHD can be produced by the cyst itself (mainly compressive effects, rupture, and infection). Local or mechanical symptoms depend on location, number, and size of cysts. They generally occur generally when cysts reach more than 5 cm in diameter. Complications occur in about half of hepatic hydatid cysts. Infection and rupture (mainly into the biliary tree, the peritoneal cavity, and the pleural cavity) are the most frequent complications. Symptoms can also develop as a general toxic reaction due to the presence of the parasite (urticaria, anaphylaxis, and asthma, among others).

LOCAL COMPLICATIONS

Compressive effects

Manifestations due to mass effects are initially non-specific abdominal pain, cough and dyspeptic symptoms. In the liver, compressive effects of cysts include right upper quadrant pain (60% of cases) due to the hepatic capsule distension, obstructive jaundice (15% of cases) due to biliary tree compression, portal hypertension due to portal vein obstruction, and Budd-Chiari syndrome due to hepatic veins compression.[36]

Cyst rupture

Cyst rupture occurs in 3-40% of cases and it results from an increased pressure within the cyst. Rupture is habitually to the biliary tree, the peritoneal cavity, or the pleural cavity. (**Figure 4**)

Figure 3. Multiple daughter cysts evacuated from a large hydatid cyst.

Intrabiliary rupture (**Figure 4**). During cyst growth, biliary ducts that pass through pericysts lose their elasticity, and compression of their wall leads to necrosis and fissures. As a consequence, biliocystic communication can occur.[31] This is a major turning-point in hydatid cyst development. The true incidence of communication with bile ducts is not well known but may range from 6.6-37%.[31] This situation represents a well-defined anatomic entity illustrated by various clinical manifestations, depending mainly on size of biliocystic communication. Minor communications lead to cystic fluid drainage while major ruptures allow passing of extra intracystic material. The classic triad of biliary rupture in CHD (biliary colic, jaundice, and urticaria) can eventually be associated with fever (in case of cholangitis), which occurs mainly in major communications. However, jaundice due to biliary compression can be temporarily relieved following biliary communication (reduction of intracystic pressure). On the other hand, eventual bacterial inoculation can result in secondary cyst infection, hepatic abscess, and ultimately severe sepsis. The migration of daughter cysts through the biliocystic communication can lead to jaundice secondary to obstruction at the level of the duodenal papilla. Minor leaks of the cyst can produce flushing and urticaria, and major rupture can lead to a potentially fatal anaphylactic reaction.

Rupture to the biliary tree mainly occurs in centrally located cysts and most frequently into the right hepatic duct branches (55-60%) or left hepatic duct branches (25-30%), but communication can also occur into the hepatic duct confluence, common bile duct, cystic duct, or gallbladder. Diagnosis is usually suggested by the clinical findings described above associated with a combination of dilated bile ducts and a hepatic cystic lesion on imaging studies. Seldom, biliary tract communication can result in fibrosis of the papilla or external biliary fistulas.

Peritoneal rupture (**Figure 4**). Rupture of a hydatid cyst into the peritoneum (1-8% of cases) may occur spontaneously or after blunt trauma and can be followed by anaphylactic shock.[37,38] Large cysts located superficially on the liver are more likely to present peritoneal rupture. Symptoms typically include acute abdominal pain, nausea, vomiting, and urticaria. The presence of bile (due to previous biliary rupture) can lead to hydatid choleperitonitis. Acute peritoneal rupture is suggested on imaging studies by the presence of a collapsed hepatic cyst and peritoneal effusion or daughter cysts. On the other hand, rupture to the peritoneum can be insidious, with no acute manifestation. In this situation the spillage of scolices leads to multiple abdominal daughter cysts, which develop months to years later (secondary echinococcosis).[39]

Intrathoracic rupture (**Figure 4**). Hepatic hydatid cysts near the diaphragm can rupture into the thoracic cavity (0.6-16% of cases). Adhesions occur during cystic erosion (due to pericystic inflammation) and determine the extension of damage. Thus, intrathoracic rupture can lead to myriad findings according to extension of communication (pleural, pulmonary, or bronchial), and include hydatid pleurisy, bronchobiliary fistula, hemoptysis, and cystic or bile expectoration.[40,41] Clinical presentation is predominantly pulmonary, including coughs, expectoration, and dyspnea. Computed tomography scan is useful for diagnosis of thoracic complications from hepatic hydatid cysts.

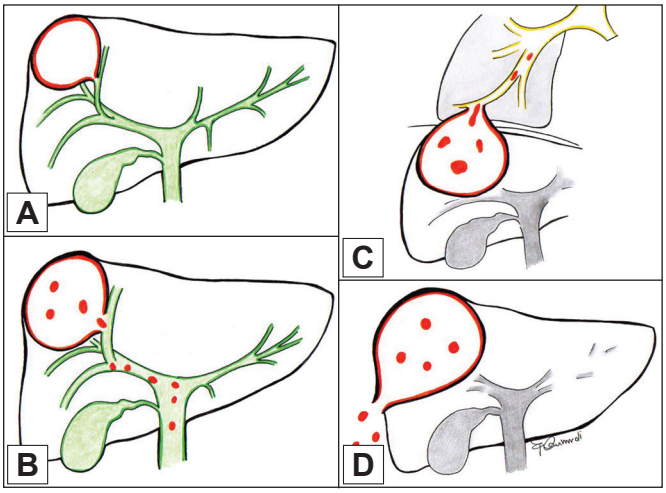

Figure 4. Schematic representation of ruptured hydatid liver cysts: **A**) Rupture to the biliary tree (biliary communication); **B**) rupture to the biliary tree with migration of daughter cysts into the biliary tree; **C**) Rupture to the thorax; **D**) Rupture to the peritoneum.

Secondary bacterial infection

Secondary bacterial infection occurs in approximately 10% of hydatid cysts but it is usually latent and subacute. Right upper abdominal pain, hepatomegaly, and fever can be present. Following secondary bacterial infection a hydatid cyst can become unfertile.

Other complications

Hepatic CHD can fistulize to the skin (with welling of pus and/or hydatid membranes), to the digestive tube with eventual hydatimesis (release of daughter vesicles during vomiting) or hydatid enterica (hydatid cyst in stool), or to blood vessels (such as hepatic veins or vena cava).

DIAGNOSIS

Hydatid liver disease diagnosis is based on a combination of epidemiological data, clinical features, radiological imaging and serologic blood tests.[30,42] Clinical suspicion of liver hydatid disease can be confirmed by imaging (such as ultrasonography, computed tomography, or magnetic resonance imaging), detection of specific antibodies with immunodiagnostic tests (ELISA, arc 5 test, among others), or by examination of material obtained by biopsy puncture.

Radiological imaging

Calcifications are seen in 20-30% of cases on **plain films** of the abdomen. Curvilinear or ring-like pattern calcifications are more common, but a complete calcification can be seen in some cases, frequently indicating death of the parasite. However, all of these findings are non-specific.

Ultrasonography is a well-established and very sensitive and specific tool for liver hydatid cyst diagnosis, being the screening method of choice in endemic area.[1,42–44] Ultrasonography is useful to define number, site, dimensions, and vitality of hydatid cysts. The method is particularly accurate when hydatid sand, daughter cysts, and/or calcifications are seen. Some findings are considered pathognomonic of hydatid disease: i) unilocular anechoic lesion with a cyst wall (laminated layer) and snowflake-like inclusions or floating laminate membranes; ii) multivesicular or multisepate cysts with a wheel-like appearance; and iii) unilocular cysts with daughter cysts with a honeycomb appearance. A cyst with echogenic material that moves according to the patient's position, as well as the imaging of one or more cysts within a cyst, provides a very strong diagnostic probability.

Most classifications of cystic hydatid disease of the liver are based on ultrasound findings. The most widely adopted, especially for surgeons, is the one proposed by Gharbi et al.[45] in 1981 (**Figure 5**).[3,14,17,18,39,45–54]The World Health Organization Informal Working Group on Echinococcosis (WHO-IWGE) developed a similar classification based on activity status of cysts suggested by sonographic appearance.[55] Three categories were defined: i) active (CE1 and CE2), indicating fertile cysts containing viable scolices; ii) transitional stage (CE3), owing to compromise of the cyst either by host defense or by chemotherapy; and iii) inactive (CE4 and CE5), having lost their fertility, and being degenerative (**Figure 5).** Both classifications are intended to correlate with the natural history of the disease. It's of note that Gharbi type II cysts correspond to CE3a (WHO-IWGE classification) and vice versa. Also, the WHO-IWGE classification includes the predominantly solid cyst with daughter cysts, which is not explicitly included in Gharbi's classification, in the CE3 group.

Cysts with a visible split wall inside (floating membrane or water lily sign) and those with septations, or with a honeycomb pattern, are pathognomonic of hydatid cysts. On the other hand, simple hepatic cysts with well-defined borders, cyst wall not visible, and uniform anechoic contents (defined as CL on WHO-IWGE classification) are not characteristic of hydatid disease. Similarly, solid heterogeneous masses or cysts (corresponding to CE4 and CE5 with the WHO-IWGE classification, and type IV and type V with the Gharbi classification) can be difficult to differentiate from granulomas or tumors.

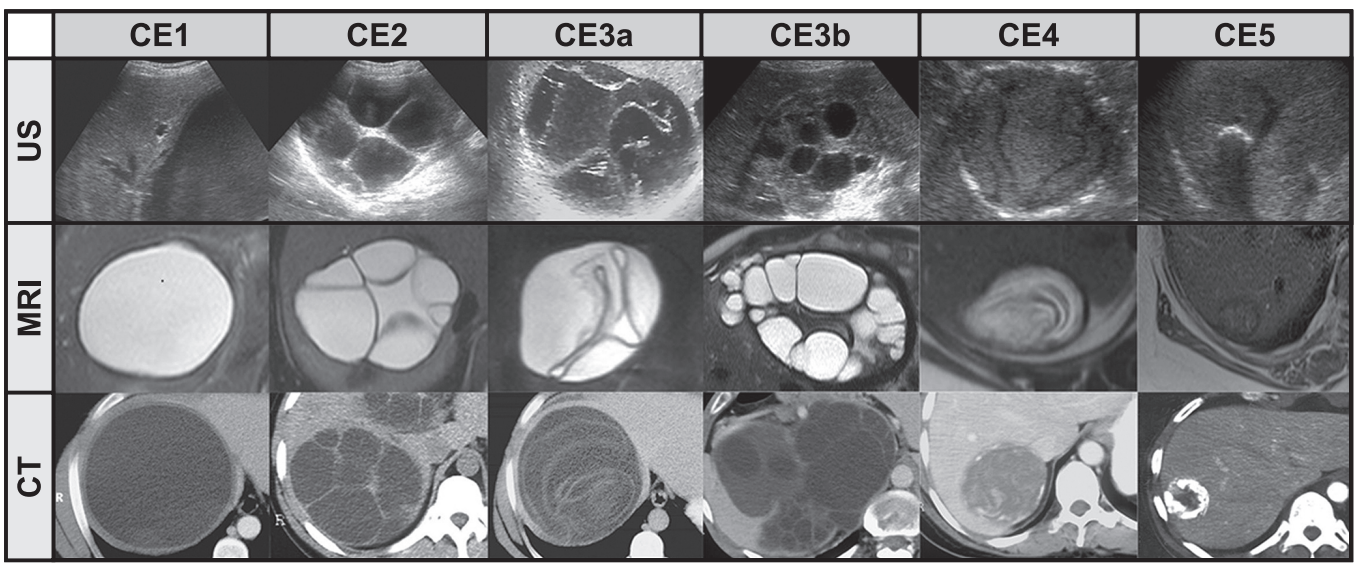

Figure 5. WHO-IWGE (World Health Organization – Informal Working Group on Echinococcosis) classification for liver hydatid cysts. **CE1**: unilocular, simple cysts with liquid content and often with the CE1-specific "double line sign", **CE2**: multivesicular, multiseptated cysts, **CE3a**: cysts with liquid content and the CE3a-specific detached endocyst, **CE3b**: unilocular cysts with daughter cysts inside a mucinous or solid cyst matrix, **CE4**: heterogenous solid cysts with degenerative, CE4-specific canalicular structure of the cyst content, and **CE5**: cysts with degenerative content and heavily calcified wall. Note that CE2 and CE3b correspond to GHARBI III classification (fluid collection with septa and/or daughter cysts), and CE3a corresponds to GHARBI II classification. Additional class on WHO-IWGE classification, cystic lesion (CL), corresponds to cyst with no visible wall and homogeneous anechoic content (not shown in the figure). Despite being considered "inactive", cysts CE4 and CE5 can carry viable scolices. (From: *Stojkovic M, Rosenberger K, Kauczor H-U, Junghanss T, Hosch W* Diagnosing and Staging of Cystic Echinococcosis: How Do CT and MRI Perform in Comparison to Ultrasound? *PLoS Negl. Trop. Dis.* **6**, e1880 (2012).[62]

Abdominal computed tomography (CT) can detect small-sized cysts, as well as visualize membrane detachment and the presence of the multivesicular pattern. CT is indicated in cases in which ultrasound fails due to patient-related difficulties (e.g., obesity, excessive intestinal gas, abdominal wall deformities, previous surgery) or disease complications. CT has a high sensitivity and specificity for hepatic hydatid disease.[56] Specificity can be increased by presence of calcified rim of daughter cysts. CT can be useful when US diagnosis is uncertain, mainly in cysts types CE4 and CE5. In cases of wide cysto-biliary communication CT demonstrates rupture in 77% of cases.[57]

Magnetic resonance imaging (MRI) has accuracy comparable to CT, and both methods bring further anatomical details for surgeons to anticipate their surgical approaches.[7,29,58,59] MRI may, however, be superior to CT in the evaluation of postsurgical residual lesions and recurrences, and also to identify rupture into the biliary tree.[58,60–63]

Serological tests.

Eosinophilia is present in up to 25% of cases (mainly in the presence of cyst rupture). Serological tests detect specific antibodies to *E. granulosus* and circulating hydatid antigen. Antibody assays are useful to confirm presumptive radiologic findings of cystic echinococcosis. However, some patients with hydatid disease do not demonstrate a detectable immune response.[32,64]

Enzyme-linked immunosorbent assay (ELISA) has a high sensitivity to detect antibodies, although it is dependent on the method of antigen preparation, and cross-reactions with other helminthic diseases occur if crude antigens are used. Purified fractions may yield high sensitivity (95%) and specificity (100%).[5,65–67] While approximately 10% of patients with hepatic hydatid cysts do not produce detectable serum IgG antibodies, ELISA is useful in follow-up to detect recurrence. Double diffusion and immune-electrophoresis demonstrate antibodies to antigen 5 (arc 5 test) and provide specific confirmation of reactivity.

Despite high rates of false-negative results (particularly in the early cyst stages, when hydatid fluid is still tightly contained within the endocysts, and in the final stage of involution, when cyst content is solid and the cyst wall largely calcified)[62] and false-positive results of serological tests, they remain very helpful to guide diagnosis in some equivocal cases, especially outside endemic areas,[68] using ELISA as a screening test and immuno-electrophoresis as a confirmatory test.[1,14,17,43]

Diagnostic puncture

Percutaneous fine-needle aspiration (PFNA) can provide definitive diagnosis if scolices are recovered from a suspected hydatid cyst; however, this technique carries a risk of spilling scolices into the peritoneal cavity. PFNA may be helpful to differentiate hydatid cysts, malignancies, and abscesses, particularly in cases with inconclusive imaging appearance and negative serological tests. Puncture should be performed by transhepatic routes and chemotherapy should be used for four days before puncture and for at least one month after puncture.[69]

TREATMENT

Although most patients with LHC are asymptomatic or paucisymptomatic, treatment should be instituted to prevent complications, such as infection, rupture of the cyst to the adjacent structures, or anaphylaxis. Currently, four major approach options are available: surgery, chemotherapy with benzimidazole compounds,[27,38,70–73] interventional approaches (such as radiological percutaneous needle aspiration,[73–79] radiofrequency,[80,81] or endoscopic therapeutics,[82–86] and follow-up with no specific treatment ("wait and see").[2,87] However, there is no consensus for the best approach.[28,30,33,43,55,87,88] Treatment of cystic echinococcosis should be a combination of general goals and rules with individual decisions and indications,[43] tailored according to surgical fitness of patients, characteristics of the cysts, and physician team experience and medical resources available.[3,7,29,47,67,74,89–91] Medical teams should know all available options and opt for the most adequate (individually or in combination), according to each individual situation. However, surgery remains the gold standard treatment for liver hydatid cysts.[3,4,6,7,18,27,30,41,43,47–49,51–54,68,81,84–86,89–102] The main intended goals of treatment of hydatid disease of the liver are to ensure complete elimination of the parasite (including the destruction or resection of the germinal layer) and prevention of recurrent disease with lower morbidity and mortality.

Thus, small cysts that are densely calcified (Gharbi V or CE4 or CE5) could be followed with no specific treatment or excised if the patient has a good performance status; viable but uncomplicated deep small cysts could be treated by chemotherapy or interventional procedures; complicated cysts or peripheral cysts in a fit patient should be treated by surgery.[103]

Surgical approach

Surgery is the treatment of choice especially in large (>10 cm) lesions, complicated cysts (associated with rupture, biliary tree communication, compression of adjacent organs or vessels, secondary infection, hemorrhage), and cysts situated superficially that may rupture spontaneously or as a result of trauma.

The main principles of the surgical treatment are: i) to inactivate scolices contained in the cyst; ii) to prevent spillage of cyst contents during its evacuation; iii) to eliminate all viable elements of the cyst; iv) to manage the residual cavity of the cyst; and v) to search for and manage any

communications with the biliary tract.

Anaphylaxis and secondary recurrence due to accidental spilling of the cyst content are specific complications added to ordinary surgical risks associated with any surgical procedure. Operative mortality rate varies from 0.5% to 4% but increases with repeated intervention. Relative contraindications to surgery include pregnancy, poor clinical status, and diffuse hepatic cysts.

Surgical approach includes **conservative surgery**, when the pericyst is not resected but the germinal and laminated membranes are resected; and **radical surgery**, when the pericyst is included in the resection (pericystectomy and partial hepatectomy). Usually more radical procedures are associated with higher intraoperative risk but lower chance of relapses, and vice versa.

Perioperative chemotherapy. Preoperative chemotherapy could soften the cysts and reduce intracystic pressure, reducing the risk of peritoneal spillage during evacuation of the cysts. Postoperative chemotherapy is useful to reduce the rate of recurrences and should be used for at least one month after the procedure.

Installation and approach. For most cases the patient is positioned supine. No special rolls or padding are necessary. Laparoscopic access may be used; however, usually open laparotomy is preferred through a large incision (a right subcostal incision, extended to the left and/or to the xiphoid process). Depending on the topography and number of cysts on the liver and the possibility of the presence of hydatid cysts in other viscera, the surgeon can proceed to an upper midline incision. In the last decade, studies examining the use of pure laparoscopic approach and hand-assisted technique have been published.[104–108] In fact, these minimally invasive surgical approaches can be performed safely in selected patients with liver hydatid cysts.

The first step after peritoneal access is to explore the peritoneal cavity, the liver, and the extrahepatic biliary tract through both visual, manual palpation, and intraoperative ultrasonography (IOUS) examination.

Concerning the treatment of the hepatic hydatid cysts, numerous surgical techniques have been proposed. These include radical and conservative surgical approaches. The more aggressive options are hepatectomy and total pericystectomy. They involve removing the whole cyst with the pericyst, with unnecessary loss of normal hepatic parenchyma. Conversely, conservative operations aim to unroof the cyst after evacuating its contents, and to manage the residual cavity. Comparisons between radical and conservative techniques remain at the center of many controversies.[28,29,37,55,83,89,100,101,105–107,109] The choice between one of these two approaches depends mainly on the habits and skills of the surgical team and the technology available more than the known results of each procedure.

Scolicide substances. During surgical approach, scolicidal agents can be used to protect surrounding organs and to inactivate the cyst. Potential communication between the hydatid cyst and the biliary tree should be taken into account since most scolicidal agents can cause chemical cholangitis and lead to subsequent sclerosing cholangitis. Formalin was completely abandoned as scolicidal agent owing to its severe complications, such as sclerosing cholangitis.[4,6,36,48,97] Other agents were used in the past, such as alcohol, chlorexidine, cetrimide or silver nitrate solution, but were mostly abandoned.[30,102,108,110] Nowadays the three most used scolicidal agents, depending on surgeons' habits, are: hydrogen peroxide,[4,6,7,40,96,110,111] hypertonic saline 15% or 20%,[4,28,30,33,35,54,64,87,88,97,99] or polyvinyl pyrolidone-iode.[46,89] Studies comparing usual scolicidal agents are rare and not conclusive.[112–114] The use of hydrogen peroxide results in an exothermic reaction and boiling when applied to the larvae or the cavity. Colorless characteristics of this scolicidal liquid help in identifying hydatid fluid that is bile stained.

Conservative approach

The principal aims of conservative surgery are: i) inactivation of viable parasitic elements; ii) evacuation of the cyst cavity leaving part or all the pericyst; and iii) management of the residual cavity and cyst-bile duct communications, if existing.

After complete exploration of the peritoneal cavity, the area around the cyst is covered and isolated with packs immersed in a scolicidal agent. The cyst is then punctured and incised at its most accessible part. Aspect of the liquid is noted; yellowish coloration suggests biliary communication, while purulent content indicates infection, which is frequently associated with biliary fistulae. It is highly recommended to use two suction cannulas (one for cyst contents, the other for eventual spread and leaks around it) and a jar trap to avoid obstruction of aspiration systems. All cyst content is aspirated and the cyst largely opened. The germinal membrane is easily removed with forceps and the cavity is flushed with scolicidal agent for 10 minutes. The pericyst is cleaned by the interior of the cyst and smoothed out, and possible daughter cysts developing in the pericyst are removed. It is prudent to proceed to meticulous operative inspection of the inner surface of the remaining cavity, peeling the laminated membrane to reduce thickness of the pericyst, and remove daughter cysts hidden in the pericyst layer (exogenous daughter cysts). Using hydrogen peroxide to again flush the remaining cavity for at least 10 minutes may play a role in sterilizing remaining exogenous cysts exposed by the peeling procedure. Exogenous vesiculation occurs when the pericyst becomes thicker.[3,90]

Before injection of scolicidal agents it is necessary to look for an eventual fistula. Scolicidal agents should be avoided in case of biliary fistulae because the contact of these agents with the biliary tract can be harmful. Thus, scolicidal agent injection is not recommended while the cyst

is still closed. Many methods can be used to help identify fistulas, such as injection of isotonic serum, methylene blue or air through the cystic duct, or through common bile duct puncture.[52,89,99] The visible biliary openings should be sutured when they are less than 5 mm, or these communications can be treated by directed external fistulization when they are more than 5 mm.[52,82,93,115] If the hydatid fluid is bile stained, after a negative meticulous sought of biliary openings, the possible fistula is left alone and the residual cavity is kept under aspiration during the postoperative period using external drainage. After puncture, the cyst is widely unroofed by excising the projecting part of the pericyst (**Figure 6**).[27,29,37,46,47,82,115–117] Then, the obliteration of the remaining cavity is completed by introflexion or capitonage (increasing the risk of injuring the major duct and vessel passing next to the pericyst), suture of the pericyst with slowly resorbing thread, omentum (**Figure 7**) or muscle flaps, or simple drainage.[7,29,37,46,64,82,93,101,107,117] In some rare cases, cystojejunostomy can be performed by a wide anastomosis between pericystic edges and jejunum.[28,64,82,93,101,107] All of these techniques prevent dead space in the remaining cavity and further potential complications. Filling the inner cystic cavity prevents fluid collection and infection in postoperative period. Cholecystectomy can be performed along with intraoperative cholangiography whenever biliocystic communication is suspected, or in the case of a dilated common bile duct, to ensure the vacuity of biliary tract. A T-tube drain can be placed in the common bile duct (**Figure 8**). A conservative approach can result in a rigid residual cavity due to the thickness of the pericyst. This fibrous tissue can make it difficult to suture eventual biliary communications and can also make it difficult to identify exogenous daughter cysts. Scolices in the common bile duct can be evacuated intraoperatively or postoperatively through endoscopy. The intervention is completed with drainage of the perihepatic area.

In the postoperative period, drainage of the remaining cavity should be maintained until at least the fifth day. If a postoperative external biliary fistula presents during this period, it is appropriate to maintain the drain. Endoscopic sphincterotomy and/or nasobiliary catheter may be very useful in the management of persistent bile leakage by accelerating the healing.[29,89]

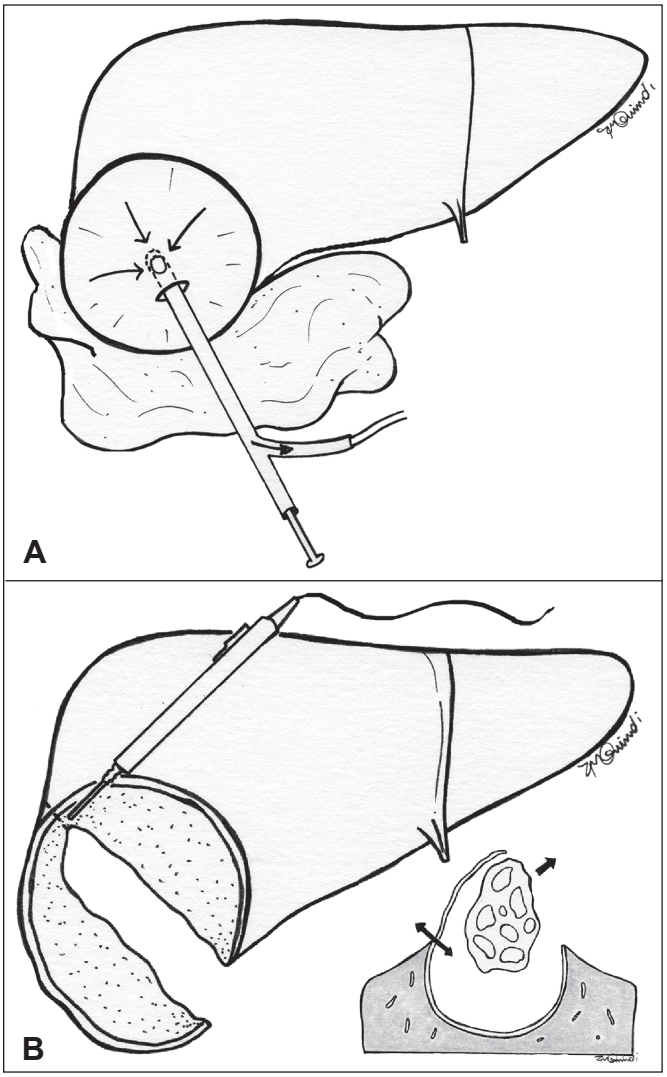

Figure 6. Schematic representation of a conservative surgery for hydatid cyst. **A**) After protection of surroundings of the cyst by packs soaked with scolicidal agent, the cyst is punctured with a trocar with a system for release obstructions, the content of the cyst is aspirated, and if it is not of bilious aspect, the cyst is filled with scolicidal agent for 15-20 minutes. **B**) The cyst is largely opened and the endocyst is removed, then the cyst is unroofed by removing the portion not involved by hepatic parenchyma. Meticulous search for communications with bile ducts and/or exogenous daughter cysts is performed and if present they are treated as described in the text.

Radical approach

The main procedures of radical approach are total pericystectomy and liver resection. With these techniques all objectives of the surgical treatment of hydatid cysts are met. Authors who support radical surgery for liver hydatid cysts report that it results in fewer postoperative complications, such as biliary leakage and recurrence.[33,36,98,107,108] The most common radical approach is pericystectomy (**Figure 9**). In this procedure, the whole cyst (including the pericyst) is removed along with nearby healthy liver parenchyma. This parenchymal margin should be slight, to minimize the loss of liver tissue, representing a non-anatomical liver resection. Whenever it is difficult or risky to manage the intraparenchymal portal pedicle (bile duct and portal vein) due to proximity to the hydatid cyst, an anatomical liver resection is preferred and should follow general rules as detailed in other chapters of this book.

Complete resection of the cyst can be performed either

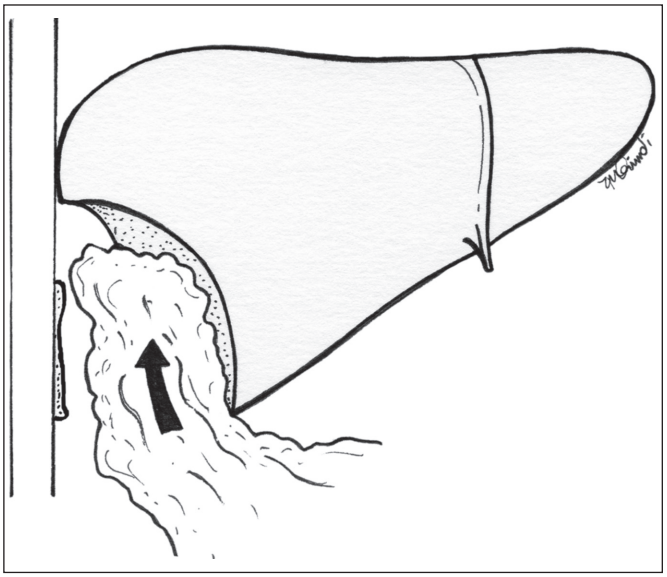

Figure 7. Schematic representation of epiploonplasty as a method of treatment of the residual cavity after unroofing or pericystectomy of hydatid liver cyst.

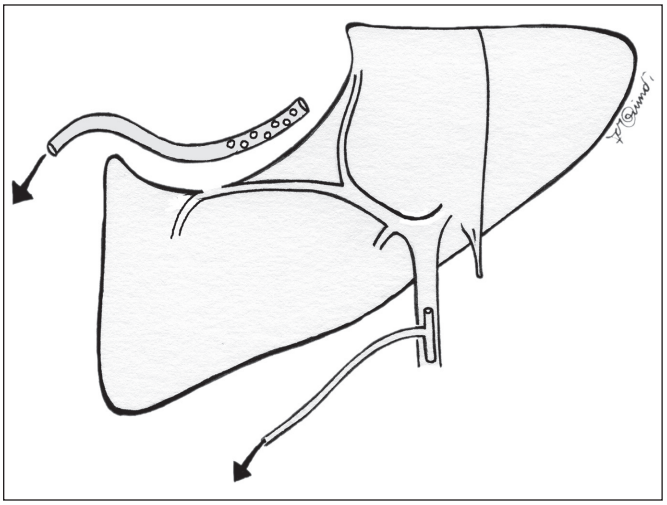

Figure 8. Option for treatment of biliary communication after conservative surgery of hydatid cyst. A "T" tube placed in the main bile duct reduces the pressure in the biliary tree and a tubular drain placed near the suture of the bile duct communication avoid fluid collection until complete healing.

by an "open-cyst" approach (with resection after opening and sterilization of the cyst), or "closed-cyst" approach (without opening of the cyst).[97,100] The open-cyst technique brings the risk of intra-abdominal seeding of scolices, especially if no additional measures are applied as described in conservative approaches (protection and scolicidal agents). In this situation, some benefits of the radical approach are lost. Otherwise, the open technique can reduce the risk of accidental rupture of the cyst during the resection or the mobilization of a closed cyst.

Advantages of pericystectomy include the preservation of normal hepatic parenchyma (in contrast with anatomical liver resections) and the complete resection of the parasite and pericyst, resulting in a resilient residual cavity that is easy to obliterate and allows for adequate treatment of eventual biliary communication. During pericystectomy, a fragment of pericyst can be left in place to avoid dangerous dissection in contact with major vascular or biliary structures (**Figure 10**). Similarly to the conservative approach, the residual cavity can be obliterated. The main indication for anatomical liver resections is complex compromise of the biliary tree or vascular intrahepatic structures. However, a recent large study comparing conservative and radical surgical approaches showed no difference in perioperative complications, nor in recurrence rates.[118]

In endemic areas and less equipped medical facilities, radical approaches can lead to high postoperative morbidity and mortality rates. In addition to the non-malignant aspect of this disease and its slow progression, other reasons could justify conservative approaches, such as the presence of secondary inflammation in the nearby liver resulting from long-term compression by the cyst, and the difficulties in estimating remnant liver function. However, recent technological developments and the generalization of modern surgical techniques, such as intraoperative ultrasonography, ultrasonic dissection, LigaSure, metal bands and radiofrequency, make a strong case for adopting radical approaches. Hepatic resections can be reserved for cysts involving major vascular-biliary structures of the liver (anatomical resection), small cysts located peripherally (pericystectomy), pedunculated cysts, anatomical hepatic segments or sectors with severe damage by a cyst or being the

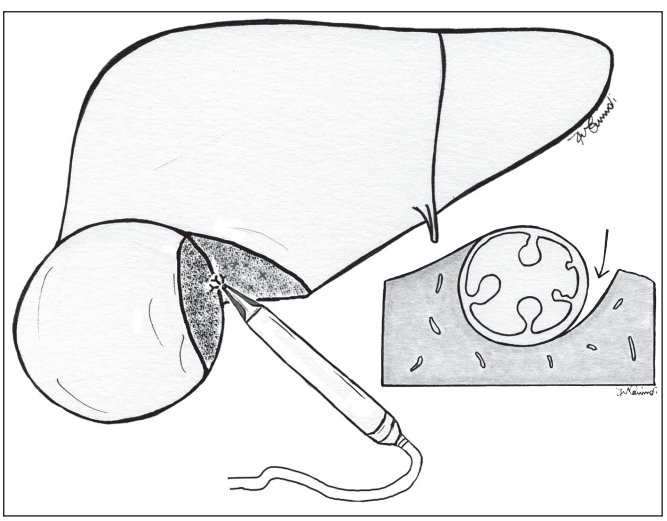

Figure 9. Schematic representation of a pericystectomy. The cyst is completely removed with the pericyst. The residual cavity is more supple than if the pericyst is preserved.

are preferable, such as large cysts rendering liver mobilization impossible or dangerous, blood vessels in a perilous situation, or when there is high risk of trauma to nearby organs (colon, diaphragm, stomach and duodenum). In these situations it is safer to be conservative and to perform an open cyst resection instead of radical removal of the cyst.

Perioperative chemotherapy (using benzimidazole compounds) can reduce recurrence risk. However, despite all precautions, dissemination and spillage of hydatid liquid into the abdomen or wound edges during the intervention can still happen.[3,4,7,29,38,48,87,104]

Laparoscopic approach

Surgery for uncomplicated hydatid cysts of the liver can be performed safely by laparoscopic approach.[119–122] The advantages of this less invasive approach (including shorter hospital stay, lower incidence of wound infection and less postoperative pain) should be weighed against the potential increased risk of spillage of scolices (difficulties in aspirating), difficulties in approaching deeply located cysts and the possibility of eventual increased recurrence rates.[123,124]

Results of surgical treatment

Most studies demonstrate that mortality and morbidity of radical and conservative approaches are similar.[47,48,87,99,125] Generally, mortality ranges from 0 to 6.5%.[73,82,92,125] However, some factors such as perioperative complications, disseminated disease and weight loss seem to be involved.[7,73,91,126] All interventions on liver hydatidosis should be considered as potentially major surgery.[7,90]

Specific morbidity is represented particularly by deep abdominal complications, which range from 10% to 29.5%.[7,28,73,87,109,115,127] Bile leakage represents the main source of immediate postoperative complications. It is related to persistent biliary fistula on a thick, calcified and infected remaining pericyst, and poor or defective drainage of the residual cavity. In most cases, fistulae close spontaneously, or after endoscopic sphincterotomy.

After surgery, all patients should undergo abdominal ultrasound surveillance. It is usually recommended at the first month after discharge, every six months during the first four years, and then annually thereafter, to detect recurrences. In the case of highly suspected liver hydatid disease recurrence on an ultrasound, abdominal CT scan should be performed. Recurrence is defined as the appearance of a new growing cyst, undetected by radiological exploration before the surgery or by the surgeon during the procedure, whether in the first location of the hydatid cyst in the liver or in another liver segment. During follow-up, if cystic areas appear on an ultrasound and/or CT scan without change in size and without evidence of daughter cysts, fine-needle aspiration cytology (FNAC) can be used to confirm recurrence.[68] Immunological tests are less sensitive and specific, and

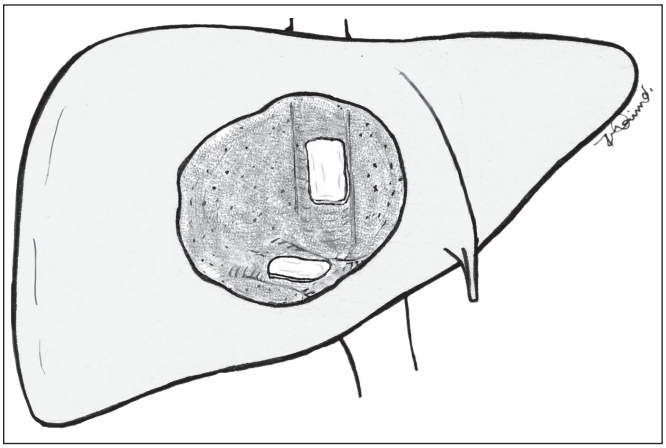

Figure 10. Schematic representation of pericystectomy with partial preservation of pericyst in zones of adherence to vascular structures.

are helpless to recognize recurrence when compared to radiological explorations. Recurrence rates of liver hydatid cysts after surgery range from 0 to 25%.[4,29,46,48,49,70,79,87,91,128–133]

Some authors report a significant high rate of recurrence after conservative approaches and following radical resection.[48,87,97–99] They report that recurrences with conservative procedures are due to the possibility of leaving viable material on the outer surface of the pericyst (exogenous vesiculations).[3,4,52,79,90,129] Some surgeons may fail to ensure a meticulous strategy in order to avoid missing residual vesicles.[3,127] Surgeons' skills and experiences can be another determining factor of recurrences.[29,90,91] Peritoneal soiling during emptying of the cysts can explain some recurrences and seems to be a more complex problem.[3,130] When all described precautions are taken and all parameters are adjusted, no statistically significant difference is observed between radical and conservative approaches in terms of postoperative recurrences.[68] Recurrence may occur many years later, which is the reason why extended follow-up is recommended. Postoperative recurrence can occur anywhere from four months to 35 years after the first surgery. Thus, in patients who have a high risk of developing recurrences, a conservative approach may be preferred because technical difficulties may occur during further hepatic operations, leading to high postoperative morbidity and mortality or a lengthy postoperative stay.[97]

Percutaneous aspiration, injection, re-aspiration (PAIR)

Percutaneous aspiration, injection of scolicidal agent, and re-aspiration (PAIR) for the treatment of hydatid cysts of the liver was introduced in 1980s,[134] and is a low invasive procedure with less morbidity and mortality than surgery.[135] Cyst puncture for treatment of hydatid disease of the liver comprises: i) percutaneous puncture under ultrasonic guidance; ii) aspiration of a substantial amount of cyst fluid;

iii) injection of scolicidal agent; and iv) re-aspiration of the fluid cyst content after 15 to 20 minutes. The PAIR procedure should be accompanied by perioperative chemotherapy to reduce risks of secondary echinococcosis (due to spillage of scolices).[134,136] Some crucial points for the PAIR technique include the use of transhepatic puncture (surrounding liver parenchyma protect against peritoneal spillage) (**Figure 11**) and immediate analysis of the aspirated fluid for traces of bilirubin (since biliary tree communication precludes the injection of scolicidal agents).

PAIR is mainly indicated for hydatid cysts in patients not suitable for surgery and those who refuse surgery. Cysts classified CL, CE1, CE2, and CE3 are good candidates for PAIR. However, cysts that are superficially located, honeycomb-like cysts, cysts with solid patterns or that are calcified, and cysts with associated biliary tree communication are generally refused for PAIR. Superficially located cysts carry a higher risk of spillage and puncture should be avoided, or, if necessary, performed using transhepatic technique (**Figure 11**).

Percutaneous Thermal Ablation (PTA). The percutaneous evacuation of a hydatid cyst of the liver followed by radiofrequency thermal ablation is another percutaneous method that is able to inactivate the germinal layer without the use of scolicidal substances.[76,137]

Chemotherapy

Chemotherapy using benzimidazole compounds can result in significant regression (degeneration or size reduction in up to 70% of cases) or complete disappearance (10% to 30% of cases);[134,136,138] however, some studies found no response in 40% of patients.[136] Relapses after chemotherapy occur in up to a quarter of cases, but are usually sensitive to retreatment. Favorable response is mostly expected in isolated small cysts with minimal surrounding adventitial reaction. Conversely, large, old, or complicated cysts are less likely to respond well to chemotherapy. Thus, it is indicated as a sole treatment in patients with contraindications for surgery or PAIR, or it can be used as a perioperative treatment adjunct to invasive procedures (such as surgery or PAIR). Patients with unfavorable fitness status and/or with multiple simultaneous cysts in other organs or the peritoneum are examples of poor surgical candidates that could undergo a conservative approach by chemotherapy alone. Chemotherapy as sole treatment should be done for at least three months.

The two available benzimidazoles, albendazole (10-15 mg/kg/day) and mebendazole (40-50 mg/kg/day), have demonstrated efficacy, but results for albendazole have been superior (probably due to easer intestinal absorption and penetration into the cysts). Contraindications for the use of benzimidazoles include early pregnancy, chronic hepatic diseases, and bone marrow suppression. Adverse reactions (such as neutropenia, liver toxicity and alopecia) are reversible upon cessation of treatment.

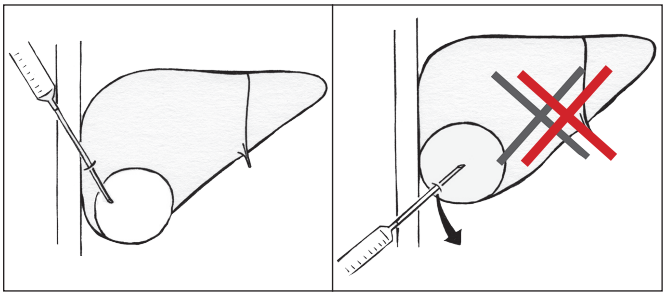

Figure 11. Technique for puncture of hydatid cysts of the liver. Transhepatic technique avoids spillage of parasites in superficially located cysts.

Praziquantel (50 mg/kg/day), an isoquinolone derivative, has a marked in vitro efficacy on reducing scolex viability,[139] and it has been used in combination with albendazole, resulting in more rapid results than benzimidazoles alone.[140–143]

ALVEOLAR ECHINOCOCCOSIS

Alveolar echinococcosis (AE) is caused by the larval stage of *Echinococcus multilocularis*, a tapeworm with a life cycle similar to that of *Echinococcus granulosus*, but having foxes, coyotes, dogs and cats as definitive hosts instead (**Figure 1**). Humans are accidental intermediate hosts (rodents are regular intermediate ones), infected by ingestion of eggs discharged with the feces of definitive hosts, probably by handling definitive hosts or by ingesting contaminated food or water. Despite the worldwide presence of the parasite, mainly in the northern hemisphere, and the high prevalence of definitive hosts in certain areas, alveolar echinococcosis is rare in humans.[144,145] It is considered to be the most pathogenic zoonosis in temperate and arctic regions of the Northern Hemisphere and more recently in Asia and Europe, and it has expanded from rural to urban areas.[145,146] Despite the fact that alveolar echinococcosis is a benign disease, it is well known as potentially fatal.[147]

Once in the liver, nearly exclusively the primary site of AE, the parasite develops, resulting in an alveolar structure, made up by multiple vesicles whose diameter varies from less than 1 mm up to 15-20 cm. Each vesicle has a structure similar to that of cystic hydatid disease, with germinal and laminate layers; however, brood capsules or scolices are uncommon and the small cysts are surrounded by dense connective tissue and granulomas. The disease is characterized by infiltrative local proliferation (exogenous tumor-like proliferation) and the potential to metastasize.

Because the cysts usually grow slowly, parasite infection may not produce any symptoms for many years (**initial**

phase) and may be cured spontaneously or continue growing, resulting in symptoms (**progressive phase**).[148] Initial clinical manifestations include mainly abdominal pain, jaundice and hepatomegaly.[149] In this phase, the liver is largely affected. The **advanced phase** is characterized by liver failure, often associated with portal hypertension, ascites and splenomegaly. The natural course for untreated (or inadequately treated) patients is frequently death, some years after diagnosis. Death eventually results from biliary complications (such as cholangitis, septicemia, and secondary biliary cirrhosis), portal hypertension, Budd-Chiari disease, or complications related to involvement of other distant organs. A **stable phase**, with inhibition of parasite proliferation, can occur in patients undergoing long-term chemotherapy. Also, in some asymptomatic cases, the parasite dies out and the lesion becomes calcified, representing an **abortive phase**.

The clinical diagnosis is based on: i) clinical findings and epidemiological data,[65] ii) lesion morphology shown by imaging techniques (mainly ultrasound examination, CT scan, MR imaging or FDG-PET),[150–152] iii) histopathology and/or nucleic acid detection, and iv) serology.

Typical ultrasound aspects of AE are a pseudotumoral hepatic mass, which is heterogeneous, with irregular edges and scattered calcification. Central necrosis may result in a cystic aspect with surrounding hyperechogenic tissue. CT scanning reveals the morphological aspect of the lesions and is useful for preoperative evaluation of vascular involvement and extension to adjacent structures and metastatic lesions (especially in the lungs and brain). MRI is the method of choice to assess invasion of adjacent structures and is helpful in differential diagnosis from similar lesions from other etiologies. Also, magnetic resonance cholangiography reveals the relationship between the AE lesion and the biliary tree. Intrahepatic biliary obstruction and/or communication with a central necrotic area can also be identified by percutaneous cholangiography or endoscopic retrograde cholangiography. Fluorodeoxyglucose positron emission tomography (FDG-PET) assesses the parasite metabolic activity (but not parasite viability, and in negative exams viable parasite can be present). The different methods of imaging play complementary roles in detecting and characterizing lesions and their complications.

Clinical features have been clearly outlined and updated by the expert consensus for diagnosis and treatment of cystic echinococcosis and alveolar echinococcosis in humans,[99] which established the WHO-IWGE (World Health Organization - Informal Working Group on Ecchinoccocosis) PNM classification system as the international benchmark for standardized evaluation of diagnostic and therapeutic measures.[153,154] This classification takes into account the primary mass in the liver (P), the involvement of neighboring organs and lymph nodes (N), and the presence of metastasis (M) (**Table 1**).

Serological tests are usually positive. Purified *E. multilocularis* antigens allow high specificity and serologic differential diagnosis from *E. granulosus* infection.

Percutaneous needle biopsy is useful in some cases and can confirm the diagnosis if larval elements are demonstrated.[65]

Diagnosis of alveolar echynococcosis is confirmed if at least two of the following four parameters are achieved:[147]

1) Typical organ lesions detected by imaging techniques
2) Detection of *E. spp'* specific serum antibodies by tests of high sensitivity and confirmed by assays with high specificity
3) Histopathology compatible with a metacestode of *E. multilocularis*
4) Detection of the *E. multilocularis* nucleic acid in a clinical specimen.

Guidelines for the management of alveolar echinococcosis have also been recently updated.[149] Anti-parasitic therapy with benzimidazoles (albendazole or mebendazole) over many years (in cases of surgical resection) or lifelong if necessary, combined with interventional procedures, can inhibit disease progression, reduce metastases, and improve both the quality and length of survival.[155,156] Radical surgery combined with anti-parasitic therapy (for two years at least) should be the primary choice, and, when performed in an early stage of the infection, may lead to cure. Interventional procedures (percutaneous bile or abscess drainage, or endoscopic dilatation of the bile duct with or without plastic stents) should be preferred to palliative surgery whenever possible.

To achieve a complete radical surgery, resectability should be carefully analyzed by precise preoperative imaging. The entire parasitic lesion should be excised including a 2 cm safety margin and should be classified according to the quality of resection by histopathology in R0 (no residual disease); R1 (microscopic residual disease); or R2 (macroscopic residual disease).[149]

Hepatic AE can spread by different ways: i) hematogenous; ii) biliary; iii) contiguity; and iv) lymphatic.[157–159] Thus, regional lymph nodes (hepatic and subpyloric) should be included in curative resection (although WHO guidelines provide no instructions on how to deal with regional lymph nodes).[160]

Incomplete resection (R1 or R2) should be avoided; however, it might be useful in some rare cases of sepsis if neither R0 resection nor percutaneous or endoscopic drainage are possible.[161]

Liver transplantation may be proposed in exceptional cases of very advanced alveolar echinococcosis when usual radical liver resection is not feasible.[162,163]

POLYCISTIC ECHINOCOCCOSIS

Polycystic echinococcosis (PE) is a rare parasitosis caused by *E. vogeli* (neotropical echinococcosis) and *E. oligarthrus* (unicystic echinococcosis).[164–169] It is present mainly in tropical areas of South America.[167] The life cycle of this parasite includes the bush dog and some wild mammals as definitive hosts, while human beings are accidental hosts.[169]

Despite the clinical aspects of PE being similar to alveolar echinococcosis, the cysts are relatively large and contain brood capsules and scolices. Diagnosis is performed by enzyme-linked immunosorbent assay (ELISA, high sensitivity) and Western blot (high specificity).

Because of its rarity, management of this disease remains controversial and not well established. Lesions are usually so extensive that surgical resection is always difficult, frequently incomplete, and carries a high mortality rate.[167] However, whenever possible, surgical resection combined with benzimedazoles is the most likely to succeed.

PYOGENIC HEPATIC ABSCESS

Pyogenic liver abscess (PLA) is a relatively uncommon but life-threatening disease. Incidence of PLA appears to have increased over the last decades, possibly due to progress in imaging studies.

PLA results from a bacterial infection of the hepatic parenchyma with subsequent inflammatory infiltration, and formation of a collection of pus.[170] A failure of clearance of bacteria that reach the liver may result on PLA. The most frequent routes for bacterial hepatic invasion are **biliary** (46%) and **portal** (15-25%). Biliary obstacles (benign or malignant), cholecystitis and dysfunctional bilioenteric anastomosis are possible biliary causes of PLA. Portal route occurs following a portal phlebitis from organs with portal drainage, such as with diverticulitis, appendicitis, infected colorectal or pancreatic cancer, and pancreatitis. If no clear risk factor is identified, the abscess is called **cryptogenic** (18-25%). It has been suggested that cryptogenic PLA could be a sign of occult gastrointestinal malignancy.[171,172]

Table 1. PNM classification of alveolar echinococcosis.

P	**HEPATIC LOCALIZATION OF THE PARASITE**
PX	Primary tumour cannot be assessed
P0	No detectable tumour in the liver
P1	Peripheral lesions without proximal vascular and/or biliar involvement
P2	Central lesions with proximal vascular and/or biliar involvement of one lobe [a]
P3	Central lesions with hilar vascular or biliar involvement of both lobes and/or with involvement of two hepatic veins
P4	Any liver lesion with extension along the vessels [b] and the biliary tree
N	**NODAL INVOLVEMENT**
N	Extrahepatic involvement of neighbouring organs [diaphragm, lung, pleura, pericardium, heart, gastric and duodenal wall, adrenal glands, peritoneum, retroperitoneum, parietal wall (muscles, skin, bone), pancreas, regional lymph nodes, liver ligaments, kidney]
NX	Not evaluable
N0	No regional involvement
N1	Regional involvement of contiguous organs or tissues
M	**DISTANT METASTASES**
M	The absence or presence of distant metastasis [lung, distant lymph nodes, spleen, CNS, orbital, bone, skin, muscle, kidney, distant peritoneum and retroperitoneum]
MX	Not completely evaluated
M0	No metastasis [c]
M1	Metastasis

[a] For classification, the plane projecting between the bed of the gall bladder and the inferior vena cava divides the liver in two lobes.
[b] Vessels mean inferior vena cava, portal vein and arteries.
[c] Chest X-ray and cerebral CT negative.

Single abscesses are more likely to be cryptogenic than multiple hepatic abscesses.[173–175] The **arterial** route (5-15%) is uncommon and eventually associated with dental abscesses.[176] PLA due to **direct extension** of a contiguous infection (such as cholecystitis or subphrenic abscess), trauma, or invasive procedures (such as hepatic resection, transarterial chemoembolization, and radiofrequency ablation) are rare (<5%).[177,178]

Symptoms of PLA are variable, from the more classic presentation (with right upper abdominal pain fever, and leukocytosis) to an oligosymptomatic presentation (with progressive fatigue and weight loss). Hepatic abscess due to biliary obstruction usually has more evident and precocious infectious signs. Local complications of PLA include thoracic or peritoneal rupture and fistulization. Sepsis and malnutrition, together with their consequences, may lead to death. Overall mortality for PLA from recent series varies from 2% to up to 32%.[175,179–183] Many risk factors have been suggested, such as the presence of malignancy, advanced stage, multiloculated abscess, and polymicrobial infection.[175,184,185]

Most pyogenic liver abscesses are unique lesions, located in the right liver, and measure more than 5 cm at the moment of diagnosis. However multiple or even diffuse forms can be present at the diagnosis.

Imaging studies have a high accuracy in diagnosing PLA, particularly CT and MRI. A central fluid-like pus collection surrounded by a multilayered hypovascular or hypervascular rim (corresponding to the fibrotic wall or to hyperemic granulation tissue, respectively) is the classic, most frequent radiological finding.[186] A solid pattern can be observed during the initial stage of a PLA, but the infection progressively leads to necrosis and cystic areas. CT and MRI are useful to differentiate solid tumors from solid organizing PLA.[186]

Most often, PLA is polymicrobial. The most common bacterial species cultured are *Escherichia coli*, *Streptococcus*, *Klebsiella pneumonia* and anaerobic agents. However, culture of purulent material can be negative in up to 28-52% of cases,[170,175,176,179] especially if antibiotic therapy is initiated before material sampling. PLA by *Klebsiella spp* has increased in the last decade, especially in Asia and North America, possibly associated with malignancies.[170,175,187] This particular PLA usually has a more aggressive course, with a high propensity to metastatize.

Nowadays, the first choice of treatment for PLA is based on antibiotic therapy alone (for small unilocular abscesses), or combined with imaging-guided percutaneous puncture and drainage.[188,189] Success rates of 70% to 90% are obtained with non-surgical approaches for single and unilocular abscesses, and even for multiloculated ones.[180,182,190]

Risk factors for failure of percutaneous drainage include mainly multiloculated abscesses and abscesses with biliary communication.[179,182,189,191] Percutaneous or surgical drainage of PLA with biliary tract communication should have concomitant treatment of biliary obstruction if present. PLA in the setting of biliary tract cancer is more likely to have a biliary communication and a higher mortality.[185] Biliary obstruction can be treated by percutaneous or endoscopic techniques, but eventually surgical approach is needed. Also, large abscesses containing thick viscid pus are prone to failure by percutaneous treatment.[192] Furthermore, underlying disease treatment is indicate whenever possible, such as in cases of cholecystitis, biliary fistula, pylephlebitis secondary to appendicitis, and malignancies (such as hepatocellular carcinoma, cholangiocarcinoma, liver metastases, gallbladder carcinoma, carcinoma of the papilla, and pancreatic cancer).

Surgical drainage allows the placement of a soft large-bore tube drain, which enables complete drainage of viscid pus and necrotic debris (**Figure 12**) and frequently the treatment of causal disease. Intraoperative ultrasound allows accurate localization, planning of drainage route, localization and avoidance of vascular and biliary structures.[180]

Thus, surgical drainage is indicated mainly for PLA that failed to percutaneous treatment or when surgery is need for the underlying cause of the PLA.[181,193] However, salvage surgery is associated with high mortality rates and should be performed soon if percutaneous drainage is not efficacious.[179,182] Overall surgical mortality for PLA varies from to 2% to 11%.[179,180,194]

Surgical drainage may be the initial treatment of PLA in selected groups of patients. Some authors found better results from initial surgical drainage than from percutaneous drainage in patients with large hepatic abscess (more than 5 cm).[180] Open surgical drainage resulted in fewer treatment failures, less requirement for secondary procedures, and shorter length of hospital stay, but overall morbidity and mortality

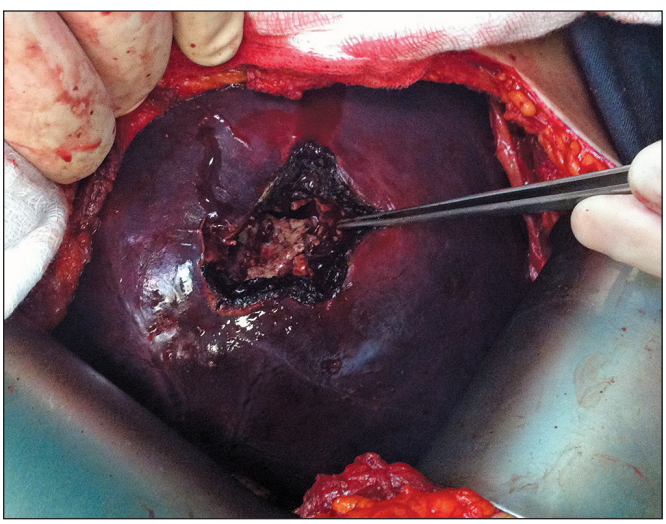

Figure 12. Intraoperative aspect of a single cryptogenic pyogenic liver abscess with necrotic debris, not suitable for percutaneous drainage.

rates were similar to those with percutaneous approach. Hope et al.[188] suggest that surgical treatment should be the first choice for multilocular abscesses of more than 3 cm. Patients with large multiloculated liver abscesses secondary to malignancies should undergo early surgical approach.[184] Initial surgical approach has also been suggested for critically ill patients because of the high mortality of percutaneous approach in this group of patients.[176] Other indications for initial surgical approach are ruptured abscesses and those relating to localization unfavorable to percutaneous access.

Hepatic resection is a safe and efficacious option for PLA that could be exceptionally indicated when the initial presentation is intraperitoneal rupture, when hepatolithiasis is associated, or if severe hepatic destruction is associated.[174,181,195]

SUGGESTED READING

Brunetti, E., Kern, P. & Vuitton, D. A. Expert consensus for the diagnosis and treatment of cystic and alveolar echinococcosis in humans. *Acta Trop.* **114**, 1–16 (2010).

A well-structured review on the two most important types of echinococcosis: cystic and alveolar. It represents the expert consensus from the World Health Organization (WHO) – Informal Working Group on Echinococcosis (IWGE) for the treatment of these diseases, mainly cystic echinococcosis.

El Malki, H. O. *et al.* Predictive model of biliocystic communication in liver hydatid cysts using classification and regression tree analysis. *BMC Surg.* **10**, 16 (2010).

Paper that evaluates preoperative predictive factors for biliocystic communication. Other results from this large series of 672 patients treated for cystic hydatid disease at a single center can be seen in references 03 and 07.

Mezhir, J. J. *et al.* Current management of pyogenic liver abscess: surgery is now second-line treatment. *J. Am. Coll. Surg.* **210**, 975–983 (2010).

It is a retrospective study of 58 patients with pyogenic liver abscesses. The mortality of salvage surgical treatment after failure of percutaneous drainage was high. The predictors of failure of percutaneous drainage were the presence of cystic yeast and cystic communication with the biliary tree.

Tan, Y. M. *et al.* An Appraisal of Surgical and Percutaneous Drainage for Pyogenic Liver Abscesses Larger Than 5 cm. *Ann. Surg.* **241**, 485–490 (2005).

The authors suggest, in a retrospective study of 80 patients with pyogenic liver abscesses larger than 5 cm, that surgical drainage could provide better results than percutaneous approach in this group of patients.

REFERENCES

1. Vuitton, D. A., Bresson-Hadni, S., Delabrousse, E. & Mantion, G. A. [Liver and parasitic diseases]. *Gastroenterol. Clin. Biol.* **28**, 1122–1137 (2004).
2. Mohamed, A. E., Al Karawi, M. A. & Ghandour, Z. Parasitic disease of the liver and biliary tree. *Saudi. J. Gastroenterol.* **3**, 22–28 (1997).
3. El Malki, H. O. *et al.* Does primary surgical management of liver hydatid cyst influence recurrence? *J. Gastrointest. Surg.* **14**, 1121–1127 (2010).
4. Safioleas, M. C. *et al.* Hydatid disease of the liver: a continuing surgical problem. *Arch. Surg.* **141**, 1101–1108 (2006).
5. Bouree, P. Hydatidosis: dynamics of transmission. *World J. Surg.* **25**, 4–9 (2001).
6. Zaouche, A. & Haouet, K. [Traitment chirurgical des kystes hydatiques du foie.] In *E.M.C. - Tech. Chir. - Appar. Dig.* **40**, 775 (Elsevier Masson, Paris, France, 2006).
7. El Malki, H. O. *et al.* Predictive factors of deep abdominal complications after operation for hydatid cyst of the liver: 15 years of experience with 672 patients. *J. Am. Coll. Surg.* **206**, 629–637 (2008).
8. Kehila, M. *et al.* [Statistical study of hydatid locations. Apropos of 644 cases--1980-1988]. *Tunis. Med.* **66**, 587–591 (1988).
9. McManus, D. P., Zhang, W., Li, J. & Bartley, P. B. Echinococcosis. *Lancet* **362**, 1295–1304 (2003).
10. Ramos, G., Orduna, A. & Garcia-Yuste, M. Hydatid cyst of the lung: diagnosis and treatment. *World J. Surg.* **25**, 46–57 (2001).
11. Solak, H. *et al.* Surgery in hydatid cyst of the lung. A report of 460 cases. *Scand. J. Thorac. Cardiovasc. Surg.* **22**, 101–104 (1988).
12. Sokouti, M. & Sokouti, B. The value of X-ray and CT scan in diagnosing pulmonary hydatid cyst. *Clin. Imaging* **37**, 978 (2013).
13. El Malki, H. O. *et al.* Le traitement conservateurs du kyste hydatique de la rate. *Médecine du Maghreb* **139**, 33–36 (2006).
14. Amahzoune, B. *et al.* Kyste hydatique récidivant de la thyroide: à propos d'un cas. *Ann. Endocrinol.* **65**, 469–471 (2004).
15. El Malki, H. O. *et al.* Kyste hydatique du muscle psoas. *Sante.* **17**, 177–179 (2007).
16. El Harroudi, T., souadka, A., Tijami, F., El Othmany, A. & Jalil, A. Primary paraspinal hydatid cyst: a case report. *Internet J. Orthop. Surg.* **13**, (2009).
17. Rajabi, M. T. *et al.* Orbital hydatid cyst with diverse locality in the orbit and review of literatures. *Arch. Iran. Med.* **17**, 207–210 (2014).
18. Ibn Elhadj, Z. *et al.* Cardiac hydatid cyst revealed by ventricular tachycardia. *J. Saudi. Heart Assoc.* **26**, 47–50 (2014).
19. Dhingra, D., Sethi, G. R. & Mantan, M. Intracranial hydatid cyst. *Indian J. Pediatr.* **81**, 212 (2014).
20. Yilmaz, M., Akbulut, S., Sogutlu, G., Arabaci, E. & Kayaalp, C. Hydatid cyst of the thyroid gland: report of three cases. *Surg. Today* **43**, 937–941 (2013).
21. Kizildag, B., Dagistan, E., Gurel, S. & Alan, C. CT and MRI findings of renal infestation by a huge active hydatid cyst. *BMJ Case Rep.* **2013**, (2013).
22. El Malki, H. O. *et al.* [Hydatid cyst of the psoas muscle]. *Sante* **17**, 177–179 (2007).
23. Benhamiche, H. *et al.* Peritoneal hydatidosis and hepatic hydatid cyst perforation. *Diagn. Interv. Imaging* **94**, 1157–1160 (2013).
24. Zidi, A. *et al.* [Hydatid cyst of the mediastinum: 14 case reports]. *J. Radiol.* **87**, 1869–1874 (2006).
25. Makhlouf, R. *et al.* [Hydatid cyst of ovary. Report of 7 cases]. *Tunis. Med.* **84**, 592–594 (2006).
26. Polat, P. *et al.* Hydatid disease from head to toe. *Radiographics* **23**, 475–477 (2003).
27. Dziri, C. Hydatid disease--continuing serious public health problem: introduction. *World J. Surg.* **25**, 1–3 (2001).
28. Balik, A. A. *et al.* Surgical treatment of hydatid disease of the liver: review of 304 cases. *Arch. Surg.* **134**, 166–169 (1999).
29. Safioleas, M., Misiakos, E., Manti, C., Katsikas, D. & Skalkeas, G. Diagnostic evaluation and surgical management of hydatid disease of the liver. *World J. Surg.* **18**, 859–865 (1994).
30. Filippou, D., Tselepis, D., Filippou, G. & Papadopoulos, V. Advances in liver echinococcosis: diagnosis and treatment. *Clin. Gastroenterol. Hepatol.* **5**, 152–159 (2007).
31. El Malki, H. O. *et al.* Predictive model of biliocystic communication

in liver hydatid cysts using classification and regression tree analysis. *BMC Surg.* **10**, 16 (2010).
32. Romig, T., Dinkel, A. & Mackenstedt, U. The present situation of echinococcosis in Europe. *Parasitol. Int.* **55 Suppl**, S187–91 (2006).
33. Torgerson, P. R. *et al.* Present situation of cystic echinococcosis in Central Asia. *Parasitol. Int.* **55 Suppl**, S207–12 (2006).
34. Sadjjadi, S. M. Present situation of echinococcosis in the Middle East and Arabic North Africa. *Parasitol. Int.* **55 Suppl**, S197–202 (2006).
35. Eckert, J., Conraths, F. J. & Tackmann, K. Echinococcosis: an emerging or re-emerging zoonosis? *Int. J. Parasitol.* **30**, 1283–1294 (2000).
36. Rasheed, K. Hydatid cyst of liver complicated with budd-Chiari syndrome and portal vein thrombosis. *N. Am. J. Med. Sci.* **5**, 242–244 (2013).
37. Dziri, C., Haouet, K., Fingerhut, A. & Zaouche, A. Management of cystic echinococcosis complications and dissemination: where is the evidence? *World J. Surg.* **33**, 1266–1273 (2009).
38. El Malki, H. O., El Mejdoubi, Y., Mohsine, R., Ifrine, L. & Belkouchi, A. [Intraperitoneal perforation of hepatic hydatid cyst]. *Gastroenterol. Clin. Biol.* **30**, 1214–1216 (2006).
39. Lissandrin, R., Agliata, S. & Brunetti, E. Secondary peritoneal echinococcosis causing massive bilateral hydronephrosis and renal failure. *Int. J. Infect. Dis.* **17**, e141–2 (2013).
40. Kabiri, E. H., El Maslout, A. & Benosman, A. Thoracic rupture of hepatic hydatidosis (123 cases). *Ann. Thorac. Surg.* **72**, 1883–1886 (2001).
41. Tocchi, A. *et al.* Treatment of hydatid bronchobiliary fistulas: 30 years of experience. *Liver Int.* **27**, 209–214 (2007).
42. Schipper, H. G. Modern management of echinococcosis. In *Updat. Gastroenterol. 2004 new Dev. Manag. benign Gastrointest. Disord.* (ed. Gouma, D. J.) 137–153 (John Libbey Eurotext, Paris, France, 2004).
43. Brunetti, E., Garcia, H. H. & Junghanss, T. Cystic echinococcosis: chronic, complex, and still neglected. *PLoS Negl. Trop. Dis.* **5**, e1146 (2011).
44. Frider, B. & Larrieu, E. Treatment of liver hydatidosis: how to treat an asymptomatic carrier? *World J. Gastroenterol.* **16**, 4123–4129 (2010).
45. Gharbi, H. A., Hassine, W., Brauner, M. W. & Dupuch, K. Ultrasound examination of the hydatic liver. *Radiology* **139**, 459–463 (1981).
46. Akgun, Y. & Yilmaz, G. Efficiency of obliteration procedures in the surgical treatment of hydatid cyst of the liver. *A.N.Z. J. Surg.* **74**, 968–973 (2004).
47. Chautems, R. *et al.* Surgical management and long-term outcome of complicated liver hydatid cysts caused by Echinococcus granulosus. *Surgery* **137**, 312–316 (2005).
48. Kapan, M., Kapan, S., Goksoy, E., Perek, S. & Kol, E. Postoperative recurrence in hepatic hydatid disease. *J. Gastrointest. Surg.* **10**, 734–739 (2006).
49. Atmatzidis, K. S., Pavlidis, T. E., Papaziogas, B. T., Mirelis, C. & Papaziogas, T. B. Recurrence and long-term outcome after open cystectomy with omentoplasty for hepatic hydatid disease in an endemic area. *Acta Chir. Belg.* **105**, 198–202 (2005).
50. Akyildiz, H. Y. *et al.* Recurrent liver hydatid disease: when does it become symptomatic and how does one diagnose it? *Clin. Imaging* **33**, 55–58 (2009).
51. Erzurumlu, K. *et al.* Intrabiliary rupture: an algorithm in the treatment of controversial complication of hepatic hydatidosis. *World J. Gastroenterol.* **11**, 2472–2476 (2005).
52. Demircan, O., Baymus, M., Seydaoglu, G., Akinoglu, A. & Sakman, G. Occult cystobiliary communication presenting as postoperative biliary leakage after hydatid liver surgery: are there significant preoperative clinical predictors? *Can. J. Surg.* **49**, 177–184 (2006).
53. Secchi, M. A. *et al.* Surgical management of liver hydatidosis: a multicentre series of 1412 patients. *Liver Int.* **30**, 85–93 (2010).
54. Al-Bahrani, A. Z., Al-Maiyah, M., Ammori, B. J. & Al-Bahrani, Z. R. Factors predictive of frank intrabiliary rupture in patients with hepatic hydatid cysts. *Hepatogastroenterology* **54**, 214–217 (2007).
55. International classification of ultrasound images in cystic echinococcosis for application in clinical and field epidemiological settings. *Acta Trop.* **85**, 253–261 (2003).
56. De Diego Choliz, J., Lecumberri Olaverri, F. J., Franquet Casas, T. & Ostiz Zubieta, S. Computed tomography in hepatic echinococcosis. *AJR Am. J. Roentgenol.* **139**, 699–702 (1982).
57. Mendez Montero, J. V *et al.* Fat-fluid level in hepatic hydatid cyst: a new sign of rupture into the biliary tree? *AJR Am. J. Roentgenol.* **167**, 91–94 (1996).
58. Marrone, G. *et al.* Multidisciplinary imaging of liver hydatidosis. *World J. Gastroenterol.* **18**, 1438–1447 (2012).
59. Oruc, E. *et al.* The role of diffusion-weighted MRI in the classification of liver hydatid cysts and differentiation of simple cysts and abscesses from hydatid cysts. *Diagn. Interv. Radiol.* **16**, 279–287 (2010).
60. Coskun, A. *et al.* Alveolar echinococcosis of the liver: correlative color Doppler US, CT, and MRI study. *Acta Radiol.* **45**, 492–498 (2004).
61. Kantarci, M. *et al.* Can biliary-cyst communication be predicted by Gd-EOB-DTPA-enhanced MR cholangiography before treatment for hepatic hydatid disease? *Clin. Radiol.* **69**, 52–58 (2014).
62. Stojkovic, M., Rosenberger, K., Kauczor, H.-U., Junghanss, T. & Hosch, W. Diagnosing and staging of cystic echinococcosis: how do CT and MRI perform in comparison to ultrasound? *PLoS Negl. Trop. Dis.* **6**, e1880 (2012).
63. Hosch, W. *et al.* MR imaging for diagnosing cysto-biliary fistulas in cystic echinococcosis. *Eur J. Radiol.* **66**, 262–267 (2008).
64. Sayek, I. & Onat, D. Diagnosis and treatment of uncomplicated hydatid cyst of the liver. *World J. Surg.* **25**, 21–27 (2001).
65. Moro, P. & Schantz, P. M. Echinococcosis: a review. *Int. J. Infect. Dis.* **13**, 125–133 (2009).
66. Zhang, W., Li, J. & McManus, D. P. Concepts in immunology and diagnosis of hydatid disease. *Clin. Microbiol. Rev.* **16**, 18–36 (2003).
67. Biava, M. F., Dao, A. & Fortier, B. Laboratory diagnosis of cystic hydatic disease. *World J. Surg.* **25**, 10–14 (2001).
68. El Malki, H. O. *et al.* Why fine-needle aspiration cytology is not an adequate diagnostic method for liver hydatid cyst. *Arch. Surg.* **142**, 690 (2007).
69. Stefaniak, J. Fine needle aspiration biopsy in the differential diagnosis of the liver cystic echinococcosis. *Acta Trop.* **67**, 107–111 (1997).
70. Turkcapar, A. G. *et al.* Surgical treatment of hepatic hydatidosis combined with perioperative treatment with albendazole. *Eur. J. Surg.* **163**, 923–928 (1997).
71. Liu, Y., Wang, X. & Wu, J. Continuous long-term albendazole therapy in intraabdominal cystic echinococcosis. *Chin. Med. J.* **113**, 827–832 (2000).
72. Smego Jr., R. A., Bhatti, S., Khaliq, A. A. & Beg, M. A. Percutaneous aspiration-injection-reaspiration drainage plus albendazole or mebendazole for hepatic cystic echinococcosis: a meta-analysis. *Clin. Infect. Dis.* **37**, 1073–1083 (2003).
73. Yagci, G. *et al.* Results of surgical, laparoscopic, and percutaneous treatment for hydatid disease of the liver: 10 years experience with 355 patients. *World J. Surg.* **29**, 1670–1679 (2005).
74. Aygun, E. *et al.* The management of liver hydatid cysts by percutaneous drainage. *Can. J. Surg.* **44**, 203–209 (2001).
75. Benazzouz, M. & Essaid, E. [Traitment percutané du kyste hydatique du foie.] In *E.M.C. Hépatologie* **7-023**, (Elsevier, Paris, France, 2004).
76. Brunetti, E. & Filice, C. Radiofrequency thermal ablation of echinococcal liver cysts. *Lancet* **358**, 1464 (2001).
77. Akhan, O. & Ozmen, M. N. Percutaneous treatment of liver hydatid cysts. *Eur. J. Radiol.* **32**, 76–85 (1999).
78. Khuroo, M. S. *et al.* Percutaneous drainage compared with surgery for hepatic hydatid cysts. *N. Engl. J. Med.* **337**, 881–887 (1997).
79. Ustunsoz, B. *et al.* Percutaneous treatment of hydatid cysts of the liver: long-term results. *AJR Am. J. Roentgenol.* **172**, 91–96 (1999).
80. Lamonaca, V. *et al.* Cystic echinococcosis of the liver and lung treated by radiofrequency thermal ablation: an ex-vivo pilot experimental study in animal models. *World J. Gastroenterol.* **15**, 3232–3239 (2009).
81. Bastid, C., Ayela, P. & Sahel, J. Percutaneous treatment of a complex hydatid cyst of the liver under sonographic control. Report of the first case. *Gastroenterol. Clin. Biol.* **29**, 191–192 (2005).

82. Zaouche, A., Haouet, K., Jouini, M., El Hachaichi, A. & Dziri, C. Management of liver hydatid cysts with a large biliocystic fistula: multicenter retrospective study. Tunisian Surgical Association. *World J. Surg.* **25**, 28–39 (2001).
83. Beyrouti, M. I. *et al.* [Internal trans-Oddi's sphincter fistula drainage of hydatid cysts communicating with the bile ducts]. *Press. Med* **30**, 1863–1867 (2001).
84. Tarcin, O. Rupture of hydatid cyst into the biliary tract. *Gastrointest. Endosc.* **63**, 325–6; discussion 326 (2006).
85. Selmi, M., Mounir Kharrat, M., Chouket, A., Hedfi, S. & Ben Salah, K. [A hydatid cyst of the liver destroying the biliary convergence: treatment by internal drainage]. *J. Chir.* **142**, 120–122 (2005).
86. Vuitton, D. A. & Wen, H. Treatment of cystic echinococcosis: a combination of general goals and rules, individual decisions and indications. *Neth. J. Med.* **65**, 86–88 (2007).
87. Gollackner, B. *et al.* Radical surgical therapy of abdominal cystic hydatid disease: factors of recurrence. *World J. Surg.* **24**, 717–721 (2000).
88. Guidelines for treatment of cystic and alveolar echinococcosis in humans. WHO Informal Working Group on Echinococcosis. *Bull. World Heal. Organ.* **74**, 231–242 (1996).
89. Skroubis, G., Vagianos, C., Polydorou, A., Tzoracoleftherakis, E. & Androulakis, J. Significance of bile leaks complicating conservative surgery for liver hydatidosis. *World J. Surg.* **26**, 704–708 (2002).
90. Cirenei, A. & Bertoldi, I. Evolution of surgery for liver hydatidosis from 1950 to today: analysis of a personal experience. *World J. Surg.* **25**, 87–92 (2001).
91. Yorganci, K. & Sayek, I. Surgical treatment of hydatid cysts of the liver in the era of percutaneous treatment. *Am. J. Surg.* **184**, 63–69 (2002).
92. Daradkeh, S., El-Muhtaseb, H., Farah, G., Sroujieh, A. S. & Abu--Khalaf, M. Predictors of morbidity and mortality in the surgical management of hydatid cyst of the liver. *Langenbecks Arch. Surg.* **392**, 35–39 (2007).
93. Dziri, C. *et al.* Omentoplasty in the prevention of deep abdominal complications after surgery for hydatid disease of the liver: a multicenter, prospective, randomized trial. French Associations for Surgical Research. *J. Am. Coll. Surg.* **188**, 281–289 (1999).
94. Muftuoglu, M. A., Koksal, N. & Topaloglu, U. The role of omentoplasty in the surgical management of remnant cavity in hepatic hydatid cyst. *H.P.B.* **7**, 231–234 (2005).
95. Ozacmak, I. D., Ekiz, F., Ozmen, V. & Isik, A. Management of residual cavity after partial cystectomy for hepatic hydatidosis: comparison of omentoplasty with external drainage. *Eur. J. Surg.* **166**, 696–699 (2000).
96. Maaouni, A. *et al.* [Surgery of hydatid cysts of the liver: 581 patients, 952 cysts]. *Chirurgie* **115 Suppl** , 61–8 (1989).
97. Akbulut, S. *et al.* Radical vs conservative surgery for hydatid liver cysts: experience from single center. *World J. Gastroenterol.* **16**, 953–959 (2010).
98. Motie, M. R., Ghaemi, M., Aliakbarian, M. & Saremi, E. Study of the Radical vs. Conservative Surgical Treatment of the Hepatic Hydatid Cyst: A 10-Year Experience. *Indian J. Surg.* **72**, 448–452 (2010).
99. Yuksel, O. *et al.* Efficacy of radical surgery in preventing early local recurrence and cavity-related complications in hydatic liver disease. *J. Gastrointest. Surg.* **12**, 483–489 (2008).
100. Tagliacozzo, S., Miccini, M., Amore Bonapasta, S., Gregori, M. & Tocchi, A. Surgical treatment of hydatid disease of the liver: 25 years of experience. *Am. J. Surg.* **201**, 797–804 (2011).
101. Stamatakos, M. *et al.* Intrahepatic bile duct rupture of hydatid cyst: a severe complication for the patient. *Chir.* **102**, 257–262 (2007).
102. Kayaalp, C. Evacuation of hydatid liver cysts using laparoscopic trocar. *World J. Surg.* **26**, 1324–1327 (2002).
103. Shaw, J. M., Bornman, P. C. & Krige, J. E. Hydatid disease of the liver. *S. Afr. J. Surg.* **44**, 70–72,74–77 (2006).
104. Busic, Z. *et al.* Surgical treatment of liver echinococcosis--the role of laparoscopy. *Acta Chir. Belg.* **106**, 688–691 (2006).
105. El Fares, F., Abi, F., Rabeh, G., Mehhane, M. & Moumen, M. Traitement chirurgical coelio-assité du kyste hydatique du foie. *Maroc. Med.* **667**, 21–25 (2000).
106. Acarli, K. Controversies in the laparoscopic treatment of hepatic hydatid disease. *H.P.B.* **6**, 213–221 (2004).
107. Dervenis, C., Delis, S., Avgerinos, C., Madariaga, J. & Milicevic, M. Changing concepts in the management of liver hydatid disease. *J. Gastrointest. Surg.* **9**, 869–877 (2005).
108. Sahin, M., Kartal, A., Haykir, R. & Cakir, M. RF-assisted cystectomy and pericystectomy: a new technique in the treatment of liver hydatid disease. *Eur. Surg. Res.* **38**, 90–93 (2006).
109. Kayaalp, C., Sengul, N. & Akoglu, M. Importance of cyst content in hydatid liver surgery. *Arch. Surg.* **137**, 159–163 (2002).
110. Daali, M., Hssaida, R., Zoubir, M. & Borki, K. L'experience marocaine dans le traitement chirurgical des kystes hydatiques multiples du foie: a propos de 94 cas. *Sante* **11**, 235–237 (2001).
111. Djilali, G. *et al.* [Hydrogen peroxide in the surgery of hydatid cyst]. *Press. Med.* **12**, 235–237 (1983).
112. Mahdi, N. K. & Al-Johar, M. H. Scolicidal agents in hydatid cyst surgery. *Saudi. Med. J.* **27**, 562–563 (2006).
113. Besim, H., Karayalcin, K., Hamamci, O., Gungor, C. & Korkmaz, A. Scolicidal agents in hydatid cyst surgery. *H.P.B. Surg.* **10**, 347–351 (1998).
114. Karayalcin, K. *et al.* Effect of hypertonic saline and alcohol on viability of daughter cysts in hepatic hydatid disease. *Eur. J. Surg.* **165**, 1043–1044 (1999).
115. Paquet, J. C. *et al.* Prevention of deep abdominal complications with omentoplasty on the raw surface after hepatic resection. The French Associations for Surgical Research. *Am. J. Surg.* **179**, 103–109 (2000).
116. Filippou, D. K., Kolimpiris, C., Anemodouras, N. & Rizos, S. Modified capitonage in partial cystectomy performed for liver hydatid disease: report of 2 cases. *BMC Surg.* **4**, 8 (2004).
117. Dziri, C. & Nouira, R. Surgical treatment of liver hydatid disease by laparotomy. *J. Visc. Surg.* **148**, e103–10 (2011).
118. El Malki, A. *et al.* Radical versus conservative surgical treatment of liver hydatid cysts. *Br. J. Surg.* **101**, 669–675 (2014).
119. Khoury, G., Abiad, F., Geagea, T., Nabout, G. & Jabbour, S. Laparoscopic treatment of hydatid cysts of the liver and spleen. *Surg. Endosc.* **14**, 243–245 (2000).
120. Descottes, B. *et al.* Laparoscopic liver resection of benign liver tumors. *Surg. Endosc.* **17**, 23–30 (2003).
121. Katkhouda, N. *et al.* Laparoscopic management of benign solid and cystic lesions of the liver. *Ann. Surg.* **229**, 460-466 (1999).
122. Zaharie, F. *et al.* Open or laparoscopic treatment for hydatid disease of the liver? A 10-year single-institution experience. *Surg. Endosc.* **27**, 2110–2116 (2013).
123. Palanivelu, C. *et al.* Laparoscopic management of hepatic hydatid disease. *J.S.L.S.* **10**, 56–62 (2006).
124. Souadka, A. & El Malki, H. O. Laparoscopic Approach for Liver Hydatid Cyst: Primum No Nocer. *Surg Laparosc Endosc. Percutan. Tech.* **24**, 391 (2014).
125. El Malki, A. *et al.* Conservative surgery should be the first line treatment for liver hydatid cyst surgery: results of comparative randomised study. *10th World Congr. Int. Hepatobiliary Pancreat. Assoc. (IHPBA),* Paris, France (2012).
126. Bulbuller, N. *et al.* The results of surgical treatment for hepatic hydatid cysts in an endemic area. *Turk. J. Gastroenterol.* **17**, 273–278 (2006).
127. Agaoglu, N., Turkyilmaz, S. & Arslan, M. K. Surgical treatment of hydatid cysts of the liver. *Br. J. Surg.* **90**, 1536–1541 (2003).
128. Little, J. M., Hollands, M. J. & Ekberg, H. Recurrence of hydatid disease. *World J. Surg.* **12**, 700–704 (1988).
129. Sielaff, T. D., Taylor, B. & Langer, B. Recurrence of hydatid disease. *World J. Surg.* **25**, 83–86 (2001).
130. Mottaghian, H. & Saidi, F. Postoperative recurrence of hydatid disease. *Br. J. Surg.* **65**, 237–242 (1978).
131. Karavias, D. D., Vagianos, C. E., Bouboulis, N., Rathosis, S. & Androulakis, J. Improved techniques in the surgical treatment of

hepatic hydatidosis. *Surg. Gynecol. Obst.* **174**, 176–180 (1992).
132. Vagianos, C. E., Karavias, D. D., Kakkos, S. K., Vagenas, C. A. & Androulakis, J. A. Conservative surgery in the treatment of hepatic hydatidosis. *Eur. J. Surg.* **161**, 415–420 (1995).
133. Demirci, S., Eraslan, S., Anadol, E. & Bozatli, L. Comparison of the results of different surgical techniques in the management of hydatid cysts of the liver. *World J. Surg.* **13**, 81–88 (1989).
134. Eckert, J. & Deplazes, P. Biological, Epidemiological, and Clinical Aspects of Echinococcosis, a Zoonosis of Increasing Concern. *Clin. Microbiol. Rev.* **17**, 107–135 (2004).
135. Khuroo, M. S. Hydatid disease: current status and recent advances. *Ann. Saudi. Med.* **22**, 56–64 (2002).
136. Pawlowski, Z. *et al.* Echinococcosis in humans : clinical aspects, diagnosis and treatment. In: *WHO/OIE Man. echinococcosis humans Anim. a public Heal. Probl. Glob. concern.* 20–72 (World Organization for Animal Health, Paris, France, 2001).
137. Buttenschoen, K. & Carli Buttenschoen, D. Echinococcus granulosus infection: the challenge of surgical treatment. *Langenbecks Arch. Surg.* **388**, 218–230 (2003).
138. Ammann, R. W. [Chemotherapy alone or as adjuvant treatment to surgery for alveolar and cystic echinococcosis]. *Chirurg.* **71**, 9–15 (2000).
139. Dautovic-Krkic, S. *et al.* [Praziquantel in the prevention of recurrence of human echinococcosis]. *Med. Arh.* **56**, 263–266 (2002).
140. Alvela-Suarez, L. *et al.* Safety of the Combined Use of Praziquantel and Albendazole in the Treatment of Human Hydatid Disease. *Am. J. Trop. Med. Hyg.* **90**, 819-822 (2014).
141. Jamshidi, M., Mohraz, M., Zangeneh, M. & Jamshidi, A. The effect of combination therapy with albendazole and praziquantel on hydatid cyst treatment. *Parasitol. Res.* **103**, 195–199 (2008).
142. Moreno, M. J., Urrea-Paris, M. A., Casado, N. & Rodriguez-Caabeiro, F. Praziquantel and albendazole in the combined treatment of experimental hydatid disease. *Parasitol. Res.* **87**, 235–238 (2001).
143. Mohamed, A. E., Yasawy, M. I. & Al Karawi, M. A. Combined albendazole and praziquantel versus albendazole alone in the treatment of hydatid disease. *Hepatogastroenterology* **45**, 1690–1694 (1998).
144. Eckert, J. & Deplazes, P. Alveolar echinococcosis in humans: the current situation in Central Europe and the need for countermeasures. *Parasitol. Today* **15**, 315–319 (1999).
145. Vuitton, D. A. *et al.* A historical view of alveolar echinococcosis, 160 years after the discovery of the first case in humans: part 1. What have we learnt on the distribution of the disease and on its parasitic agent? *Chin. Med. J.* **124**, 2943–2953 (2011).
146. Kern, P. *et al.* European echinococcosis registry: human alveolar echinococcosis, Europe, 1982-2000. *Emerg. Infect. Dis.* **9**, 343–349 (2003).
147. Kern, P. Clinical features and treatment of alveolar echinococcosis. *Curr. Opin. Infect. Dis.* **23**, 505–512 (2010).
148. Ammann, R. W. & Eckert, J. Cestodes. Echinococcus. *Gastroenterol. Clin. North Am.* **25**, 655–689 (1996).
149. Brunetti, E., Kern, P. & Vuitton, D. A. Expert consensus for the diagnosis and treatment of cystic and alveolar echinococcosis in humans. *Acta Trop.* **114**, 1–16 (2010).
150. Czermak, B. V *et al.* Echinococcosis of the liver. *Abdom. Imaging* **33**, 133–143 (2008).
151. Bresson-Hadni, S. *et al.* Imaging aspects and non-surgical interventional treatment in human alveolar echinococcosis. *Parasitol. Int.* **55 Suppl**, S267–72 (2006).
152. Stumpe, K. D. *et al.* F-18-fluorodeoxyglucose (FDG) positron-emission tomography of Echinococcus multilocularis liver lesions: prospective evaluation of its value for diagnosis and follow-up during benzimidazole therapy. *Infection* **35**, 11–18 (2007).
153. Kern, P. *et al.* WHO classification of alveolar echinococcosis: principles and application. *Parasitol. Int.* **55 Suppl**, S283–7 (2006).
154. McManus, D. P., Gray, D. J., Zhang, W. & Yang, Y. Diagnosis, treatment, and management of echinococcosis. *B.M.J.* **344**, e3866 (2012).
155. Ammann, R. W. *et al.* Recurrence rate after discontinuation of long-term mebendazole therapy in alveolar echinococcosis (preliminary results). *Am. J. Trop. Med. Hyg.* **43**, 506–515 (1990).
156. Wilson, J. F., Rausch, R. L., McMahon, B. J. & Schantz, P. M. Parasiticidal effect of chemotherapy in alveolar hydatid disease: review of experience with mebendazole and albendazole in Alaskan Eskimos. *Clin. Infect. Dis.* **15**, 234–249 (1992).
157. Urdiales-Viedma, M., Martos-Padilla, S., Nogales-Fernandez, F. & Lopez-Yevenes, A. Lymph node changes in echinococcosis. *Arch. Pathol. Lab. Med.* **108**, 528 (1984).
158. Reuter, S., Seitz, H. M., Kern, P. & Junghanss, T. Extrahepatic alveolar echinococcosis without liver involvement: a rare manifestation. *Infection* **28**, 187–192 (2000).
159. Uchino, J. & Sat¿*, N. *Alveolar echinococcosis of the liver. Hokkaido Univ. Med. Libr. Ser.* (Hokkaido University School of Medicine, 1993).
160. Buttenschoen, K., Kern, P., Reuter, S. & Barth, T. F. Hepatic infestation of Echinococcus multilocularis with extension to regional lymph nodes. *Langenbecks Arch. Surg.* **394**, 699–704 (2009).
161. Buttenschoen, K. *et al.* Palliative operation for the treatment of alveolar echinococcosis. *Langenbecks Arch. Surg.* **394**, 199–204 (2009).
162. Koch, S. *et al.* Experience of liver transplantation for incurable alveolar echinococcosis: a 45-case European collaborative report. *Transplantation* **75**, 856–863 (2003).
163. Bresson-Hadni, S. *et al.* Indications and results of liver transplantation for Echinococcus alveolar infection: an overview. *Langenbecks Arch. Surg.* **388**, 231–238 (2003).
164. Atanasov, G. *et al.* Alveolar echinococcosis-spreading disease challenging clinicians: a case report and literature review. *World J. Gastroenterol.* **19**, 4257–61 (2013).
165. Craig, P. S. *et al.* Prevention and control of cystic echinococcosis. *Lancet Infect. Dis.* **7**, 385–394 (2007).
166. Wei, J. *et al.* Epidemiological evaluations of the efficacy of slow-released praziquantel-medicated bars for dogs in the prevention and control of cystic echinococcosis in man and animals. *Parasitol. Int.* **54**, 231–236 (2005).
167. D'Alessandro, A. & Rausch, R. L. New aspects of neotropical polycystic (Echinococcus vogeli) and unicystic (Echinococcus oligarthrus) echinococcosis. *Clin Microbiol. Rev.* **21**, 380–401(2008).
168. D'Alessandro, A. Polycystic echinococcosis in tropical America: Echinococcus vogeli and E. oligarthrus. *Acta Trop.* **67**, 43–65 (1997).
169. Tappe, D., Stich, A. & Frosch, M. Emergence of polycystic neotropical echinococcosis. *Emerg. Infect. Dis.* **14**, 292–297 (2008).
170. Cerwenka, H. Pyogenic liver abscess: differences in etiology and treatment in Southeast Asia and Central Europe. *World J. Gastroenterol.* **16**, 2458–2462 (2010).
171. Lai, H. C. & Lin, H. C. Cryptogenic pyogenic liver abscess as a sign of colorectal cancer: a population-based 5-year follow-up study. *Liver Int.* **30**, 1387–1393 (2010).
172. Chong, V. H. & Lim, K. S. Pyogenic liver abscess as the first manifestation of hepatobiliary malignancy. *Hepatobiliary Pancreat. Dis. Int.* **8**, 547–550 (2009).
173. Huang, C. J. *et al.* Pyogenic hepatic abscess. Changing trends over 42 years. *Ann. Surg.* **223**, 600–609 (1996).
174. Chou, F. F., Sheen-Chen, S. M., Chen, Y. S. & Chen, M. C. Single and multiple pyogenic liver abscesses: clinical course, etiology, and results of treatment. *World J. Surg.* **21**, 384–389 (1997).
175. Ali, A. H., Smalligan, R. D., Ahmed, M. & Khasawneh, F. A. Pyogenic liver abscess and the emergence of Klebsiella as an etiology: a retrospective study. *Int. J. Gen. Med.* **7**, 37–42 (2013).
176. Alkofer, B. *et al.* Are pyogenic liver abscesses still a surgical concern? A Western experience. *H.P.B. Surg.* **2012**, 316013 (2012).
177. Hsieh, C. H. *et al.* Liver abscess after non-operative management of blunt liver injury. *Langenbecks Arch. Surg.* **387**, 343–347 (2003).
178. Kong, W. T. *et al.* Major complications after radiofrequency ablation for liver tumors: analysis of 255 patients. *World J. Gastroenterol.* **15**, 2651–2656 (2009).

179. Mezhir, J. J. *et al.* Current management of pyogenic liver abscess: surgery is now second-line treatment. *J. Am. Coll. Surg.* **210**, 975–983 (2010).
180. Tan, Y. M. *et al.* An Appraisal of Surgical and Percutaneous Drainage for Pyogenic Liver Abscesses Larger Than 5 cm. *Ann. Surg.* **241**, 485–490 (2005).
181. Strong, R. W., Fawcett, J., Lynch, S. V & Wall, D. R. Hepatectomy for pyogenic liver abscess. *H.P.B. (Oxford).* **5**, 86–90 (2003).
182. Lai, K. C. *et al.* Factors associated with treatment failure of percutaneous catheter drainage for pyogenic liver abscess in patients with hepatobiliary-pancreatic cancer. *Am. J. Surg.* **205**, 52–57 (2013).
183. Yu, S. C. *et al.* Treatment of pyogenic liver abscess: prospective randomized comparison of catheter drainage and needle aspiration. *Hepatology* **39**, 932–938 (2004).
184. Chen, S. C. *et al.* Clinical outcomes and prognostic factors of cancer patients with pyogenic liver abscess. *J. Gastrointest. Surg.* **15**, 2036–2043 (2011).
185. Yeh, T. S. *et al.* Pyogenic liver abscesses in patients with malignant disease: a report of 52 cases treated at a single institution. *Arch. Surg.* **133**, 242–245 (1998).
186. Kim, Y. K. *et al.* Solid organizing hepatic abscesses mimic hepatic tumor: Multiphasic computed tomography and magnetic resonance imaging findings with histopathologic correlation. *J. Comput. Assist. Tomogr.* **30**, 189–196 (2006).
187. Pope, J. V, Teich, D. L., Clardy, P. & McGillicuddy, D. C. Klebsiella pneumoniae liver abscess: an emerging problem in North America. *J. Emerg. Med.* **41**, e103–5 (2011).
188. Hope, W. W., Vrochides, D. V, Newcomb, W. L., Mayo-Smith, W. W. & Iannitti, D. A. Optimal treatment of hepatic abscess. *Am. Surg.* **74**, 178–182 (2008).
189. Liu, C. H. *et al.* Percutaneous hepatic abscess drainage: do multiple abscesses or multiloculated abscesses preclude drainage or affect outcome? *J. Vasc. Interv. Radiol.* **20**, 1059–1065 (2009).
190. Zerem, E. & Hadzic, A. Sonographically guided percutaneous catheter drainage versus needle aspiration in the management of pyogenic liver abscess. *AJR Am. J. Roentgenol.* **189**, W138–42 (2007).
191. Sugiyama, M. & Atomi, Y. Pyogenic hepatic abscess with biliary communication. *Am. J. Surg.* **183**, 205–208 (2002).
192. Barakate, M. S. *et al.* Pyogenic liver abscess: a review of 10 years' experience in management. *Aust. N. Z. J. Surg.* **69**, 205–209 (1999).
193. Ng, S. S., Lee, J. F. & Lai, P. B. Role and outcome of conventional surgery in the treatment of pyogenic liver abscess in the modern era of minimally invasive therapy. *World J. Gastroenterol.* **14**, 747–751 (2008).
194. Malik, A. a, Bari, S. U., Rouf, K. A. & Wani, K. A. Pyogenic liver abscess: Changing patterns in approach. *World J. Gastrointest. Surg.* **2**, 395–401 (2010).
195. Chu, K. M., Fan, S. T., Lai, E. C., Lo, C. M. & Wong, J. Pyogenic liver abscess. An audit of experience over the past decade. *Arch. Surg.* **131**, 148–152 (1996).