

PAPER*J Forensic Sci*, 2013

doi: 10.1111/1556-4029.12172

Available online at: onlinelibrary.wiley.com

PATHOLOGY/BIOLOGY

Mehdi Ben Khelil,^{1,2} M.D.; Mohamed Allouche,^{1,2} M.D.; Ahmed Banasr,^{1,2} M.D.; Fatma Gloulou,^{1,2} M.D.; Anis Benzarti,^{1,2} M.D.; Mongi Zhioua,^{1,2} M.D.; Slim Haouet,^{2,3} M.D.; and Moncef Hamdoun,^{1,2} M.D.

Sudden Death Due to Hydatid Disease: A Six-Year Study in the Northern Part of Tunisia

ABSTRACT: Human echinococcosis also known as hydatid disease is a zoonotic infection caused by the tapeworm *Ecchinococcus* with 2–3 Million cases worldwide. We hereby report a 6 years period study of Sudden death due to hydatidosis aiming to analyze the epidemiological criteria, death circumstances, and autopsy observations attributed to hydatid disease. During the past 6 years, 26 death cases were due to hydatid disease. Our analysis shows that the sex ratio (M/F) was 1.6, the mean age was 31-year old, and 65% of the subjects lived in rural places. In 17 cases, death occurred in the victim's place, five victims died after a heavy exercise, and in two cases, death occurred immediately after trauma. At autopsy, 91% of the cysts were found in the liver. In three cases, death followed a septic state, and in two cases, it followed an acute respiratory failure. Death was attributed to anaphylaxis in 17 cases.

KEYWORDS: forensic science, forensic pathology, hydatidosis, echinococcosis, sudden death, anaphylaxis, autopsy

Human echinococcosis also known as hydatid disease is a zoonotic infection caused by the tapeworm *Ecchinococcus* (*E.*). Human infection is frequently caused by *Ecchinococcus granulosus*, responsible for 95% of the 2–3 Million global cases worldwide mainly in the Mediterranean both costs and Middle East countries, Great Britain, Southern Africa, Australia, New Zealand and South America (1,2) followed by *E. multilocularis* which causes cystic and alveolar *Ecchinococcosis*, respectively (1–9). It is a widespread disease, endemic in rural areas where sheep raising is a common activity, and therefore, a close contact between humans and sheep is established (1,3,5,10).

In Tunisia, Hydatidosis is endemic/hyperendemic as the annual average incidence within the general population is estimated to be 1.67 cases per 100.000 inhabitants per year (Ministry of Public Health, unpublished data). The annual surgical incidence (ASI) is decreasing from 15.1 cases per 100.000 inhabitants between 1988 and 1992 (11) to 12.6 cases per 100.000 inhabitants per year between 2001 and 2005, for the total of 6249 surgical interventions. (12). Comparing to Mediterranean countries, always for 100.000 inhabitants, the ASI in Tunisia is significantly high. Records from the western Mediterranean countries show that ASI is between 1.1 and four cases in Spain, <0.28 cases in France and 1.57–9.7 cases in Italy. In North Africa (The Maghreb), ASIs in Libya, Algeria, and Morocco are, respectively: 4.2, 3.6–4.6, and 4.55 (13). However, the geographical distribution of this disease has tended to change over the past 40 years due to the migration flow (5).

The evolution of the hydatid cyst is frequently slow, patients are generally asymptomatic during long periods (1,4,5). The cysts are often discovered incidentally during regular examinations or investigations of nonspecific symptoms, yet in worst cases, in a postsudden death situation (3,5,6,8).

The objective of this study is to analyze the epidemiological criteria, circumstances, and autopsy observations of death attributed to hydatid disease in the north of Tunisia.

Materials and Methods

The study was conducted in the Forensic Medicine Department of the Charles Nicolle Hospital situated in Tunis the capital of Tunisia, which perform medicolegal autopsies (*c.* 1600 per year) of corpses from almost all the northern part of Tunisia (nine of 24 districts of Tunisia, and *c.* 30% [3.7 million] of the total population).

We retrospectively studied all the autopsy cases performed over a 6-year period: from 1 January, 2004 to 31 December 2009. We have identified 39 cases of Hydatid cyst discovered during the autopsies. We have included only the cases where death is related to hydatid disease (*n* = 26). Data have been collected from the police minutes, the deceased's families, autopsy reports and then divided into three groups: Epidemiological criteria, disease circumstances, and autopsy observations.

At autopsy, we transposed two ultra sound imaging classifications: Gharbi's (14) and the Informal WHO group on *Ecchinococcosis*' (WHO-IWGE) (15) in order to classify the macroscopic aspect of the cysts.

Results

During the study period, we performed a total of 7654 autopsies, 2155 of them have concluded to a natural death. In 26 cases, death was due to hydatid disease which corresponds to

¹Service de Médecine Légale de Tunis, Hôpital Charles Nicolle, 138 Boulevard du 9 avril 1938, Tunis 1006, Tunisia.

²Université de Tunis El Manar, Faculté de Médecine de Tunis, Tunis 1007, Tunisia.

³Service d'Anatomie Pathologique, Hôpital La Rabta, Tunis 1007, Tunisia.

Received 11 Aug. 2011; and in revised form 14 June 2012; accepted 1 July 2012.

0.3% of the autopsies' total and 1.1% of the natural deaths autopsied in this period. The main findings of the 26 cases are summarized in Table 1.

Epidemiological Criteria

The sex ratio (M/F) was 1.6. Twenty-one cases of 26 were under 39-year old.

The mean age was 31-year old (between 9 and 61) and it vary according to the sex of the victim, 27-year old for men and 36-year old for women, the difference statistical significance cannot be determined due to the small sample in our study.

Sixty-five percent of the cases used to live in rural places with dogs and/or sheep nearby. Only seven of 26 cases had a known medical history: one had a liver hydatid cyst removed with surgery 3 years prior to death, four had an abdominal pain couple of weeks before their death, and two had a dyspnea.

Circumstances of Death

In 17 cases of 26, death occurred in the victim's place while resting. Five of the victims died on work or a place of leisure after a heavy exercise: two masons died at their workplace after moving a heavy load, a pupil died in his school court while playing with his friends and two men died while playing football. Finally, four cases took place in a public area.

Death occurred without a notion of effort or trauma in 19 cases. In five cases, people died after a heavy exercise, and in two cases, death occurred immediately after abdominal or chest trauma perpetrated during an aggression.

Five subjects only had short notice symptoms before death: two had dyspnea and two had abdominal pain 3–5 h before their death and one victim had a generalized erythema and hot flushes 3 days before a rapid death.

Fifteen cases were conveyed to hospital, nine of them were dead upon arrival, 6 were hospitalized, and two only went to the surgery room, all of them died in <24 h.

Autopsy Observations

On external examination, all the victims had nonspecific signs of asphyxia and none of them had petechia.

A generalized erythema was discovered in five cases. In the two cases of rapid death after aggression mentioned earlier, we noticed the presence of right abdominal ecchymosis in one case and ecchymosis of the face and the arms in the other.

During dissection, we identified, a brain and lung edema in all cases, a congestion of the viscera in 24 cases, a frothy white secretion in the airway in seven cases and a glottis edema in only three cases.

In 18 cases, we noticed a single cyst, in five cases two cysts and in three cases three cysts. Ninety-one percent of the cysts were found in the liver. We also noticed two lung cysts, one heart cyst (Fig. 1) and one cyst of the left renal artery wall. The cyst's diameter varied between 3 and 15 cm with a mean diameter of 8.8 cm. In 16 cases, cysts were ruptured, eight of them had a normal translucent cyst fluid, six had a bloody cyst fluid, and three had purulent cyst fluid. In most of the cases ($n = 16$), cysts had a multivesicular content (Fig. 2) (Gharbi's classification type 3), in seven cases, cysts had a floating inner membrane into the cyst (Gharbi's classification type 2), and three cases cysts had a heterogeneous and pasty content (Gharbi's classification type 4) which were infected.

The cause of death was determined to be the consequence of a severe pulmonary embolism due to a compression of the inferior vena cava by a liver cyst, in one case. In two cases, death was the consequence of an acute respiratory failure due to complicated lung cysts. In three cases, death was due to a severe sepsis complicating liver cysts. In 17 cases, we noticed nonspecific asphyxia signs, with either ruptured or nonruptured cysts in close contact to liver vessels on autopsy. In these cases, the macroscopic and histological examination of organs showed no lesion explaining death apart the cyst (especially no cardiac lesion), and confirming the diagnosis of hydatid cyst showing a cyst with three layer wall and the presence of scolices (Fig. 3) and a toxicological screenings were negatives. Therefore, we concluded that death was likely attributed to anaphylaxis or to a cerebral anoxia complicating anaphylaxis (we were not able to perform the IgE and Tryptase blood rate as it could not be performed in Tunisia in any biological laboratory).

Three particular cases are to indicate: the first was a case of acute heart failure due to a heart hydatid cyst, symptoms were not indicated by anaphylaxis but with a cardiac complication that could be a fatal arrhythmia or a heart flow obstruction. The second of fatal mesenteric infarct in a young adult without risk factors, the most probable, secondary to a mesenteric artery obstruction by a left liver hydatid cyst. The third case was of an abdominal hemorrhage due to a rupture of the left renal artery wall hydatid cyst.

The manner of death was considered as natural death in 23 cases, as homicide in two cases and as accident in one case.

We excluded 13 cases in which hydatid cyst were observed during autopsy of sudden death cases and were not considered in the mechanism leading to death. In all these cases, cysts were observed in the liver. The mean diameter is 3.5 cm (ranging from 2 to 5 cm). They were classified as either Ghari's type 2 (six cysts) or Gharbi's type 4 or 5 (seven cysts). All of them were nonruptured. In the 13 cases, a cause of death was observed and determined as different from a hydatid cyst complication: 10 were dead due to an acute heart failure complicating an ischemic heart disease, two were dead due to drug intoxication, and one case died due to a status epilepticus.

Discussion

The parasite's life cycle involves two hosts: dog is the definitive host and sheep is the intermediate host and three development stages: adult tapeworms grow in dog's gut, free eggs contaminate water sources or grass, and cysts develop in intermediate hosts. Humans may become accidentally intermediate hosts once infested with the parasite's free eggs either by ingesting contaminated vegetables and/or water, or because of a direct contact with infected dogs (1–3,5,8,10).

When ingested by humans, the parasite eggs hatch in the duodenum and enter the portal circulation then lodge in the liver in 55–75% of the cases (1,3–5,8). If the larva bypass the hepatic filtration (15–20% of the cases) (1,16), they enter the lung through the right circulation where they can form a lung hydatid cyst or traverse the lung and lodge in any organ or vessel (1,3–5,8, 16). Once situated in an organ, larval mass will enlarge and replace the normal tissue similar to some malignancies (5). The cysts will then grow slowly (1–5 cm a year) (16). After 3–6 years, the cysts can reach the size of a chicken egg (7,16). The symptoms of hydatid disease are very wide and nonspecific, it depends on the location and the size of the cyst (5). This could explain the fact that in our series, death occurred suddenly without notice.

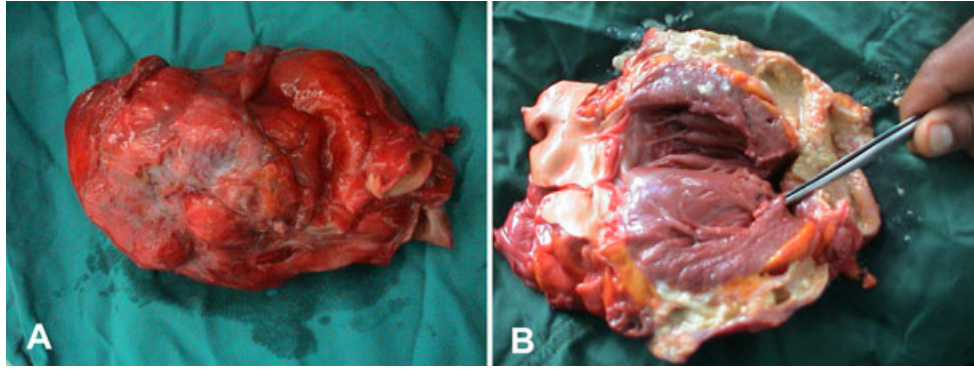


FIG. 1—Hydatid cyst in the left ventricle of the heart with an intact wall (A) and a daughter cyst protruding in the pericardial cavity (B).

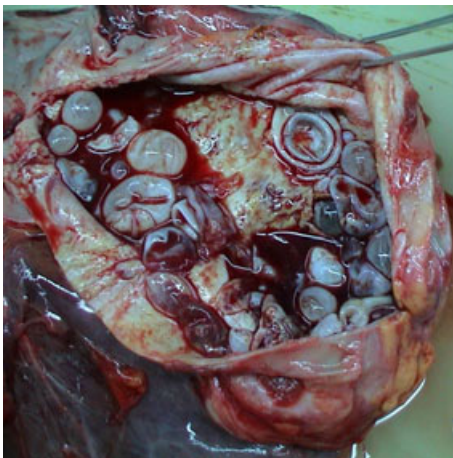


FIG. 2—Multivesicular hydatid cyst ruptured in the portal vein.

In our study, we noticed a male predominance, and victims were mainly young and living in a rural place. This was described by most of the authors (1,3,5,10) and can be explained by the fact that hydatidosis is more frequent within active population and especially some particular professions (butchers, shepherd, and veterinary) and within children who do not care about washing their hands or vegetables cultivated in fields before consumption (hydatid disease is described as the illness of “dirty hands”). Finally, by the fact that people living in rural places are in close contact to dogs and sheep, and by the noncontrolled sheep’s slaughtering, especially in the sacrifice feast, weddings and other celebrations.

The hydatid cyst presents a three-layer wall, the pericyst derive from the host fibrous tissue, the intermediate laminated layer and the inner germinal layer which produces daughter cysts. Within autopsy, the hydatid cyst will be recognized with its wall and the presence of scolices into the cyst fluid as oval structures with a circle of hooklet pathognomonic of hydatidosis (1,16). The diagnosis of the hydatid disease can be made by ELISA or immunoblot formats IgG antibodies to hydatid cyst fluid-derived native or recombinant antigen B detection, and the indirect hemagglutination (this serologic measurements are well described for the follow-up of the living but not validated for the postmortem analysis) and the gold standard remains histological confirmation of cyst (2,16). Hydatid cyst fluid is not used for the positive diagnosis of hydatid cyst; nonetheless, it can be useful in addition to the development of mitochondrial

DNA-based techniques to identify the type of *Echinococcus*, and stool-based PCR (copro-PCR) techniques for identifying infected animals (2,17).

Hydatidosis is not an interhuman contagious disease because the contagion is only possible with the eggs form and not with the cystic form living within humans. We highlight that even for eyes, the only possible way to develop an eye’s hydatid cyst is the same mechanism and eyes projection of the cyst fluid is not of a specific risk to transmit eyes hydatid cyst (18). Therefore, there is no specific risk of contagion for the forensic specialist during autopsy with observation of hydatid cyst except the normal risks related to biological contamination. The specialist should use the conventional safety precautions (gloves, mask...) as well as decontamination of the tables and instruments.

Gharbi’s (14) and WIGE’s (15) ultra sound imaging classifications divided hydatid cysts into five types and three main evolution stages:

- An active stage in which cysts are very contagious and have, respectively, a three layer wall or a multivesicular content (honeycomb like) which contains many daughter cysts (Gharbi’s type 1 and type 3 and WHO-WIGE’s type CE1 and CE2).
- An intermediate stage that includes cysts having an inner membrane floating into the cyst (Gharbi’s type 2, WHO-WIGE’s type CE3).
- An inactive stage where the cyst is in regression and no longer contagious when it has no more cyst fluid but has, respectively, a heterogenic pasty substance inside or when it is calcified (Gharbi’s type 4 and type 5 and WHO-WIGE’s type CE4 and CE5). (14,15).

In our study, 23 cases had cysts in the active stage (WHO-WIGE classification type CE2 or CE3). Most of the cases reported from sudden death due to hydatid cyst had cysts in an active stage of evolution (WHO-WIGE classification type CE1 to CE 3). This can be explained by the fact that during the active stage of evolution, cysts contain a very antigenic cyst fluid that can be responsible of an anaphylactic reaction (1,3,4,7,10).

In the 13 cases excluded from this study, we observed a cause of death not related to hydatidosis and in which the cysts were considered as an incidental observation. We noticed that the cyst were in an intermediate or an inactive stage of the cyst evolution.

Anaphylaxis is the most frequent cause of death by hydatid disease (1). In our study, anaphylaxis (or an anaphylaxis complication) was the most frequent cause of death (65%). Anaphylaxis

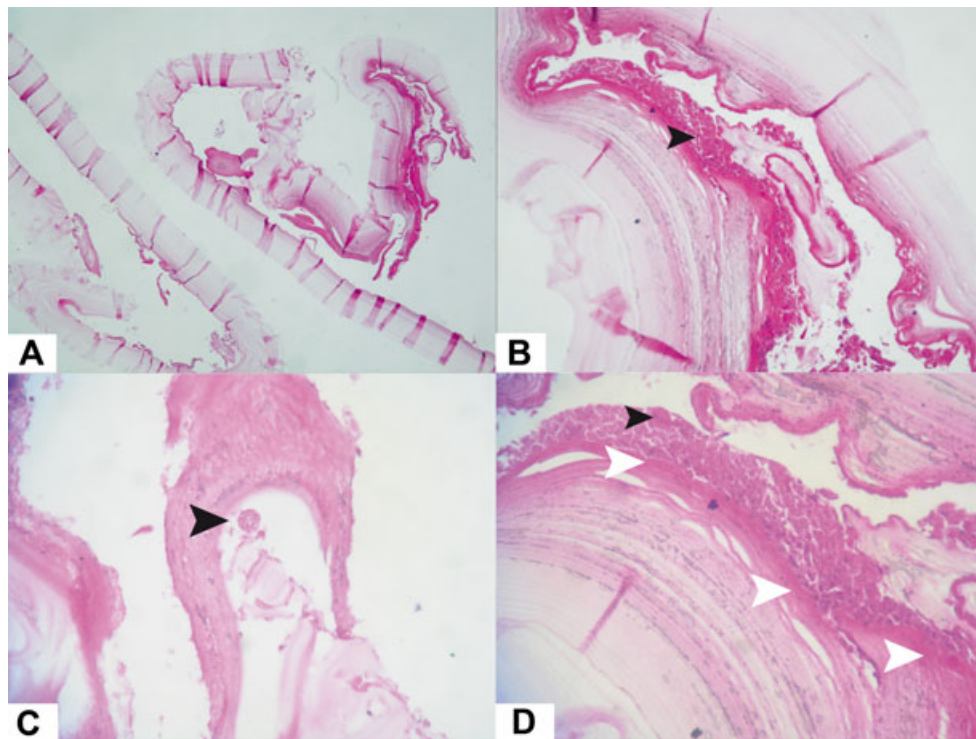


FIG. 3—Section of a hydatid cyst showing scolices (black arrowhead) and the three layer wall with the inner germinal layer (white arrowhead), Hematoxylin and eosin $\times 100$ (A), $\times 200$ (B and C), $\times 400$ (D).

is attributed to leakage of the very antigenic cyst fluid in blood vessels or in anatomic cavities (3,4,7,10). This can be caused by a macroscopic or a microscopic rupture of the cyst (19) which could be caused by a trauma usually an abdominal blunt or a sport trauma (4,20,21). However, it can also be caused by minor trauma such as falls or thoracic trauma without direct abdominal impact (1,6,9) and which may cause microscopic ruptures (8).

We noticed cyst with bloody cyst fluid and macroscopic rupture but without a history of trauma or sport accident in 11 cases (42%). Authors reported cases of spontaneous rupture of hydatid cysts (10,22–24). That could be explained by two mechanisms:

- A mechanical factor: when the cyst become very big with cyst fluid, and under pressure, the wall of the cyst will be weakened (10).
- The second mechanism is the adhesences and the inflammation that can lead to necrosis of the cyst wall (10).

Cyst rupture can be iatrogenic, that is why intra cyst puncture is not recommended for the diagnosis (25), even though this mechanism is under criticized discussion and cyst puncture, aspiration and alcohol injection “PAIR procedure” is validated by the WHO which stated that the risk of anaphylactic response due to this mechanism was overestimated (26,27).

On the other hand, in this study, four cases resulting to death were most probably the consequence of anaphylactic response but during autopsy cysts were not ruptured. As well as many other authors who reported cases of anaphylaxis with nonruptured hydatid cysts (3,8,16,19). In fact, cysts when enlarging may erode a small vessel in the liver, and a small quantity of cyst fluid can spread into bloodstream and enhance an anaphylactic response (8,19). In these cases, postmortem diagnosis can be oriented by a history of rapid death, probably after an abdominal trauma. At autopsy, the presence of a generalized erythema and a glottis edema (so informative but very rare signs) and the

presence of a hydatid cyst in the absence of another cause of death (1,8,28). Finally, the elevation of the IgE and of the mast cells Tryptase rate can also orientate to an anaphylactic origin of death (1,4,29,30). However, those blood parameters could lead to a false-positive diagnosis of fatal anaphylaxis in up to 35% of the cases, letting them be indicative yet not pathognomonic of anaphylaxis (28).

A limit of our work was that we were not able to perform the IgE and Tryptase blood rate because it could not be done in Tunisia in any biological laboratory. In these cases, we concluded that death was likely due to anaphylaxis, we performed a histological examination of all the organs (especially the heart) and a toxicological screening that did not showed any potential cause of death, in contrast to the 13 cases in which hydatid cyst were found at autopsy, but death was attributed to another cause and the cysts were considered an incidental observation.

In addition to anaphylaxis, hydatid cyst can have a fatal evolution by other mechanisms depending on its location. In this research, two cases presented pulmonary hydatid cyst which caused death by acute respiratory failure. Pulmonary hydatid cyst are usually diagnosed and treated early before complications giving evident and nonspecific symptoms chest pain, dyspnea, coughes, hemoptysis... (31). They may rupture in the bronchi giving a hydatid vomica sometimes associated with hemoptysis or purulent expectoration which, generally, disappear in few hours; however, it may leads to a real acute respiratory failure massive hemoptysis, anaphylactic shock or cardiovascular collapse (31), or rarely rupture in the pleural cavity and can be associated with pneumothorax (2,31,32).

One of the cases studied demonstrated a cardiac heart cyst, the history and the autopsy observations were more likely with acute heart failure by conduction disturbance or outflow obstruction rather than anaphylaxis. Heart hydatid cyst represents 1–3%

TABLE 1—Description of the cases reported in the study.

Sex/Age	Symptoms	Survival Time	Pathological Findings	Mechanism of Death	Manner of Death
1 M/9	Falling while playing in the school court. Dead upon arrival to hospital	<30 min	A nonspecific asphyxial syndrome Cyst of the liver ruptured in the abdomen with hemorrhagic content	Anaphylaxis	Natural
2 M/36	A mason felt pain and chest tightness after moving a heavy charge in his workplace. Dead upon arrival to hospital	1 h	Generalized erythema Frothy secretions in the trachea and the bronchi A nonspecific asphyxial syndrome Two multivesicular cysts of the liver with hemorrhagic content, ruptured in the portal vein	Anaphylaxis	Natural
3 M/47	A homeless found dead in a public place	Found dead	A nonspecific asphyxial syndrome 10 cm multivesicular ruptured cyst of the liver with purulent content	Complication of an infected hydatid cyst	Natural
4 M/14	Died suddenly while playing football without a notion of trauma. Dead upon arrival to hospital	<30 min	A nonspecific asphyxial syndrome A glottis edema Three cysts of the liver, one is ruptured with hemorrhagic content	Anaphylaxis	Natural
5 F/34	Chest pain and tightness while resting at her home. Dead upon arrival to hospital	1 h	A nonspecific asphyxial syndrome Frothy secretions in the trachea Cyst of the liver ruptured in the abdomen with translucent content	Anaphylaxis	Natural
6 F/15	Abdominal pains 4 h before. Found dead in her bed	Found dead	A nonspecific asphyxial syndrome Glottis edema Three cysts of the liver, one ruptured in the inferior vena cava	Anaphylaxis	Natural
7 F/32	Generalized erythema and hot flushes 3 days before death improved spontaneously. Had dyspnea at her home. Dead upon arrival to hospital	<1 h	A nonspecific asphyxial syndrome Generalized erythema Frothy secretions in the trachea and the bronchi Three cysts of the liver without a macroscopic rupture	Anaphylaxis	Natural
8 M/27	Fell down after being punched in the right chest during a fight. Dead upon arrival to hospital	20 min	Ecchymosis of the face and the arms Cyst of liver, ruptured and with hemorrhagic content	Anaphylaxis	Homicide
9 M/9	Complained of dyspnea 5 h before death improved spontaneously. Found dead in his bed	Found dead	A nonspecific asphyxial syndrome Frothy secretions in the trachea and the bronchi A nonruptured cyst in the liver	Anaphylaxis	Natural
10 M/17	Fell down after being punched in the abdomen. Resuscitated (two heart arrests). Operated one hour after for a ruptured hydatid cyst of the liver. Presented severe cerebral anoxia lesions. Dead 24 h after	24 h	Cyanosis Traces of resuscitation. Traces of a surgical intervention on the liver which is the site of a 6 cm diameter excavation Frothy secretions in the trachea and the bronchi	Complications of Anaphylaxis	Homicide
11 F/29	Found dead in her room	Found dead	A nonspecific asphyxial syndrome Frothy secretions in the trachea and the bronchi A nonruptured cyst of the liver	Anaphylaxis	Natural
12 F/44	Complained of abdominal discomfort and fever for 4 days neglected. Found dead in her bed	Found dead	A nonspecific asphyxial syndrome Cutaneous jaundice Two nonruptured cysts of the liver, one of them with an infected content (Gharby's stage 4)	Complication of an infected hydatid cyst	Natural

TABLE 1—Continued.

Sex/Age	Symptoms	Survival Time	Pathological Findings	Mechanism of Death	Manner of Death
13 M/37	Found dead in his bed	10 min	A nonspecific asphyxial syndrome A ruptured cyst of the liver	Anaphylaxis	Natural
14 M/28	Complained of abdominal pains 5 h before death. Found dead in the bathroom	Found dead	A nonspecific asphyxial syndrome Frothy secretions in the trachea and the bronchi One nonruptured cyst of the left ventricle of the heart A nonspecific asphyxial syndrome A ruptured cyst of the liver with translucent content	Acute heart failure secondary to a heart hydatid cyst	Natural
15 F/49	Found dead in the bathroom	10 min	A nonspecific asphyxial syndrome Cutaneous jaundice Two cysts of the liver, one of them ruptured and with a purulent content (Charby's stage 4)	Anaphylaxis	Natural
16 F/25	Diabetic. Complained of abdominal discomfort and fever during 5 days, self-treated symptomatically. Presented an acido-cetosis and died two hours after being hospitalized	2 h	A nonspecific asphyxial syndrome Two cysts of the liver, one of them ruptured and with a purulent content (Charby's stage 4)	Complication of an infected hydatid cyst	Natural
17 M/34	Mason complaining of cough and chest pain for 6 months not treated. Presented an important hemoptysis and dyspnea after moving a heavy charge. Dead upon arrival to hospital	1 h	An nonspecific asphyxial syndrome The presence of blood in the trachea and the bronchi A cyst of the right lung ruptured in the pulmonary vessels and the bronchi	Respiratory failure secondary to a complicated lung hydatid cyst	Natural
18 F/61	History of hydatid cyst of the liver treated 3 years before with surgery. Found dead in her garden	Found dead	A nonspecific asphyxial syndrome A ruptured cyst of the liver with a translucent content	Anaphylaxis	Natural
19 M/32	Complained of cough and dyspnea for 3 months, not treated. Presented a dyspnea and rapid heart arrest	<10 min	A nonspecific asphyxial syndrome A cyst of the left lung ruptured in the bronchi with vesicles enclaved in the bronchi	Respiratory failure secondary to a lung hydatid cyst	Natural
20 F/38	No embolism risk factors. Felt a dyspnea and chest pains. Transported to the hospital 8 hours after with an acute right heart failure. Dead few hours after	<24 h	A nonspecific asphyxial syndrome A crutic pulmonary embolism, with a total obstruction of the pulmonary artery at its origin A nonruptured cyst of the liver (segment IV) obstructing the inferior vena cava	Pulmonary embolism secondary to an obstruction of the inferior vena cava by a liver hydatid cyst	Natural
21 M/26	Found dead at his room	Found dead	A nonspecific asphyxial syndrome Frothy secretions in the trachea and the bronchi A glottis edema	Presumably anaphylaxis	Natural
22 M/27	Had a dyspnea 3 h before death, spontaneously improved. Dead upon arrival to hospital	30 min	A nonruptured cyst of the liver A nonspecific asphyxial syndrome A ruptured hydatid cyst of the liver	Anaphylaxis	Natural
23 M/27	Found unconscious in a public place. Hospitalized in the ER department with severe cerebral anoxia complications and dead 2 h after	2 h	A nonspecific asphyxial syndrome Resuscitation maneuvers traces Two cysts of the liver, one being ruptured	Anaphylaxis complications	Natural
24 M/18	Kicked while playing football and presented abdominal pains. Went to the hospital 4 h after the event. They diagnosed a hemoperitoneum with hemodynamic alteration. Dead just before the beginning of the surgery intervention	5 h	Signs of hemorrhage An abdominal distension Resuscitation maneuvers traces A large hemoperitoneum (estimated to 2500 mL) and a large retroperitoneum hemorrhage A cyst of the left renal artery ruptured in the peritoneum	Hemorrhagic complications of a left renal hydatid cyst	Accident

TABLE 1—Continued.

	Sex/Age	Symptoms	Survival Time	Pathological Findings	Mechanism of Death	Manner of Death
25	F/30	History of abdominal pains for 3 months treated symptomatically. Aggravation of the pains and a dyspnea. Dead few minutes after being hospitalized	20 min	A nonspecific asphyxial syndrome Two cysts, one ruptured	Anaphylaxis	Natural
26	M/51	Abdominal pains for one month treated symptomatically. Aggravation of the abdominal pains with vomiting and bloody diarrhea. Hospitalized with a hemodynamic failure, dead few minutes after	2 days	A nonspecific asphyxial syndrome Hepatomegaly (liver weight 2600 g) A 12-cm nonruptured cyst of the left liver in contact with the origin of the mesenteric artery origin An intestinal distention with a large necrosis of the jejunum	A mesenteric artery obstruction by a left liver hydatid cyst	Natural

of hydatid disease cases (1,5). Other authors who reported cases of death due to heart hydatid cyst described different mechanisms of death: anaphylaxis and/or embolization by cyst daughter complicating cyst rupture, fatal arrhythmia, pumping obturation, myocardial infarction by coronary artery obstruction, tamponade, pericarditis or pulmonary hypertension (7,8,16,24,33,34).

Other rare locations of the hydatid cyst can also lead to unexpected death. Intracerebral cysts can exert a mass effect with hydrocephaly, seizures or cerebral infraction (1). Intra-abdominal cysts could cause peritonitis by hollow organ perforation (1), or like in our study by vascular compression (one cause of mesenteric infraction) or by abdominal hemorrhage (one case of rupture of the left renal artery hydatid cyst).

In addition to the cause of death, the forensic specialist is required to determine the manner of death, especially in the cases where death follow a trauma perpetrated by another person. Hydatid disease is in most of the cases considered as natural death. However, in some cases, cyst rupture may occur following a trauma (either voluntary or not). In these cases, the external factor that caused the trauma should be considered in the determination of the death's manner. When the trauma is strong enough to cause the cyst rupture, this rupture could be directly imputed to the traumatic event, and manner of death could be seen as homicide (in case of voluntary trauma which occurred by another person) or accident (in case of involuntary trauma, for example sport accident ...).

The conclusion is more difficult when the trauma is considered not enough strong to cause the cyst rupture according to the enquiry and the autopsy observations (unimportant or none traumatic lesions). In the latest cases, the discussion would be developed regarding three hypotheses to conclude if the cyst rupture and death are respectively: directly or partially or not imputable to the trauma and to determine whether the manner of death was natural or not. The first one is if the cyst self-evolution was likely to be a spontaneous rupture (cysts larger than 8.5 cm [35]). The second is if the trauma observed was likely to cause death even though the cyst was not present, and the last one is if the combination of the trauma and the cyst is likely to cause death.

In our report, in three cases, we concluded that the manner of death is not natural. Two cases were considered as homicides because death occurred following a strong trauma one in the chest and one in the abdomen. We concluded that death was secondary to anaphylaxis due to a hydatid cyst rupture caused by an abdominal (or chest) blunt trauma. The third case was considered as sport accident. The victim was kicked involuntarily during a football game, and death was secondary to the hemorrhagic complications of a left renal hydatid cyst ruptured following an abdominal trauma.

Conclusion

Hydatid cyst is a potential cause of unexpected death especially within children and young adults. The migration flow makes it an increasing worldwide parasitic infection.

In front of a young adult's unexpected death, the forensic specialist should have in mind hydatid disease as a potential cause of death especially with a history of an abdominal trauma followed by a rapid death. Accordingly, different investigations might be helpful to determine the cause of death such as the research of a glottis edema, the meticulous dissection of all organs and vessels, and the careful dissection of the cyst to

identify a cyst wall rupture associated with the IgE and the mast Tryptase blood level.

Acknowledgment

The authors would like to thank Professor Jean-Sebastien Raul who kindly accepted to review our manuscript and send us his comments and Mr. Slim Guizani and Mr. Steve Morton for their valuable help in the manuscript editing and Mr. Hassen Jaafar for his valuable help with the artwork.

References

- Byard WR. An analysis of possible mechanisms of unexpected death occurring in hydatid disease (Echinococcosis). *J Forensic Sci* 2009;54: 919–22.
- Craig PS, McManus DP, Lightowler MW, Chabalgoity JA, Garcia HH, Gavidia CM, et al. Prevention and control of cystic echinococcosis. *Lancet Infect Dis* 2007;7:385–94.
- Georgiou S, Maroulis J, Monastirli A, Pasmazti E, Pavlidou D, Karavias D, et al. Anaphylactic shock as the only clinical manifestation of hepatic disease. *Int J Dermatol* 2005;44:233–5.
- Kök AN, Yutman T, Aydın E. Sudden death due to ruptures hydatid cyst of the liver. *J Forensic Sci* 1993;38:978–80.
- Khanfar N. Hydatid disease: a review and update. *Curr Anesth Crit Care* 2004;15:173–83.
- Gulap B, Koseoglu Z, Toprak N, Satar S, Sebe A, Gokel Y, et al. Ruptures hydatid cyst following minimal trauma and few signs on presentation. *Neth J Med* 2007;65:117–8.
- Pakis I, Akyildiz EU, Karayel F, Turan AA, Senel B, Ozbay M, et al. Sudden death due to an unrecognized cardiac hydatid cyst: three medico-legal autopsy cases. *J Forensic Sci* 2006;51:400–2.
- Büyük Y, Turan AA, Üzün I, Aybar Y, Cin Ö, Kurnaz G. Non-ruptured hydatid cyst can lead to death by spread of cyst content into bloodstream: an autopsy case. *Eur J Gastroenterol Hepatol* 2005;17:671–3.
- Elmali M, Ceyhan M, Ilgar M, Koprulu C, Ozfidik M, Sancak R. Hepatic hydatid cyst rupture and anaphylaxis after fall. *Indian J Pediatr* 2009;76:329–30.
- Louahlia S. Mort subite par rupture spontanée d'un kyste hydatique du foie. *J Med Leg Droit Med* 1995;38:551–4.
- Hsairi M, Chahed MK, Bchir A. L'incidence chirurgicale de l'hydatidose en Tunisie 1988–1992. *Tunis Chir* 1995;89:409–14.
- Chahed MK, Bellali H, Touinsi H, Cherif R, Ben Safta Z, Essoussi M, et al. Distribution of surgical hydatidosis in Tunisia, results of 2001–2005 study and trends between 1977 and 2005. *Arch Inst Pasteur Tunis* 2010;87:43–52.
- Dakkak A. Echinococcosis/hydatidosis: a severe threat in Mediterranean countries. *Vet Parasitol* 2010;174:2–11.
- Gharbi HA, Hassine W, Brauner MW, Dupuch K. Ultrasound examination of the hydatid liver. *Radiology* 1981;139:459–63.
- WHO-Infomral Working Group on Echinococcosis. International classification of ultrasound images in cystic echinococcosis for application in clinical and field epidemiological settings. *Acta Trop* 2003;85:253–61.
- Malamou-Mitsi V, Pappa L, Vougiouklakis T, Peschos D, Kazakos N, Grekas G, et al. Sudden death due to an unrecognized cardiac hydatid cyst. *J Forensic Sci* 2002;47:1062–4.
- Carmena D, Benito A, Eraso E. Antigens for the immunodiagnosis of *Echinococcus granulosus* infection: an update. *Acta Trop* 2006;98:74–86.
- Otranto D, Eberhard M. Zoonotic helminths affecting the human eye. *Parasit Vectors* 2011;4:41.
- Sanei B, Hashemi SM, Mahmoudieh M. Anaphylactic shock caused by nonruptured hydatid cyst of the liver. *J Gastrointest Surg* 2008;12: 2243–5.
- Gunay K, Taviloglu K, Berber E, Ertekin C. Traumatic rupture of hydatid cysts: a 12- year experience from an endemic region. *J Trauma* 1999;46:164–7.
- Koyuncu A, Aydın C, Turan M, Tas F, Gökçöz S, Sen M. Traumatic pelvic hydatid cyst rupture: report of case. *Ulus Travma Acil Cerrahi Derg* 2003;9:212–4.
- Fanne RA, Khamaisi M, Mevorach D, Leitersdorf E, Berkman N, Laxer U, et al. Spontaneous rupture of lung echinococcal cyst causing anaphylactic shock and respiratory distress syndrome. *Thorax* 2006;61:550.
- Wellhoener P, Weitz G, Bechstein W, Djonlagic H, Dodt C. Severe anaphylactic shock in a patient with a cystic liver lesion. *Intensive Care Med* 2000;26:1578.
- Chadly A, Krimi S, Mghirbi T. Cardiac hydatid cyst rupture as cause of death. *Am J Forensic Med Pathol* 2004;25:262–4.
- Durif S, Marinkovic Z, Febvre C, Raffoul J. Hydatid liver disease revealed by surgical acute abdominal syndrome. *Arch Pediatr* 2005;12:1617–9.
- WHO-Infomral Working Group on Echinococcosis. Guidelines for treatment of cystic and alveolar echinococcosis in humans. *Bull of the WHO* 1996;74:213–42.
- Bastid C, Sahel J. Percutaneous treatment of hydatid cysts is now validated by WHO. *Acta Endosc* 2004;34:101–9.
- Mayer DE, Krauskopf A, Hemmer W, Moritz K, Jarisch R, Reiter C. Usefulness of post mortem determination of serum tryptase, histamine and diamine oxidase in the diagnosis of fatal anaphylaxis. *Forensic Sci Int* 2011;212:96–101.
- Horn KD, Halsey JF, Zumwalt RE. Utilisation of serum tryptase and immunoglobulin E assay in the postmortem diagnosis of anaphylaxis. *Am J Forensic Med Pathol* 2004;55:37–43.
- Nishio H, Takai S, Miyazaki M, Horiuchi H, Osawa M, Uemura K, et al. Usefulness of serum mast cell-specific chymase levels for postmortem diagnosis of anaphylaxis. *Int J Legal Med* 2005;119:331–4.
- Ramos G, Orduña A, Garc a-Yuste M. Hydatid cyst of the lung: diagnosis and treatment. *World J Surg* 2001;25:46–57.
- Tor M, Atasalihi A, Altuntas N, Sulu E, Senol T, Kir A, et al. Review of cases with cystic hydatid lung disease in a tertiary referral hospital located in an endemic region: a 10 years' experience. *Respiration* 2000;67:539–42.
- Byard RW, Bourne AJ. Cardiac echinococcosis with fatal intracerebral embolism. *Arch Dis Child* 1991;66:155–6.
- Pansard Y, De Brux JL, Cohen-Solal A. Kyste hydatique du coeur droit ethypertension pulmonaire post-embolique. *Arch Mal Coeur Vaiss* 1987;5:667–9.
- Demicran O, Baymus M, Akinoglu A. Occult cystobiliary communication presenting as postoperative biliary leakage after hydatid liver surgery: are there significant preoperative clinical predictors? *Can J Surg* 2006;49: 177–84.

Additional information and reprint requests:
 Mehdi Ben Khelil, M.D.
 Service de Medecine Legale
 Hopital Charles Nicolle
 138 Boulevard du 9 avril 1938
 Tunis 1006
 Tunisia
 E-mail: benkhelilmehdi@yahoo.fr