

Review

Potentials of ultrasound in the assessment of appearances and immunopathological reactions that are caused by parasitic infestations

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This paper is intended to improve the knowledge of sonographers and clinicians on the potentials of ultrasound in the assessment of appearances and immunopathological reactions that are caused by parasitic infestations. Sonographic appearances in and of *Schistosoma haematobium*, *Ascaris lumbricoides*, *Colon taeniasis*, *Cysticercus cellulosae*, *Dracunculus medinensis* and *Echinococcus granulosus* infestation were reviewed. Pertinent sonographic features were pointed out. Ultrasonography plays an important role in establishing the diagnoses of *S. haematobium*, *A. lumbricoides*, *C. taeniasis* and *C. cellulosae* infestation. Ultrasonography is used in visualizing calcified *D. medinensis* in muscles and evaluation of echinococcal infestations. The use of ultrasonography in evaluation of some parasitic infestation benefits from an understanding of multiple sonographic appearances (echinococcosis) and the immunological changes associated with the death of parasites in the muscle (cysticercosis)

Key words: Parasitology, *Schistosoma haematobium*, *Ascaris lumbricoides*, *Colon taeniasis*, *Cysticercus cellulosae*, *Dracunculus medinensis*, *Echinococcus granulosus*.

INTRODUCTION

A parasite is an organism, such as a single-celled animal, protozoa or worm, which survives by living inside another, usually a much larger organism (the host) (Piessences, 1997). Parasitology is a word coined and first used by the lead author (AC) during a clinical discussion. It is the sonographic examination of parasites and the immunopathological reactions of the body (organs) occasioned by parasitic infestations.

Parasitic infestations are common in rural Africa, Asia and South America but are rare in developed countries. However, people from developed countries who visit developing countries can be infested with parasites.

Sonographic appearances of parasitic infestations are a rare occurrence in clinical ultrasound practice and expectedly there is paucity of knowledge and awareness in this aspect of ultrasound among sonographers and referring clinicians alike.

We describe the sonographic appearances of and in *Schistosoma haematobium*, *Ascaris lumbricoides*, *Colon taeniasis*, *Cysticercus cellulosae*, *Dracunculus medinensis* and *Echinococcus granulosus* infestations.

Schistosom haematobium

Schistosomiasis or bilharziasis is a chronic trematode infestation caused largely by 3 species: *Schistosoma mansoni*, *Schistosoma Japonicum*, *S. haematobium* (Warren, 1984). Infestation occurs on entry into fresh

water containing the larvae (cercariae) emitted by snail, the intermediate host. The cercariae penetrates the skin and the immature parasites (*Schistosomula*) migrate via the lungs and liver to their final habitat in the veins of the intestine and urinary bladder. *S. haematobium* causes symptoms in the genitourinary system or lower colon and rectum. In *S. haematobium* infestation, terminal haematuria, occasional dysuria and urinary frequency are the common clinical symptoms found. The 1-2 cm long adult male and female worms, which remain "in copulo" for many years do not themselves multiply within the human definitive host but produce a large number of eggs many of which are trapped within the tissues primarily in the intestine and liver or the urinary tract (submucosa of the bladder and to a lesser extent can be found in the muscular and subserous layers of the ureters). Immunological reactions to the eggs result in granulomatous inflammation and fibrosis obstructing blood flow within the liver or urine flow from the ureters. The appearance of Symmer's fibrosis on ultrasound is pathognomic of bilharziasis (Dear, 2006). Calcification is the most important single diagnostic finding in schistosomiasis (Edward, 1980). It is very common in the urinary bladder, less frequently in the lower ureters and in the advance disease it may involve the whole length of the ureters. Ultrasound scan of the urinary bladder usually demonstrates some intravesical, multiple, linear, immobile and seemingly confluent echogenic structures (plaques).

Ascaris lumbricoides

Roundworm infestation, one of the most common helminthic diseases worldwide is caused by *A. lumbricoides*, one of the largest parasites that infest human bowel (Mahmood et al., 2001). Humans become infested with *A. lumbricoides* by ingesting water, food or soil contaminated by faeces containing the larvae. The *Ascaris* larvae in the bowel pass through the intestinal wall into the venous system, and when they get to the lungs, the larvae penetrate into the airspace and are conveyed up the trachea into the oesophagus and then swallowed. These larvae mature into adult worms in the jejunum, where they mate and produce eggs. These eggs are excreted in the faeces and are infective to humans, thus completing the cycle (Arean and Crandall, 1971; Reeder and Palmer, 1994; Ozmen et al., 1995; Reeder, 1998; Palmer and Reeder, 2000). An adult worm measure 15 to 35 cm in length and 2 to 6 mm diameter. The worm has 2 outer coverings the cuticle and hypodermis; an inner layer contains many contractile muscles with a central alimentary tube (Arean and Crandall, 1971).

In ultrasonography of fluid-filled small intestine, *Ascaris* has been described as a "winding highway" or "parallel lines" (Peck, 1990; Brazilai and Khamaysi, 1996; Hoffmann et al., 1997) Ultrasonographic diagnosis is based on the delineation of a tubular filling defect, "3-line" or "4-line" signs on the longitudinal scan, and a doughnut

– like cross sectional appearance of the worms in the intestines. Ultrasonographic findings depend on the worm's orientation to and the resolution of the transducer, the presence or absence of fluid around the worm, the part of the worm imaged (head or body), and whether the worm is dead or alive (Mahmood et al., 2001). Using a 3.7 MHz transducer, the body of a worm is seen as parallel echogenic bars separated by an anechoic area representing the fluid-filled alimentary tube of the worm. This feature has been described as a "triple line" sign (Hoffmann et al., 1997). When a 7.5 MHz transducer was used, the worm appeared as 4 parallel lines separated by 3 anechoic bands. Each echogenic bar seen when using the 3.5 MHz transducer was resolved into 2 thin lines when the 7.5 MHz transducer was used. When the worm swallowed, the most central anechoic area could be seen to enlarge, indicating that the alimentary tract was located in this area. Also, the anechoic alimentary canal becomes temporarily echogenic during the act of swallowing. In the transverse section, a worm had a small, doughnut-like appearance with 2 to 3 mm thick echogenic rim and a thin-walled rim on high frequency imaging (Mahmood et al., 2001). If there was no fluid around the worm, the wall of the host's intestine added 1 to 2 additional lines on both transducer frequencies. Some worms showed serpentine movements. Sonographic examination of the patients in left lateral decubitus after ingestion of water improved detection and visualization of the worms in some cases (Mahmood et al., 2001). Hydrocolonography, scanning after filling the colon with water, has been described by other workers (Hoffmann et al., 1997).

Certain objects in the abdomen can give an *Ascaris* – like appearance on ultrasonography. For example, a nasogastric or jejunal feeding tube, a surgical drainage tube, a ventriculoperitoneal shunt, or even a normal small bowel during peristalsis may mimic *Ascaris* on abdominal sonography (Cremin, 1982). With the knowledge of the patient's history and careful scanning, confirmation may be obtained by provoking worm movement by transducer pressure or demonstrating swallowing by the worm. Sugary diet (solution) and banana are equally thought to provoke this movement.

Intestinal sonography is not a substitute for the much simpler methods of inspection of faeces, laboratory parasitological faecal examination and plain abdominal radiography for screening patients for *Ascaris* infestation when tubular soft tissue density filling defects may be seen within the bowel gas. The parasite may be found in biliary organs and Wirsung duct and occasionally can be detected in a calcified state in the common bile duct in obstructive icterus (Leung et al., 1987; Price and Leung, 1988).

Colon taeniasis

Modern ultrasonographic equipment using convex or linear probes of 5 or 7 MHz enables high quality analysis

of the intestinal wall and intraluminal content (Fabinjanic et al., 2001). If an abdominal ultrasonographic examination does not show abnormalities, then a repeat examination after adequate patient preparation (deaeration and filling intestine with liquid is warranted) (Limberg, 1989; Oberg, 1996; Van Ruysseult and Pauls, 1996; Northover, 1997).

Statmann (1991) presented a case of ultrasonographically detected taeniasis in the small intestine in a patient who has been prepared for ultrasonographic examination by per oral application of hyperosmolar solutions. He described the finding of taeniasis as a double intraluminal reflection, which thickness varied according to maturity of the parasite. This finding in patients, even when there are negative results of parasitologic examinations and initial therapeutic failure, should lead to the administration of barium enema, which is confirmatory. Parasitologic analysis of proglottids passed in the stool after administration of niclosamide, equally, would reveal the mature form of the beef tapeworm (*Taenia saginata*).

Cysticercus cellulosae

Cysticercosis is an infestation with the larval (*C. cellulosae*) stage of *T. solium* (adult pork tapeworm). Following the ingestion of the ova of *T. solium* by man, the embryos develop in the human intestinal tract. They penetrate through the mucosa and enter the blood stream to become distributed round the body. Some of them enter the muscle where they live for years in an encapsulated state. When they die the cysts slowly calcify. The calcified cysts produce oval structures, 10 to 15 mm long and 2 to 3 mm broad (Starer, 1980). They (larvae) may be associated with cysts in the brain, meninges, and eyes, which together constitute 86% of the cases (Sidhu et al., 2002). The rest are found in the muscles, heart, lungs and peritoneum (Piessences, 1997). Cases in the maxillofacial region, including the tongue and cheek muscles are rarely reported (Timosca and Gavrileta, 1974; Kinnman et al., 1976; Tschen, 1981). Sonography of an affected area reveals a homogenous, well defined hypoechoic lesion, possibly with an anechoic and a hyperechoic speck suggesting a calcified scolex (Sidhu et al., 2002).

The adult tapeworm measures 8-10 feet in length (Piessences, 1997). Usually the humans are the definitive host for *T. solium*. When poorly cooked pork containing the larva is ingested by man, the cyst wall is destroyed by gastric enzymes, releasing the scolex that passes into the small intestine, where it becomes fixed. Embryonated eggs and gravid proglottids are released in the faeces, deposited on the soil and later ingested by the intermediate host, pig. After passage into the duodenum, the larvae hatch from the eggs, penetrate the wall of the small intestine and are carried by blood or lymph to various body tissues of the pig. If humans ingest under-

cooked pork, the cycle starts again. Man may also act as the intermediate host; the eggs reach the stomach either when a person swallows them or when proglottids (egg – containing sections) are regurgitated from the intestine to the stomach (Piessences, 1997).

They penetrate the intestinal wall and travel to the muscles, internal organs, brain and tissues under the skin, where they form live cysts. Live cysts cause only a mild tissue reaction; whereas dead ones invoke a vigorous reaction (Piessences, 1997). Live *cysticerci* actively evade immune recognition and do not cause inflammation; however, during the death of larvae, leakage of liquid from the cysts may trigger off acute inflammatory response. According to Scully et al. (1994) the inflammatory response may appear as a surrounding hyperechoic lesion in the muscle.

***Dracunculus medinensis* (GUINEA WORM)**

This parasite, which enters the human body through drinking water, becomes visible on radiographs only when it undergoes calcification after its death (Starer, 1980). It produces an elongated coiled strip of calcium density in muscles on radiographs. This may be crushed after sometime by muscular action into a round irregular mass. It could incidentally be picked during soft tissue scanning with a suitable transducer.

Echinococcus granulosus

E. granulosus causes cystic echinococcosis (cystic hydatid disease). The characteristic cysts are usually located in the liver (60 - 75%), lung, (15 - 20%), and the remainder of the body (10 - 15%), most commonly the brain, bone and mediastinum (Sinner, 1997). Only 0.2 to 0.9% of all echinococcal cysts have been reported in the female pelvis, with most located in the ovary, parametrium, or adnexae and occasionally in the omentum with adherence to the pelvic organs (Geogakopoulos et al., 1980; Baba et al., 1991). According to Manterola et al. (2004), the natural history of *Echinococcus* in pregnant women is not well understood due to its low prevalence rate. In addition, there are few cases reported in the literature and related knowledge is scarce (Semeschyshy, 1970; Bickers, 1970; Rahman et al., 1982; Kekioh et al., 1992; Blochele et al., 1993; Golaszewski et al., 1995; Van Vliet et al., 1995).

Sonography of the pelvis in a patient with the mass reveals a hypoechoic mass with thin, smooth wall and multiple thin internal septations (Ranzini et al., 2002). It may have different appearances in the female pelvis. Hepatic or pelvic echinococcosis can range from cystic lesions (Birkhoff and McClennan, 1973; el Fortia et al., 1999), multilocular lesion with a few internal septa (Aksu et al., 1997), solid lesion (Diaz-Recasens, 1998), multicystic lesions (Hiller et al., 2000), and lesions with unusual

double layered or calcified walls (Perkindi and Tenekeci, 1997; Diaz-Recasens et al., 1998; el Fortia et al., 1999).

In the pelvis, the echinococcal cysts can be mistaken for other benign processes, including benign ovarian tumours, haemorrhagic ovarian cysts and uterine myomas (Starer, 1980). The source of this parasite is dog faeces and its entry route is the mouth (Piessences, 1997).

CONCLUSION

High-resolution sonography, being noninvasive and non-ionizing, plays an important role in the investigation of patients with *S. haematobium*, *A. lumbricoides*, *C. taeniasis*, *C. cellulosae*, *D. medinensis* and *E. granulosus*. If lesions with the sonomorphologic signatures described above are encountered on sonography, the suggestions of these parasites should be accordingly considered high.

REFERENCES

- Aksu MF, Budale E, Aksu C (1997). Hydatid cyst of the ovary. Arch. Gynecol. Obstet. 261: 51-53.
- Arean VM, Crandall CA (1971). Ascariasis In: Marcial-Rojas RA (ed). Pathology of Protozoal and helminthic disease. Baltimore, MD: Williams and Wilkins. Pp. 19-22.
- Baba A, Chaieb A, Khairi H, Keskes J (1991). Profil epidemiologique de L'hydatidose pevlvienne: a propos de is cas. J. Gynecol. Obstet. Biol. Reprod. (Paris) 20: 657-660.
- Bickers VM (1970). Hydatid disease of female pelvis. Am. J. Obstet. Gynecol. 107: 477-483.
- Birkhoff JD, McClennan BI (1973). Echinococcal disease of the pelvis: urologic complications, diagnosis and treatment. J. Urol. 109: 473-476.
- Blöchele C, Lloy DM, Izbicki JR, Schröder S, Brolsch CE (1993). Right-sided hemihepatectomy in echinococcosis of the liver in pregnancy. Chirurg 64: 580-583.
- Brazilai M, Khamaysi N (1996). Sonographic imaging of ascaris lumbricoides. Harefuah 131: 247-248.
- Cremin BJ (1982). Realtime ultrasound paediatric biliary ascariasis. S. Afr. Med. J. 61: 914-916.
- Dear AS (2006). Schistosomiasis. Oxford textbook of medicine online med. Linb-ru/English/Oxford schist. Shtml.
- Diaz-Recasens J, Garcia-Enguidanos A, Munoz I, Sainz de la Cuesta R (1998). Ultrasonographic appearance of an echinococcus ovarian cyst. Obstet. Gynecol. 91: 841-842.
- Edward D (1980). Urinary infections. In: Sutton D (ed). A textbook of radiology and imaging. London: Churchill Livingstone, p. 881.
- el Fortia M, Bendaoud M, el Durrega S (1999). Primary uterine hydatid cyst and the wall sign criteria. Ultrasound Obstet. Gynecol. 13: 374.
- Fabinjanic D, Guinio L, Ivani N, Fabinjanic A, Miric D, Kardum D (2001). Ultrasonographic appearance of colon taeniasis. J. Ultrasound Med. 20: 257-277.
- Geogakopoulos PA, Gogas CG, Sariyanniv HG (1980). Hydatid disease of the female genitalia. Obstet. Gynecol. 55: 555-559.
- Golaszewshi T, Susani M, Golaszewshi S (1995). A large hydatid cyst of the liver in pregnancy. Arch. Gynecol. Obstet. 256: 43-47.
- Hiller N, Zagal L, Hadas-Halpern I (2000). Echinococcal ovarian cyst: a case report. J. Reprod. Med. 45: 224-226.
- Hoffmann H, Kawooya M, Esterre P, Voahangy ER, Roth J, Thomas AK, Roux J, Seitz HM, Doehring E (1997). *In vivo* and *in vitro* studies of the sonographic detection of ascaris lumbricoides. Pediatr. Radiol. 27: 226-229.
- Kekioh MA, Abed H, Cheli M (1992). Kyste hydatique pelvien et grossesse a proposed 4 cas (Pelvic hydatid cyst, report of 4 cases). J. Gynecol. Obstet. Biol. Reprod. 21: 803-805.
- Kinnman J, Chi CH, Park JH (1976). Cysticercosis in otolaryngology. Arch. Otolaryngol. 102: 144-147.
- Leung JWC, Mok SD, Metreweli C (1987). Ascaris induced pancreatitis. AJR Am. J. Roentgenol. 149: 512.
- Limberg B (1989). Diagnosis of acute ulcerative colitis and colonic Crohn's disease by colonic sonography. J. Ultrasound Med. 17: 25-31.
- Mahmood T, Mansoor N, Qkuraishy S, Ilyas M, Hussain S (2001). Ultrasonographic appearance of ascaris lumbricoides in the small bowel. J. Ultrasound Med. 20: 269-274.
- Manterola C, Espinoza R, Munoz S, Vial M, Bustos L, Losada H, Barroso M (2004). Abdominal echinococcosis during pregnancy: clinical aspects and management of a series of cases in Chile. Trop. Doc. 34: 171-173.
- Northover JM (1997). Staging and management of colorectal cancer. World J. Surg. 21: 672-677.
- Oberg E (1996). The ultimate biochemical diagnosis of gastroenteropancreatic tumours. Digestion 57(1): 45-47.
- Ozmen MN, Oguzkurt L, Ahmet B, Akata D, Akhan O (1995). Ultrasonographic diagnosis of intestinal ascariasis. Pediatr. Radiol. 25(1): 5171-5172.
- Palmer PES, Reeder MN (2000). The imaging of tropical diseases vol. 2. Heidelberg, Germany: Springer, Verlag. Pp. 11-39.
- Peck RJ (1990). Ultrasonography of intestinal ascariasis. J. Clin. Ultrasound 18: 741-743.
- Perkindi G, Tenekeci N (1997). Solid-appearing pelvic hydatid cyst: transabdominal and transvaginal sonographic diagnosis. Ultrasound Obstet. Gynecol. 9: 289-291.
- Piessences WF (1997). Parasitic infections. In: Berkow R, Beers MH, Bogin MR (eds). The Merck manual of medical information (Home edition). Whitehouse Station NJ: Merck and Co. Inc. Pp. 895-908.
- Price J, Leung JWC (1988). Ultrasound diagnosis of ascaris lumbricoides in the pancreatic duct: the "four-line" sign. Br. J. Radiol. 61: 411-413.
- Rahman MS, Rahman J, Lysikibwicz A (1982). Obstetric and gynaecological presentation of hydatid disease. Br. J. Obstet. Gynaecol. 89: 665-670.
- Ranzini AC, Hale DC, Sonam V, Phentok L, Adams V (2002). Ultrasonographic diagnosis of pelvic echinococcosis. J. Ultrasound Med. 21: 207-210.
- Reeder MN, Palmer PES (1994). Infections and infestations of the gastrointestinal tract. In: Freeny PC, Stevenson GW (ed). Margulis and Burhene alimentary tract radiology. 5th edition. St. Louis MO: Mosby. Pp. 1475-1542.
- Reeder MN (1998). The radiological and ultrasound evaluation of ascariasis of the Gastrointestinal tract. Semin Roentgenol 33: 57-78.
- Scully RE, Mark EJ, McNeely WF (1994). Case records of Massachusetts General Hospital weekly clinicopathological exercises, cases 26-1994. N. Engl. J. Med. 330: 1887.
- Semeschysky S (1970). Echinococcus discovered during pregnancy. Am. J. Obstet. Gynecol. 107: 477-483.
- Sidhu R, Nada R, Palta A, Mohan H, Suri S (2002). Maxillofacial cysticercosis: uncommon appearance of a common disease. J. Ultrasound Med. 21: 199-202.
- Starer F (1980). The soft tissue. In: Sutton D (ed). A textbook of radiology and imaging. 3rd edition. London: Churchill Livingstone, pp. 1026-1046.
- Statmann B (1991). Songraphischer nachweis desgeschlechtsreifen rinderfinnband wurms. In: Ultrashalldiagnostik 90. Berlin: Springer Verlag P. 109.
- Timosca A, Gavrileta L (1974). Cysticercosis of maxillofacial region. Oral Surg. Oral Med. Oral Pathol. 37: 390-400.
- Tschen EH, Tschen EA, Smith EB (1981). Cutaneous cysticercosis treated with metrifonate. Arch. Dermatol. 117: 507-509.
- Van Ruyseuelt C, Pauls C (1996). Sonography of appendicitis and acute disease of lower abdomen. Acta Gastroenterol. Belg 59: 152-153.
- Van Vliet W, Scheele F, Sibinga-Muloer L, Dekker GA (1995). Echinococcosis of the liver during pregnancy. Int. J. Gynecol. Obstet. 49: 323-324.
- Von Sinner W (1997). Advanced medical imaging and treatment of human cystic echinococcosis. Semin. Roentgenol. 32: 276-290.

Warren K (1984). Schistosomiasis. In: Weatheral DJ, Ledingham JGG, Warrell DA (eds). Oxford textbook of medicine vol. 1. London: Oxford University Press. p. 449.