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Hydatidosis in animals and man in India: An overview

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ABSTRACT

Cystic echinococcosis (CE) popularly referred to as hydatidosis, is an important zoonotic infection of global prevalence. It is the most common bladderworm found in food animals. Its economic impact due to productivity losses and viscera condemnation, not worked out so far in India, must be considerable, as the disease is endemic in India and affects all livestock species. In man, the cysts may lodge in vital organs and cause morbidity. In India, developments have not kept pace with the attention and progress on CE elsewhere. The objective of this review is to provide comprehensive information on various aspects of the problem from an Indian perspective. Particular attention was paid to include advances in our understanding of the molecular biology and data generated on genotype frequency. Significant gaps which merit being addressed on priority, as well as control strategies for implementation, have been spelt out.

Key words: Cystic echinococcosis, Epidemiology, Hydatidosis, Livestock, Zoonosis

Cystic echinococcosis popularly known as and usually referred to as hydatidosis or hydatid disease is caused by the larval stage or bladder worm of the dog tapeworm *Echinococcus granulosus*. It is recognized as one of the world's major zoonotic diseases of increasing public health concern (WHO/OIE 2001, Moro and Schantz 2009). Comparatively harmless as adult tapeworm in dog, and as larval form in the liver or lungs of farm animals, the cystic infection in man may often be a chronic disease with serious complications. Cystic echinococcosis is a cyclozoonosis that requires 2 vertebrate hosts for its life cycle. The adult tapeworm is fairly common in dogs (and other candids) as definitive hosts while various herbivores act as intermediate hosts. Humans can accidentally become intermediate hosts by ingesting the eggs of the tapeworm (Thompson 1995). The disease has cosmopolitan distribution and areas of endemicity cover various countries across all the continents. Endemicity is high in several sheep and cattle rearing countries, where conditions for association with dogs are favourable. The economic losses to livestock industry are attributed to reduced quality and yield of milk, meat or wool, retarded growth, decreased fertility and condemnation of infected organs (Torgerson 2003, Umur and Kaaden 2003). In India, ideal conditions exist for the establishment and propagation of the disease, yet the problem has not received due attention until recently. Of the only two significant reviews on the disease in India, the first (Das *et al.* 2003) was based entirely on pre-2000 literature and the second (Juyal *et al.* 2005) dealt exclusively with veterinary aspects of the problem. With considerable advancement since then on the epidemiology, transmission, immunogenicity, pathogenesis, diagnosis and genotype frequencies, a comprehensive update of information in the Indian context, seems justified.

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Etiology: The genus *Echinococcus* contains very minute tapeworms, which live as adults in the intestines of canine and feline animals. Echinococcosis is a near-cosmopolitan zoonosis caused by adult or larval stages of tapeworms belonging to the genus *Echinococcus*. The genus consists of 4 species, which are presently recognized as *Echinococcus granulosus*, *E. multilocularis*, *E. oligarthrus* and *E. vogeli* (Eckert and Deplazes 2004), besides a new species of *Echinococcus shiquicus* (Xiao *et al*. 2005). On a global basis, *Echinococcus granulosus* is the most important of the 5 species. Till date, 10 distinct strains, sub-species or genotype of *E. granulosus* have been defined on the basis of genetic studies, of which the dominant one is the sheep–dog form or G1 genotype (WHO/ OIE 2001).

Of the 5 taxonomically recognized species of *Echinococcus*, only 2 are of zoonotic importance. While *E. granulosus* is the predominant species in the Asian continent including India, 2 reports of *E. multilocularis* in man (Aikat *et al*. 1978, Khuroo *et al.* 1980) based on autopsy, remain as exceptions. According to Chowdhury (1994), *E. granulosus* has 4 subspecies, which differ from each other not only morphologically but also on the basis of their hosts. Recent evidence has proved genetic variations in different strains/isolates of *E. granulosus* collected from different intermediate hosts. These strains also differ in their host

preference and several of them are not infective to man. Since, strain identification is a complex phenomenon involving several markers, such studies were not conducted in India till date. The hydatid cyst is fluid filled and contains brood capsules in which large number of larvae or protoscolices develop. These are the infective stages which develop mostly in lungs and liver of food animals (Sangaran *et al.* 2011, Singh *et al*. 2012). Hydatid cyst was also reported from unusual sites of neck (Knoch *et al.* 1999), cervicofacial region (Laraqui 1995) and thigh region (Arora *et al*. 2006, Mudasir *et al*. 2011). Depending on the intermediate host involved, only a variable percentage (0-100) of them is fertile. *E. granulosus* may follow either domestic or feral cycle. The former is maintained between dog as the definitive host and any of the livestock species as intermediate host. The feral cycle involves wild canids and wild herbivores. Man is accidental intermediate host for both domestic and feral cycles. Intermediate hosts including man acquire infections by ingestion of food or water contaminated with dog faeces containing the eggs of *E. granulosus.*

Epidemiology: There are important factors like socio-economic status, cultural behavior, tradition, food habits and ecology which determine the high incidence and propagation of infection. In India, unhygienic slaughter of food animals, free access of dogs to slaughter houses/offals, and irrigation of vegetables with contaminated water are additional factors (Traub *et al.* 2005).

Prevalence in animals: Prevalence of *E. granulosus* adult tapeworms in stray dogs in Asom, Meghalaya and Mizoram was reported as 17.02% overall (Deka *et al*. 2008). For detection of echinococcal cysts, postmortem examination of slaughtered animals is the standard practice. Based on some pre-2000 Indian reports, Das *et al.* (2003) tabulated the incidence (%) in cattle (1.74-62.3), buffalo (4.07-48.0), sheep (1.39-50.0), goat (1.5-47.64), pig (0.90-11.2), camel (71.42) and yak (80.0). The figures for camel and yak were based on single reports from Rajasthan and Sikkim, respectively. The average percentage for other livestock species was 29.15 in cattle, 21.23 in buffalo, 12.39 in goat, 11.90 in sheep and 4.08 in pig. No mention was made regarding fertility rates of the cysts. Juyal *et al*. (2005) gave tabulated data from several parts of the country in a wide percentage range, viz 4.0–62.3 in cattle, 8.9–48.0 in buffalo, 2.0–30.0 in sheep, 1.1–21.0 in goat and 1.0–11.2 in pig. Data on cyst fertility was available in only 12 of the 24 reports surveyed; and although highly variable, it tended to be higher in sheep and goat, regardless of geographical region, viz. North (Singh and Dhar 1988), South (Hafeez *et al.* 1994) and in East (Das and Das 1998). In a slaughter house and necropsy-based study of lesions in bovines (Nair *et al*. 2006), hepatic (14.5%), pulmonary (5.0%) and splenic (4.3%) cystic presence was noted. Irrespective of species of host, fertility rate was higher in hepatic cyst than the cyst located anywhere else in the body (Pednekar *et al.* 2009a). Cyst size (average) was the highest in buffalo and lowest in sheep. Summary of some recent reports and some significant ones omitted in earlier reviews is presented here (Table 1). Hydatid cyst with protoscolex have occasionally been recorded in wild herbivores, mainly cervids in India (Rao and Acharjyo 1984, Chakraborty *et al.* 1994, Arora and Chakraborty 2009, Sathasivam *et al.* 2009) suggesting the existence of a feral or sylvatic cycle, completing in wild canids. Seroprevalance of hydatid disease in cattle (Bandyopadhyay and Basu 1996) and in goats (Pal and Singh 1995) were reported earlier.

A survey of 208 cattle slaughtered at Corporation Slaughter House in Bengaluru revealed 53.8% positive cases (Hegde *et al.* 1974). The highest incidence was in lungs (85.9 %) followed by liver (12.5 %) and spleen and heart (0.8 % in each). Of the recovered cysts, 74.17 % were sterile and 25.83 % were fertile.

Molecular epidemiology: Observations on differences in developmental biology and infectivity of *E. granulosus* isolates from different species of intermediate hosts were recorded. These variants/strains in due course led to their identification as genotypes of *E. granulosus*, presently 10 (G_1 to G_{10}) which can be differentiated by molecular methods using mitochondrial DNA sequences (WHO/OIE 2001, Bhattacharya *et al*. 2008 a). In India, larval stages of the parasite were isolated from cattle, buffalo, sheep and goat from slaughter houses of eastern parts of India (Sarma *et al.* 1998, Bhattacharya *et al*. 2000). Bhattacharya *et al*. (2000) found higher positivity (39.28 %) as well as cyst fertility (27.38 %) in buffaloes than in cattle (33.28 % and 9.25%, respectively) but the viability of protoscoleces was more in cysts of bovine origin. Isolates (12) collected later in Kolkata from cattle, buffalo and sheep, were characterized (Bhattacharya *et al*. 2007). While all the isolates could be grouped into *E. granulosus sensu stricto* (s.s.), 2 sheep isolates and 1 buffalo isolate were homologous to G_2 genotype; rest of the isolates were microvariants of G_2 genotype. *Echinococcus* characterization on the basis of phenotypic (Maity *et al*. 2007) and genotypic characters (Bhattacharya *et al.* 2008 b) from the eastern part of India, was also reported. Another report on livestock in West Bengal (Gudewar *et al*. 2009) found isolates from sheep and goat belonging to G_1, those from cattle as G_1 (66.7%) and G_5 (33.3%), and buffalo strains as G_1 (85.7%) and G_5 (14.3%). More recently, Pednekar *et al.* (2009b) concluded that in India the buffalo strain or G_3 genotype was the predominant genotype in all species of livestock, followed by the cattle strain or G_5 genotype and the common sheep strain or G_1 genotype. The ability of the G_3 (buffalo) and G_5 (cattle) genotype of *E. granulosus* to infect and produce fertile hydatid cysts in pigs was also demonstrated. Molecular epidemiology of echinococcosis from herbivore intermediate host species in north India (Singh *et al.* 2012) indicated that 7 (77.7%) of the isolates, viz. 2 each from cattle, pigs and goats and 1 from buffalo were clustered with the Indian buffalo (G_3) strain of *E. granulosus*, while 2 (22.2%) isolates from sheep were clustered with the sheep strain of *E. granulosus*. Currently *E. granulosus* s.s. is considered as the

Table 1. Reports of hydatidosis in livestock in India

References and locality	Species	Total animals examined	% positive	Organs infected with cysts				
				Liver	Lung	Spleen	Kidney (K) heart (H)	Fertile%
Hegde (1974) Bengaluru	Cattle	208	53.8	12.5%	85.9%	0.8%		25.83
Das and Das (1998) Greater Calcutta (W. Bengal)	Cattle	5415	45	1012	1420	4	-	6.3
	Buffalo	4212	48	1105	1095	-	K2	15.3
	Sheep	230	9	15	6	-	-	90.0
	Goat	410	5	12	7	-	K1	91.4
	Pig	105	8	4	4	-	-	80.0
Raman and Chellappa (1998) Chennai	Sheep	40	7.5	1	2	-	-	-
Das and Sree-krishna (1998) Puducherry	Sheep	325	37.84	24.25%	35.83%	2.02%	H12.30 %	>78.0
		680	47.64	26.85%	32.01%	-	H14.75 %	>82.0
Sharma *et al.* (2000) Guwahati	Cattle,	313	13.73	-	-	-	-	6.6
	Buffalo	47	27.6 1.79					5.9
	Pigs	279	2.24					40.0
	Goats	223						60.0
Balamurugan *et al.* (2003) Tamil Nadu	Cattle	-	14.8					
	Buffalo	-	7.3					
	Sheep	-	8.92					
Gaurat and Gatne (2005) Mumbai	Pig	-	5.58					
Rashid *et al.* (2005) Jammu	Sheep	70	42.85					
	Goat	130	46.15					
Khan and Purohit (2006) Mumbai	Buffalo		34.5					
Deka *et al.* (2008) Asom	Cattle	346	16.76					
	Buffalo	46	6.52					
	Goat	616	4.87					
	Pig	465	0.43					
Meghalaya	Cattle	112	21.43					
	Pig	292	0.34					
Sangaran and John (2009) Chennai	Sheep	1141	5.6	29	33	-	-	
	Goat	452	7.1	44	33	-	-	
Pednekar *et al.* (2009 a), Deonar abattoir, Mumbai	Cattle,	824	5.10	1.68	1.71	3.25	-	25.0
	Buffalo	1050	3.81	1.90	1.72	-	-	22.37
	Pig	3888	0.82	2.0	1.69	7.5	K1.0	52.38
	Sheep	16099	0.07	- Average no. of cysts	1.80 Average no. of cysts	1.0 Average no. of cysts	H.3.0	97.14
Borua *et al.* (2010) Guwahati	Cattle	150	16.66	36%	40%	-	-	
	Buffalo	60	19.99	33.3%	50%	-	-	
	Goat	132	6.81	33.3%	55.5%	-	-	
	Pig	130	7.68					
Sangaran and John (2010a) Chennai	Buffalo	-	10.0	29	61	1	-	53
Gupta *et al.* (2011) Agra (Uttar Pradesh)	Buffalo	324	9.87	7	25	-	-	

Echinococcus genotype most frequently circulating among livestock species in Asia while *E. canadensis* and / or *E. artleppi* coexist with *E.granulosus* s.s. in India and Iran (Cardona and Carmena 2013).

Prevalence in man: Although cystic echinococcosis is essentially an infection cycled between dog and livestock and humans are only accidental intermediate hosts, the disease is endemic in many livestock-raising countries including India. There have been surveys and increasing number of case reports from most parts of the country due to availability of improved imaging techniques (Parija 2004). In Bengaluru 46 cases of human hydatidosis were recorded between 1969 and 1972 (Hegde *et al.* 1974). According to a hospital based study in north India (Khurana *et al.* 2007), there was an increase in seropositive cases of cystic echinococcosis (CE) from 10.97% in 1984-1988 to 23.12% in 1999-2003. Despite this, a majority of cases being asymptomatic, only cases coming for surgery are sporadically reported in India. According to Traub *et al.* (2005), in 50 years over 500 cases of hydatid disease

requiring surgery had been reported in Indian medical literature. Another report (Hemachander *et al*. 2008) estimated that the annual incidence of CE per 10^5 persons varied from 1 to 200. Contrary to these, a single hospital based study (Fomda *et al.* 2002) recorded 705 surgically confirmed cases in 17 years.

Clinical manifestations and pathogenesis: A univascular fluid-filled hydatid cyst develops by endogenous growth. The severity depends on the quantum of infection, organ involved, location and size of cyst and resultant mechanical pressure. Histopathological observations on hydatidosis in buffalo liver (Nishant *et al*. 2005), initially revealed cysts composed of a germinal layer surrounded by connective tissue capsule and a linear arrangement of fibroblasts around it. The metacestode growth was slow, increasing 1-5 cm/ year and may take several years to become symptomatic. As such, the disease is rare in the young animals/ children (Jairajpuri *et al*. 2012). The encapsulated cyst gradually merges with the surrounding host tissue without provoking any inflammatory reaction. Rupture of cysts during diagnostic puncture, trauma or surgery, may lead to anaphylactic reaction or growth of secondary cysts.

Disease in animals: Almost all domestic animals and a large number of wild animals may suffer from hydatidosis in India (Chowdhury 1994). Since, the animals have shorter life span than humans, the cysts do not get to grow large enough to cause overt symptoms despite carrying heavy infections, and are revealed only at postmortem examination. However, in slaughtered animals in India, hydatidosis is the commonest infection, average 79.5% (Das *et al*. 2003). In a study in Akola, Maharashtra (Dhote *et al.* 1992), hydatidosis was found the commonest (56.45%) hepatic lesion in 1,133 slaughtered cattle. While fertile cysts showed protoscolices, sterile cysts often turned caseous or calcified. In general, the disease is higher in older animals than young ones. Pulmonary hydatidosis is very common in animals and may cause severe dyspnoea.

Disease in man: In humans, as in herbivorous intermediate hosts, the most commonly affected organs are the liver and the lungs where about 90% of the echinococcal cysts develop (Fomda *et al*. 2002). All other organs are considered as uncommon sites of localization of the cysts which was reported from almost every part of the body (Rao *et al*. 2012). Human CE cases also present clinical manifestation according to the affected organ with immense morbidity (Hemachander *et al*. 2008). It was documented that CE is endemic in the country with highest prevalence in Andhra Pradesh and Tamil Nadu (Nepalia *et al*. 2006). Most primary infections in humans result in a single hydatid cyst; however, 20 to 40% cases are reported to have multiple cysts or multiple organ involvement in a single patient suggesting ingestion of many eggs of *E. granulosus* (Hemachander *et al*. 2008). The highly variable involvement of organs/tissues and clinical presentations of CE was recorded in recently—ranging from the more frequent hepatic (Bhat *et al*. 2002, Rajgopal and Bishwas 2002) and pulmonary forms (Kakrani *et al.* 2000, Beg and Mansoor 2002); to the extra hepato-pulmonary sites, which together make up for about 10% of the development sites for echinococcal cysts. Usually these are spleen and kidneys (3%), heart, bone and brain (1 to 2%) and the muscles (3 to 5%) making the remainder (Mandal and Mandal 2011). Summary of some recent published reports from India is presented in Table 2.

Diagnosis

Dog: Detection of *E. granulosus* in dogs by microscopic examination of faecal material is not confirmatory since *Taenia* and *Echinococcus* eggs are morphologically indistinguishable. Detection of faecal antigens by ELISA (Ahmad and Nizami 1998) had shown promise. Faecal supernatant (copro) antigens were used in detecting antibodies in serum by latex agglutination test in 21.2% of 250 field dogs (Ananda *et al.* 2008). The sensitivity and specificity of the test was 100% and 78.8%, respectively. These antigens were also used in sero diagnosis by counter immunoelectrophoresis (CIEP) in another report (Prathiush *et al.* 2008).

In animal intermediate hosts: As infection with hydatid cyst is asymptomatic, routine PM examination of slaughtered animals is the standard for detecting the presence of echinococcal cysts. However, several conditions may affect the reliability up to the extent of 37% false positive cases (Cardona and Carmena 2013). An *in vitro* method to assess the cell mediated immune response, viz. leukocyte migration inhibition test had some utility in diagnosis of hydatidosis in food animals with an overall positivity of 73.4% in cattle, buffalo and sheep (Vijayasmita *et al.* 1993). Immunological tests like agar gel precipitation (AGP), counter immunoelectrophoresis (CIEP), indirect haemagglutination (IHA), indirect fluorescent antibody (IFA) and bentonite flocculation (BF) were evaluated in sheep (Sekar *et al.* 1989) and CIEP with 92% and 100% sensitivity and specificity, respectively, and gave the best results. Other workers used CIEP in sheep and buffaloes (Raman and Chellappa 1998, Sangaran and John 2010b), ELISA in goats (Pal and Singh 1995) and in buffaloes (Singh and Raina 1996, Sangaran and John 2010b). Muralidhara *et al.* (1996) evaluated IHA, AGP and intradermal tests in cattle. They screened 45 serum samples which had shown hydatid cyst at postmortem and when tested with IHA only 20% gave positive results with a high titre of 80 and lowest titre of 40. Among 29 serum samples of cattle 37.93% gave positive reaction to IHA with highest titre of 160 and lowest of 40. Forty serum samples revealed the presence of hydatid cysts on PM examination that were tested with AGPT and 29% showed precipitation lines indicating positive reaction.

Konapur *et al.* (1999) evaluated AGID and CCIEP in the diagnosis of hydatidosis in cattle and buffaloes and reported the sensitivity and specificity of AGID test. Concentrated crude and partially purified antigens were found to detect 30 and 83.9% infection in cattle and 50 and 84.84% in buffaloes, respectively, whereas sensitivity and specificity of CCIEP test were 90.7 and 88.1% in cattle

Table 2. Recent reports of occurrence of hydatid cysts in various organs and tissues of humans in India

Localization	Size	Number	Detection	Authors
Liver, lungs, spleen and neck	-	-	-	Hegde *et al.* (1974)
Intracranial (case series)	-	Single (1) Multiple (2)	CT, MRI	Gupta *et al.* (1999)
Ovary (bilateral)	-			Konar *et al.* (2001)
Breast (lump)	-			Das and Choudhary (2002)
Various organs including kidney, ovary, brain and pancreas	-	Single/Multiple	Casoni's i/d and ELISA confirmed by surgery	Fomda *et al.* (2002)
Gall bladder (concomitant with liver cyst)	-	Single		Raza *et al.* (2003)
Broad ligament	-	Single		Arora *et al.* (2005)
Spinal cord (case series)	-	Multiple	CT, MRI	Prabhakar *et al.* (2005)
Muscle	-	Single	US	Arora *et al.* (2006)
Mediastinal associated with pneumothorax	-	Single (Multiple after rupture)	Casoni's i/d and ELISA confirmed by surgery	Shameem *et al.* (2006)
Disseminated abdominal			CT	Yadav *et al.* (2007)
Peritoneum (Disseminated primary)	12cm × 10cm	Two	USG & CECT	Acharya and Gupta (2009)
Spleen, kidney, peritoneal cavity	4cm × 3cm	Multiple	Laprotomy	Shukla *et al.* (2009)
Intracranial	Large	Single	CT	Kamath *et al.* (2009)
Space in between right pelvis and right lumbar	17.5cm×12.6cm	Single	US	Roychowdhury *et al.* (2010)
Multi-organ	-	Multiple	CT, US	Mishra *et al.* (2010)
Pulmonary with massive haemoptysis	4cm × 4 cm	Single	CECT	Bhakri *et al.* (2011)
Gall bladder	-	Single	US	Mushtaque *et al.* (2011)
Pelvis	10.5 cm × 8.8 cm	Multiple	CT	Gorad *et al.* (2011)
Seminal vesicle	7cm × 8cm	Single	US, MRI	Mushtaque *et al.* (2012)
Pleuro - pulmonary	3cm × 2cm 2.5cm × 2cm	Two	CT	Vaideeswar *et al.* (2012)
Spleen	20 × 22 cm	single	CT	Pukar and Pukar (2013)
Rectus abdominis muscle		Single	US/CT scan	Nag *et al.* (2011)
Caecum (intraluminal)	6–8 cm	Single	Laproscopy	Pawar *et al.* (2013)
Tail of pancreas	-	Single	US/CT scan	Yarlagadda *et al.* (2013)

and 69.2 and 87.8% in buffaloes, respectively.

Diagnosis of hydatidosis in cattle and buffaloes by avidin-biotin ELISA resulted in 83.7% and 96.1% sensitivity and 77.1 % and 77.23% specificity in cattle and buffaloes, respectively, as per Konapur *et al.* (1999). Antigen detection ELISA and Dot- ELISA were found reliable and with better sensitivity and specificity for diagnosis of hydatidosis in goats (Sangaran and John 2012). Hydatid cyst fluid (HF) was the most widely used antigen for serological diagnosis. Protein content of HF of hepatic cysts and fertile cysts was higher than pulmonary cysts and sterile cysts regardless of host species (Pednekar *et al* 2009a). Purification of antigen from hydatid cyst of buffalo origin by affinity chromatography and characterization by SDS-PAGE showed 2 polypeptides of 48 and 66 kDa (Bandyopadhyay and Singh 2000). Purified hydatid cyst fluid antigen might proved to be a promising tool for the diagnosis of hydatid disease (Saha *et al*. 2012). Recent molecular techniques have revolutionized parasitic identification and diagnostic procedures. Polymerase chain reaction (PCR) method to randomly amplify polymorphic DNA (RAPD) was used to differentiate bubaline and bovine strains of *E. granulosus* and buffalo host DNA (Reddy *et al*. 1998). Jeyathilakan *et al*. (2011) reported the development and evaluation of an *in vitro* flow through technique for diagnosis of CE in sheep using hydatid specific non-cross reactive 8-kDa protein. The test was shown to have high sensitivity and specificity closely correlated with enzyme linked immuno electro transfer blot.

In human intermediate host: Intradermal (Casoni's) test based on immediate hypersensitivity reaction following inoculation of hydatid antigen, was earlier in vogue. Of immunological tests, many have been tried for detection of antibodies in serum or antigens in serum, urine or other body fluids with variable sensitivity and specificity (Parija and Devi 1999). Detection of antigen was indicative of active infection and is of prognostic value (Ravinder and Parija 1997). Investigations suggested that the demonstration of circulating antigen by employing monospecific antibodies to affinity purified 8kDa antigen was more efficient (Kanwar *et al.* 1994). Counter current immunoelectrophoresis was tried to detect urinary hydatid

antigen with 47.5% sensitivity and 95.9% specificity (Parija *et al.* 1997). In a hospital based study 1984-2001 in Kashmir, serum samples from 580 patients clinically suspected for hydatid disease were subjected to Casoni's i/d test and ELISA using human hydatid cyst fluid antigen (Fomda *et al*. 2002). A total of 1,308 (22.5%) were positive by Casoni's and 2,604 (44.83%) by ELISA. The cysts were confirmed by surgery in 705 (12.13%) cases. In surgically confirmed cases, Casoni's and ELISA were positive in 424 (60.14%) and 705 (100%) cases indicating the maximum sensitivity of ELISA. Parija (2004) suggested hydatid fluid aspirated from cyst as suitable material to confirm hydatid etiology by simple microscopy of the wet mount or alternatively through detection of specific antigen by ELISA, CIEP or co-agglutination (Ravinder and Parija 1997). Currently, the diagnosis of CE in man depends upon anamnesis combined with laboratory procedures, mainly imaging and immunological. Imaging methods such as ultrasonography (US), computerized tomography (CT) and magnetic resonance imaging (MRI), are the most commonly used techniques for localization of cysts in various organs / tissues prior to surgery. Contrast enhanced (CE) CT scan of thorax is the modality for pulmonary hydatid cyst and the "air bubble" is a recently recognized radiological sign (Das and Das 2011). Chaya and Parija (2013) found enzyme immune transfer blot highly specific test for detection of hydatid antibodies in serum.

Immunity: In partially purified buffalo hydatid cyst fluid, immuno-electrophoresis showed 2 proteins of parasitic origin and protoscolices antigen showed the presence of 3 proteins of parasite origin (Bandyopadhyay and Singh 1997). These workers also demonstrated identical pattern of response against cyst fluid and affinity purified cyst fluid antigen (Bandyopadhyay and Singh 2000), where the antibody titre peaked at 12 weeks post infection (pi). Kinetics of antibody response against different antigen fractions of protoscolieces was studied by ELISA at various intervals pi (Samanta *et al*. 2008), against soluble proteins, the response was significant throughout from 15 to 180 days pi with a peak on day 120 pi. With excretory secretory antigen, significant response from day 15 to 135 and peak at day 120 pi was observed. It was postulated that the trend of anti-protoscolieces IgG level may be coinciding with cyst development in the infected host. The study (Samanta *et al.* 2008) also indicated that the initial response against cystic infection was of humoral nature followed by cellular response.

Treatment and control: For dogs, arecoline or praziquantel treatment over regular intervals (6-8 weeks) is effective. In humans, chemotherapy is done with benzimidazole series of compounds and per cutaneous aspiration injection and re-aspiration (PAIR). Combined chemotherapy with albendazole and praziquantel was more effective than either of these agents alone, and was used successfully in the management of CE patients. Chemotherapy is indicated in operable cases and when administered prior to surgery, reduces the size and number of visible protoscoleces. Pan et al. (2008) reported stressor (drug)- induced changes to the protoscoleces of E. granulosus of Indian buffalo origin. In this regard, albendazole alone or in combination with any of the other agents, administered percutaneously, had been found more effective pre-surgery intervention (Mandal and Mandal 2011).

Control options include control of stray dog population, treatment of dogs with cestodicidal drugs (praziquantel), hygienic slaughter, stringent meat inspection and disposal of infected organs, as well as health education of public. As recombinant antigen vaccine has shown promise in reduction of hydatid disease in vaccinated animals (Lightowlers *et al*. 1999, Heath *et al.* 2012) such control tools may form part of an integrated control programme in the foreseeable future.

The foregone while highlighting India-specific information on the subject from both veterinary and medical perspectives has likely provided clues to some areas of deficiency. Levels of infection in domestic animals may more closely indicated the potential threat to public health. There is a need to generate more epidemiological data which should include aspects like organ localization, size and fertility status of the hydatid cysts in the food animal intermediate hosts. The recording and reporting system for hydatidosis should be evolved and standardized on a national basis. There is also need to formulate data on economic losses on account of hydatidosis in production animals. In view of the new knowledge on the zoonotic potential of the camel and cervid stains of *Echinococcus granulosus*, these animals should also be included in the ambit of future surveys. Genotyping of isolates from human infections of CE should be undertaken. Since, rural population has greater animal contact and lacks adequate sanitation, disease surveillance should be intensified with greater involvement of public health personnel.

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