Epidemiology of *Echinococcus granulosus* in Arbil province, northern Iraq, 1990–1998

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Abstract

During the period 1990–1998, 99 cases of human cystic hydatidosis (12.4 cases per year) were surgically treated at the two main hospitals in Arbil province, northern Iraq, and from this the human occurence for the province was estimated to be 2 per 100,000 inhabitants. In the same area, 1270 sheep, 550 goats and 320 cattle were examined at slaughter for hydatid cysts and prevalence rates were found to be 15.0%, 6.2% and 10.9%, respectively. A decreasing tendency in livestock prevalences was found towards the end of the study period. As in humans, most of the hydatid cysts in livestock were located in the liver. Fertility of sheep cysts, i.e. those containing protoscoleces, was found to be significantly higher (64%) than that of goats (35.7%) and cattle (29.8%). The percentage of fertile cysts containing viable protoscoleces varied between 63 and 82% in the livers and between 72 and 79% in the lungs of the different animal species. A total of 97 stray dogs were examined post-mortem in the years 1991, 1992 and 1998, and *Echinococcus granulosus* worms were found in the intestines of 48 dogs (49.5%). High worm burdens (>1000) were observed in 37% of the dogs, medium worm burdens (200–1000) in 41%, and low worm burdens (<200) in 22%. In 1998, the prevalence of canine echinococcosis (24.3%) was found to be significantly lower than in 1991 (70.4%) and 1992 (60.6%). The prevalence of human hydatidosis did not differ significantly over the years, but the study confirmed that hydatidosis is endemic in northern Iraq, and that housewives, labourers and farmers appear to be at the greatest risk of infection.

Introduction

Cystic hydatidosis or cystic echinococcosis, a cyclozoonotic disease caused by *Echinococcus granulosus*, is highly endemic in Iraq (Babero *et al*., 1963; Tawfiq, 1987; Molan *et al*., 1990; Molan, 1993) and considered to be one of the country's most important parasitic diseases with significant socio-economic effects, since both humans and their livestock are infected. In Iraq, losses in animal production and expenses for treatment of human hydatidosis are estimated to be millions of US dollars (USD).The present study was undertaken to investigate the occurence of *E. granulosus* in humans, livestock, and dogs in Arbil province, northern Iraq during the period 1990–1998 and to evaluate any changes which may have occurred in relation to the civil war in 1995. A feature of the study was the determination of the viability of protoscoleces from hydatid cysts of livestock. Echinococcosis/hydatidosis has been detected in all parts of Iraq (Niazi,

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Table 1. The incidence of hydatidosis in patients admitted to the Arbil hospitals during 1990–1998.

	No. surgical patients			No. infected patients		
Year*	Male	Female	Both	Male (%)	Female (%)	Total (%)
1990	255	283	538	3 (1.2)	10 (3.5)	13 (2.4)
1991	155	206	361	1 (0.6)	4 (1.9)	5 (1.3)
1992	246	275	521	3 (1.2)	4 (1.5)	7 (1.3)
1993	402	359	761	7 (1.7)	9 (2.5)	16 (2.1)
1994	310	297	607	7 (2.3)	14 (4.7)	21 (3.5)
1996	314	295	609	5 (1.6)	6 (2.0)	11 (1.8)
1997	265	246	511	5 (1.9)	5 (2.0)	10 (2.0)
1998	510	553	1063	6 (1.2)	10 (1.8)	16 (1.5)
Total	2457	2514	4971	37 (1.5)	62 (2.5)	99 (2.0)

*1995 not included because of civilian war.

1974; Salih *et al*., 1983; Al-Mukhtar, 1989; Khalili *et al*., 1989; Molan *et al*., 1990), but occurs most frequently in areas where transmission between sheep and dog takes place. The prevalence of the disease in Iraq has previously been described in humans (Senekji & Beatti, 1940; Babero *et al*., 1963; Salih *et al*., 1983; Molan *et al*., 1990), ruminants (Imari, 1962; Babero *et al*., 1963; Al-Abbasy *et al*.,1980; Al-Saqur & Al-Gorani, 1987; Molan & Saeed, 1990), and dogs (Senekji & Beatti, 1940; Kelly & Izzi, 1959; Abul-Eis, 1983; Tarish *et al*., 1986; Molan & Saida, 1989; Molan & Baban, 1992).

Materials and methods

The records of patients admitted to the two main hospitals in Arbil (Rizgary Hospital and Republic Hospital) with surgically and histopathologically proven hydatid cysts were studied in the period between 1990 and 1998. In addition to the clinical picture of the patients, information on age, sex, occupation, and residency was analysed.

A total of 1270 sheep, 550 goats, and 320 cattle slaughtered at Arbil abattoir (1990–1995 and 1998) were examined for hydatid cysts. Cysts were recorded according to organ distribution and their fertility was determined by the presence of brood capsules, daughter cysts, and protoscoleces in the cyst fluid. In addition, protoscoleces of 151 of fertile cysts were tested for viability by detection of flame cell movements and the exclusion of 0.1% aqueous eosin. Ninety-seven stray dogs, shot at different localities in Arbil city in the years 1991, 1992 and 1998, were examined for infection. At necropsy, each of their intestines were incised longitudinally and examined for adult *E. granulosus*. Worms were stored in 70% ethanol and later stained with aceto-carmine stain, identified and counted.

All statistical analyses were performed using Fisher's exact-test (GraphPad Prism version 2.01, 1996).

Results

During the study period, 1990–1998, the total surgical admissions to the two main hospitals in Arbil province numbered 4971. Of these, 99 (2.0%) were diagnosed surgically and proved positive for hydatid cysts by histopathology. The average number of hydatidosis cases, 12.4 cases per annum, indicates a surgical case rate of approximately 2 per 100,000 inhabitants in Arbil province. The fluctuation of occurrence and intensity of infection during the nine year period was not significant (table 1). The occurrence among female patients (2.5%) was significantly higher than that in male patients (1.5%) ($P = 0.02$) (table 1). Among female patients, housewives were most frequently infected (59.7%) whereas labourers were most frequently infected among male patients (43.2%) (table 2). For both sexes, significantly higher occurrences were found in the 31–40 years age group ($P = 0.006$) (table 3). The distribution of hydatid cysts in various anatomical sites of the surgical patients is shown in table 4. The liver was the organ most frequently infected with 61.6% of cases having hepatic cysts ($P < 0.0001$). The right lung (16 cases) was more often found infected than the left (seven cases), but this tendency was not significant ($P = 0.08$). Single organ involvement was observed in 95 (96.0%) cases while 4 (4.0%) cases had multiple organ involvement.

During six years of the study period, the prevalence of hydatid cysts in 1270 sheep, 550 goats and 320 cattle from the Arbil abattoir was 15%, 6.2% and 10.9%, respectively (table 5). For all livestock species, the liver was the main predilection site (table 6). The fertility of cysts was 64.0%, 35.7% and 29.8% in sheep, goats and cattle (table 7), respectively, and in the respective animal species the viability of the protoscoleces was 82%, 71% and 63% for those from liver cysts, and 75%, 72% and 79% from lung

Table 2. Occupations of patients with hydatidosis admitted to the Arbil hospitals during 1990–1998.

	No. of cases (%)		
Occupation	Male	Female	Total
Housewives	–	37 (59.7)	37
Labourers	16 (43.2)	5 (8.1)	21
Farmers	7 (18.9)	12 (19.4)	19
Unemployed	5 (13.5)	4 (6.5)	9
Students	4 (10.8)	2 (3.2)	6
Teachers	3 (8.1)	2 (3.2)	5
Shopkeepers	2 (5.4)	–	2
Total	37 (100)	62 (100)	99

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Table 3. Distribution of sex and age of 99 hydatid patients admitted to the Arbil hospitals during 1990–1998.

	No. surgical patients			No. infected (%)		
Age group	Male	Female	Total	Male	Female	Both
1–10	273	254	527	0	0	0
11–20	348	314	662	6 (1.7)	4 (1.3)	10 (1.5)
21–30	461	372	833	7 (1.5)	14 (3.8)	21 (2.5)
31–40	398	470	868	11 (2.8)	19 (4.0)	30 (3.5)
41–50	306	404	710	8 (2.6)	16 (4.0)	24 (3.4)
51–60	312	383	695	3 (1.0)	7 (1.8)	10 (1.4)
61–70	359	317	676	2 (0.6)	2 (0.6)	4 (0.6)

Table 4. Predilection sites of hydatid cysts in male and female patients admitted to Arbil hospitals 1990–1998.

	No. infected (%)		
Organs	Male	Female	Total no.
Liver	25 (25.3)	36 (36.4)	61 (61.6)
Right lung	7 (7.1)	9 (9.1)	16 (16.2)
Left lung	3 (3.0)	4 (4.0)	7 (7.1)
Peritoneum	1 (1.0)	2 (2.0)	3 (3.0)
Kidney	1 (1.0)	2 (2.0)	3 (3.0)
Spleen	0	2 (2.0)	2 (2.0)
Liver and lungs*	0	2 (2.0)	2 (2.0)
Both lungs	0	1 (1.0)	1 (1.0)
Liver and spleen*	0	1 (1.0)	1 (1.0)
Pancreas	0	1 (1.0)	1 (1.0)
Liver, lung and spleen*	0	1 (1.0)	1 (1.0)
Eyes	0	1 (1.0)	1 (1.0)

*Multiple organ involvement.

cysts. The mean number of cysts in the viscera of infected sheep, goats and cattle was 6.2, 3.5 and 6.1, respectively.

Of 97 dogs examined in Arbil city during 1991, 1992 and 1998, 48 (49.5%) were found to be infected with *E. granulosus*. The prevalence in both 1991 (70.4%) and 1992 (60.6%) was significantly higher than that in 1998 (24.3%) ($P=0.02$) (table 5). High worm burdens (>1000) were found in 37% of the dogs, medium worm burdens (200–1000) in 41%, and low worm burdens (<200) in 22%.

An estimate of the costs and losses from the disease was based on reports from hospitals (personal communication with doctors) and government ministries (Anon., 1998). From this, the personal income in the northern region of Iraq was estimated to be 25 USD per month in 1998, and the economic losses related to the 99 human infections treated in Arbil province during the period 1990–1998 were estimated to be 47,520 USD: diagnosis (990 USD), hospitalization for 10 days (19,800 USD),

Table 5. The slaughterhouse prevalence of hydatid cysts in livestock and *Echinococcus granulosus* in dogs in Arbil province, 1990–1998.

	Sheep		Goats		Cattle		Dogs	
Year	Ex.	Inf. (%)	Ex.	Inf. (%)	Ex.	Inf. (%)	Ex.	Inf. (%)
1990	65	10 (15.4)	38	2 (5.3)	25	2 (8.0)	–	–
1991	155	21 (13.5)	107	6 (5.6)	31	3 (9.7)	27	19 (70.4)
1992	137	11 (8.0)	150	9 (6.0)	34	3 (8.8)	33	20 (60.6)
1994	210	46 (21.9)	33	4 (12.1)	46	8 (17.4)	–	–
1995	514	90 (17.5)	71	7 (9.8)	140	16 (11.4)	–	–
1998	189	13 (6.9)	151	6 (4.0)	44	3 (6.8)	37	9 (24.3)
Total	1270	191 (15)	550	34 (6.2)	320	35 (10.9)	97	48 (49.5)

Ex., number of examined animals; Inf., number of infected animals.

Table 6. Predilection sites of hydatid cysts in sheep, goats and cattle.

	Infected animals			% of animals with hydatid cysts in			
Host	Infected	No. of cysts	Mean cyst per animal	Liver	Lungs	Liver and lungs	Spleen
Sheep	191	656	6.2	60.7	15.2	23.6	0.5
Goats	34	102	3.5	52.9	20.6	26.5	0
Cattle	35	210	6.1	45.7	28.6	25.7	0

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Table 7. Fertility of cysts and viability of protoscoleces in sheep, goats and cattle.

	Fertility of cysts		Viability of protoscoleces (PS)			
			Liver		Lung	
Host	Examined cysts	Fertile cysts (%)	Examined cysts	Viable PS (%)	Examined cysts	Viable PS (%)
Sheep	656	419 (64.0)	49	40 (82)	37	28 (76)
Goats	102	36 (35.3)	21	15 (71)	14	10 (71)
Cattle	210	63 (30.0)	19	12 (63)	11	9 (82)

surgical costs (14,850 USD), and loss of production due to absence from work for 50 days (11,880 USD). The cost related to condemnation of livestock viscera was estimated to be 61,797 USD per year in Arbil city alone based on the daily slaughtering of 300 sheep, 200 goats and 100 cattle and values of 2 USD for each liver or lungs of sheep or goats and 5 USD for those of cattle.

Discussion

Cystic echinococcosis continues to be a significant public health and economic problem in Iraq. Previous assessments have reported variable indices of human morbidity due to hydatid disease with the surgical case rate ranging between 1 and 20 patients per 100,000 inhabitants nationwide (Hassoun & Salihi, 1973; Niazi, 1974; Al-Jeboori, 1976; Tawfiq, 1987; Molan *et al*., 1990; Molan, 1993). Results of the current study thus indicated that the prevalence of hydatidosis is less in Arbil province (2 per 100,000) than in other parts of the country (Imari, 1962; Niazi, 1974; Tawfiq, 1987; Khalili *et al*., 1989), though it is possible that this prevalence is underestimated because patients may have been diagnosed and treated in Mosul or Baghdad where better hospital facilities are available (Kamaran Aldabagh, personal communication). Also, it appears from data recorded in other provinces of Iraq, e.g. in Ninevah (northern Iraq) (Mahmoud, 1980) and Basrah (southern Iraq) (Benyan & Mahdi, 1987), that the incidence of hydatidosis in some rural areas may be double that of urban areas.

The significantly higher prevalence of hydatidosis found among female patients may be due to epidemiological factors related to cultural and occupational risk, hence the higher rate of infection observed among housewives who may have close contact with infection sources, such as soil or vegetables contaminated with eggs of *E. granulosus* from dog faeces. Consequently, education efforts to prevent transmission should be directed at this group. Wilson (1950) explained that the high incidence of hydatidosis among Arab women is due to their domesticity, resulting in greater risk of infection. The finding that maximum prevalence is found among patients in the fourth decade of age is supported by several previous studies (Hassoun & Salihi, 1973; Amir-Jahed *et al*., 1975; Tawfiq, 1987), though others have found high incidences in younger age groups (Al-Jeboori, 1976; Molan & Baban, 1989; Molan *et al*., 1990). Children are considered to be more exposed to infection from playing in the soil and having close contact with dogs, and since the clinical signs of hydatidosis may take 10–15 years to develop, their infections may not be detected until much later in life.

The prevalence of hydatid cysts in domestic animals slaughtered at Arbil abattoir is higher than that reported from the Baghdad area by Al-Abbassy *et al*. (1980) (sheep (5.9%), goats (5.4%), and cattle (4.9%)) and Wajdi & Nassir (1983) (sheep (4.5%) and cattle (5.0%)). This may be attributed to control of the stray dog population in Baghdad, whereas no such campaigns have been conducted in other parts of Iraq. However, our results from Arbil were much lower than those reported by Al-Saqur & Al-Gorani (1987) from the Basrah abattoir where 44% of the sheep were infected. Preliminary studies at Arbil abattoir were conducted earlier by Molan & Saeed (1988a) who found 23.4% of sheep infected, by Molan & Saeed (1988b) who found 27.4% of goats and 22.3% of cattle infected, and by Molan & Saeed (1990) who found 19.0% of sheep, 5.9% of goats and 13.6% of cattle infected. The differences between these studies and the present study, all conducted at Arbil abattoir, may be related to the fact that previously animals came from many different areas of Iraq whereas animals slaughtered during the past few years have only come from northern Iraq. Thus, the prevalence rate may indeed reflect the regional origin of the animals. In livestock, the prevalence could have been affected by changes in animal trading between the northern free zone and the Iraqi regime control area. In the past few years, most of the slaughtered animals at Arbil abattoir have been brought from the mountainous areas of the north (Samir Khoshnaw, personal communication). The prevalence of hydatidosis, hydatid cyst fertility, and percentage of viable protoscoleces were all found to be higher in sheep compared with goats and cattle, indicating that sheep serve as the principal intermediate host of the parasite in northern Iraq and thus serve as the most likely source of canine infection. Comparable high prevalences and fertility of sheep cysts have been found by Imari (1954), Al-Abbassy *et al*. (1980), Benyan & Mahdi (1987), Molan & Saeed (1990) and Himonas *et al*. (1994). However, Al-Yaman *et al*. (1985) found both higher prevalences and cyst fertility in cattle and camels than in sheep. The low prevalences in goats and cattle may be due to their grazing habits and association with dogs, both of which differ from that of sheep.

The observation that the liver is the predilection site in both livestock and humans is in accordance with other studies (Al-Sakkal, 1982; Salih *et al*., 1983; Molan & Baban, 1989), and may be explained by the liver serving as a primary barrier in the body after the penetration of the intestinal wall.

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The high prevalence of *E. granulosus* in the stray dogs of Arbil city is most likely to be caused by their access to waste from abattoirs. These dogs, which also roam freely around houses, shops, gardens and pasture land, have ideal conditions for transmitting the parasite to humans and livestock. The canine prevalences recorded in the present study in the years 1991 (70.4%) and 1992 (60.6%) is comparable with previous observations from Arbil in 1989 (79.1%) (Molan & Saida, 1989) the central province of Diala (38%) and the southern province of Theqar (56%) (Molan & Baban, 1992), but considerably higher than the prevalences in dogs from Baghdad, e.g. Tarish *et al*. (1986) 31.7% and Al-Tae *et al*. (1988) 20%. Interestingly, the prevalence in Arbil decreased in 1998 (24.3%) to about the same level as in Baghdad. A likely reason for this decrease may have been the introduction of mandatory offal control at the Arbil abattoir in 1996. Previously, the slaughter offal were thrown outside the abattoir providing easy access for stray dogs.

The endemic nature of hydatidosis/echinococcosis in humans, livestock, and dogs in Arbil and other Iraqi provinces is presumably due to the favourable conditions for the typical sheep–dog cycle. Thus, where human prevalence is high, the sheep is the major intermediate host and *E. granulosus* is prevalent in dogs (Tarish *et al*., 1986; Al-Tae *et al*., 1988; Molan & Saida, 1989; Molan & Baban, 1992).

It has been speculated that the prevalence of hydatidosis in humans and livestock in Arbil province may have been significantly affected by the developmental setbacks following the Iraq–Iran War, the Gulf War, restrictions placed on the northern part of the country by the Iraqi regime, and economic and political sanctions instituted by the United Nations. The destabilization caused by these events resulted for several years in lowered hygienic standards, altered animal husbandry practices, suboptimal slaughterhouse manangement, and increased unauthorized home-slaughtering of livestock. The changes in occurrence of human hydatidosis may take many years to become evident due to the long time delay between infection and diagnosis/disease manifestation and may in addition be 'masked' by the referral of surgical patients to other regions. On the other hand, the prevalence of the parasite in livestock and dogs can be assessed more rapidly. Our observations on human occurrence and animal prevalence do not indicate that enhanced transmission of *E. granulosus* in Arbil province due to these war-related events has occurred.

The significant decrease in canine echinococcosis during the study period suggests that proper control of condemned offal at slaughterhouses can be a very effective way of preventing the infection in dogs. This measure should be incorporated with others based on ethnological, epidemiological and socioeconomic information in developing an appropriate and effective prevention and control programme for echinococcosis/hydatidosis in Arbil province.

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