Original Research

Prevalence and Histopathological Studies on Porcine Cysticercosis in Mumbai Region Based on Abattoir Study

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Abstract

In the present study prevalence of Cysticercus cellulosae was studied in 9592 pigs slaughtered at Mumbai abattoir based on strict inspection of pork. Total prevalence of Cysticercus cellulosae was found to be 1.26%. Cyst were found predominantly in shoulder muscles (100%) followed by that in neck (80.99%), masseter (68.03%), thigh (49.58%), tongue (12.39%), diaphragm (10.74%) and cardiac muscles (4.95%), thus validating the current method of incising shoulder muscle during meat inspection for detection of cysticerci in pork, adopted in Mumbai abattoir. The cysts were not encountered in the visceral organs. The intensity of Cysticercus cellulosae cysts, as expressed by number of cysts per unit area, was found to be mild in 50.41%, moderate in 39.67% and heavy in 9.91%. Prevalence of porcine cysticercosis was significantly higher in monsoon as compared to the other two seasons; in female pigs as compared to male pigs and in adult pigs as compared to young ones. Peanut sized milky white colored Cysticercus cellulosae cysts in the skeletal muscles provoked mild inflammatory reaction.

Key words: *Cysticercus cellulosae*, Porcine, Prevalence, Slaughtered

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Introduction

Among the different helminths of pigs, *Cysticercus cellulosae* is considered to be the most economically and zoonotically significant helminthic parasite that settles in musculature and viscera. It is the larval stage (metacestode) of *Taenia solium*, a tapeworm that resides in small intestine of man who acquires the infection through consumption of uncooked or partially cooked pork containing these cysts. Occasionally

humans are also infected with cysts of *C. cellulosae* by consuming eggs of *T. solium* through contamination of food (uncleaned green vegetables) and water. In man, the cysts are invariably located in central nervous system (brain) thus giving rise to neurocysticercosis, a serious condition associated with symptoms of neurological disorders such as epilepsy/seizures. It is classified as Office International Epizootics listed disease and is one of the most important zoonotic diseases in the world. Approximately 50 million people are infected with the parasite and some 50,000 die of cysticercosis annually (Sarti *et al.*, 2000 and Willingham and Schantz, 2004). Although population based epidemiological data on *T. solium* taeniosis and human cysticercosis are lacking in India, the fact that it is of a major health concern is nonetheless evident from large number of neurocysticercosis patients managed in the hospitals in virtually all states of India.

For prevention of public health hazard, inspection of pork for presence of *C. cellulosae* is the key and infected carcasses have to be condemned completely or partially depending on intensity and distribution of the cysts, leading to a great economic loss. Although estimates of economic loss associated with swine cysticercosis have been reported in bits and pieces by few workers in India (D'Souza and Dhanalakshmi, 2005), the same has not been projected on national scale. Nevertheless, it must be tremendous owing to ubiquitous distribution of the metacestodes in the country.

In order to avoid the aforementioned consequences, it is imperative that coordinated efforts be made by veterinary and medical fraternities along with local governing authorities to minimize prevalence of porcine cysticercosis and human taeniosis. This can be achieved by designing strategic but feasible control programs. As a prerequisite to this, it is necessary to conduct epidemiological studies to find out endemecity of porcine cysticercosis, in different parts of India. Hence, the present study was designed to conduct a broad survey based on meat inspection in an abattoir to ascertain current status of porcine cysticercosis.

Materials and Methods

Survey of Porcine Cysticercosis

The study based on strict inspection of pork was conducted for an entire year at Deonar abattoir Mumbai during which carcasses of 9592 pigs were examined systematically for presence of metacestode in the meat as well as visceral organs. The pigs slaughtered at Deonar abattoir during the period came from different districts of Maharashtra and also from the border districts of Gujarat state. The pigs of either sex were belonging to indigenous or crossbred categories. The age of the pigs brought to the abattoir was determined by interrogating the owners/licensee. The meat was incised at few pre-decided places to detect the bladder worms embedded in the musculature. For detection of pork measles skeletal, heart, tongue, thigh, diaphragm, masseter and neck muscles were incised and intensity at each location was recorded by counting

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the number of cysts under the glass plate of two square inch and it was expressed as number of cysts per two square inch unit area.

Collection of Material

The carcass having generalised measly condition or part of it showing pork measles was separated and the meat was incised at several places. The intact cysts were bluntly dissected out from the musculature and placed in normal saline in a glass container which labelled appropriately giving all the relevant details of the samples. Few heavily infected meat pieces were also collected in 10% formalin for histopathological analysis. Collected material transported to the laboratory in ice in a thermacol box.

Parasitological Processing of Material in Laboratory

The cysticerci brought to the laboratory were washed twice with fresh normal saline. Some of the representative samples dissected and examined under the low power objective of compound microscope revealed armed scolex with rostellar spines having blade, handle and guard followed by distinct neck (Fig.1 & 2). Owing to location in the host, gross appearance morphology and biometry, the parasites were identified as *Cysticercus cellulosae*, a metacestode of *Taenia solium* that resides in small intestines of man (Soulsby, 1982).

Fig.1: Gross appearance of *C. cellulosae*

Fig. 2: Scolex of *C. cellulosae* showing rostellar spines

Statistical Analysis

The data generated during the study were subjected to chi-square test for epidemiological findings as per the method described by Snedecor and Cochran (1968).

Results and Discussion

Survey of Bladder Worms in Pigs

The survey based on strict inspection of pork of 9592 pigs was conducted for a period of one year during which 121 (1.26%) pigs were found to be infected with pork measles *Cysticercus cellulosae*. The overall prevalence rate of 1.26 % recorded in the current study is considered to be distinctly low as compared to

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that reported by Alwar (1958), Deka *et al.* (1985), Pathak and Gaur (1989) and Borkataki *et al.* (2011) in Madras (10 %), Guwahati (20.8 %), Uttar Pradesh (9.3) and Assam (9.5), respectively. Prevalence of porcine cysticercosis less than 2 % which is tallying with the current status of the disease in pigs slaughtered at Mumbai was also recorded by Mundhe (1999), Mandakhalikar *et al.* (2009) and Bhadrige (2010) at 1.79%, 0.89% and 0.57 %, respectively. Similar trend of low prevalence was also recorded by Avapal *et al.* (2003) at Ludhiana (1.75). The variation in the prevalence rate of *Cysticercus cellulosae* noted in different parts of India might be due to the several factors such as climatic conditions which decide longevity of *Taenia solium* eggs in the soil; socio-economic status of the populations in relation to the availability of well-constructed latrines and close sewage system denying the free access to pigs scavenging for human night soil; intensive or extensive management of pig farming ; literacy rate and health awareness among the population and also intensity of meat inspection in the slaughter houses.

In Maharashtra, periodic surveys to note prevalence of *Cysticercus cellulosae* have been conducted since 1966 and comparison of the percent prevalence reported previously with the present study indicates decreasing trend of occurrence of porcine cysticercosis (Shastri, 1966; Kulkarni, 1984; Shinde, 1991; Mundhe, 1999; Gaurat, 2002; Mandakhalikar *et al.*, 2009 and Bhadrige, 2010) in the last two decades. This is obviously due to improvement in the socio-economic conditions of human population and increased level of awareness pertaining to health education advocating thorough cooking of meat and use of latrines. Porcine cysticercosis accounts for economic losses which are substantial for the livestock owner which invariably belong to economically backward section of the society. D'Souza and Hafeez (1998) estimated statistically significant economic losses to the tune of Rs. 2, 62,662.00 owing to condemnation of carcass and other expenditures associated with inspection and processing of meat. In the slaughter house where the present survey was conducted, the carcass was condemned if found harbouring cysticerci in shoulder muscles of both sides. Likewise, during the period of study, 121 carcasses were rejected for human consumption which caused economic loss to owners. Bhadrige (2010) also reported projected economic loss of Rs. 3, 97, 05.00 during the period from March to June 2010. Hence, in this context also close monitoring of not only porcine cysticercosis but all those parasites and or their stages which cause economic losses is necessary. However, owing to economic and public health significance of cysticercosis, it is necessary to conduct periodic surveys after every two to three years to monitor occurrence of porcine cysticercosis which also has direct bearing on prevalence of human taeniosis and cysticercosis, as revealed by number of reports of neurocysticercosis in human beings from different parts of India (Selvam *et al.*, 2005 in Karnataka; Khurana *et al.*, 2006 at Chandigarh; Prasad *et al.*, 2007 in Uttar Pradesh; Vora *et al.*, 2008 at Goa; Prabhakaran *et al.*, 2008 in Andhra Pradesh and Borkataki *et al.*, 2009 in Assam) in the recent past.

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Histopathological Analysis of Measley Pork

Measely meat was subjected to histopathological analysis which revealed mild intensity of inflammatory reaction with infiltration of mononuclear as well as polymorphs only in heavily infected musculature. The inflammatory reaction was more pronounced in the area close to the portion of the cyst showing invagination of scolex (Fig. 3 & 4).

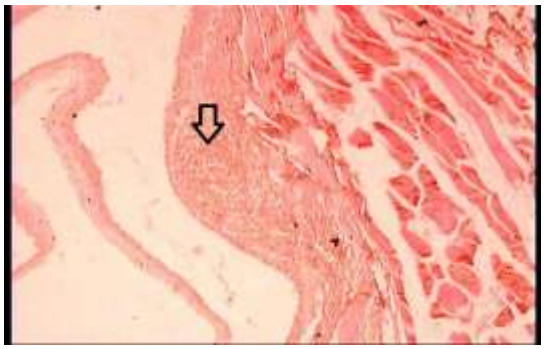

Fig. 3: Microphotograph (H & E 100X) showing inflammatory exudates containing mononuclear and polymorphonuclear cells in the immediate vicinity of the cyst wall

Fig. 4: Microphotograph (H & E 40X) showing inflammatory exudate in the area opposite to the entrance canal of scolex.

The cellular changes surrounding the cyst had a close resemblance to the lesions of porcine cysticercosis as described in brain by Prakash *et al.* (2007). However, muscular tissue carrying less number of cysts did not show cellular reaction. This discrepancy is attributed to the number of cysts present, survivability of the cysts and locations of the cysts (Gonzalez *et al.*, 1990). No cellular response noted in majority of cases in the present study, also indicated mutual tolerance by both the partners of the parasitic association *i.e. Cysticercus cellulosae* and pig and thus the relationship could be highly evolved.

Intensity of *Cysticercus cellulosae* in Pork

In the present study intensity of *Cysticercus cellulosae* cysts was also noted and expressed as number of cysts present per unit area of two square inch (Fig. 5).

Fig. 5: Heavily infected pork with 26 cysts per unit area

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Among the 121 pigs found positive for *Cysticercus cellulosae*, 61 (50.41 %) pigs had mild intensity (1 – 4 cysts / unit area), 48 (39.67 %) pigs had moderate degree (5 to 8 cysts /unit area) and remaining 12 (9.91%) pigs were heavily (9 and more no of cysts / unit area) infected (Table 1). Previous study conducted in Maharashtra by Bhadrige (2010) also recorded same trend of more percentage of mild intensity cases as compared to cases with moderate or heavy intensity of the muscle cysts. More percentage of porcine cysticercosis with number wise mild intensity of cysts definitely warrants more intense meat inspection in the slaughter houses.

Table 1: Location- wise prevalence and intensity of *Cysticercus cellulosae* in pigs slaughtered at Deonar abattoir, Mumbai

Locations	No. of Positive Cases	Percentage	Intensity of Cysticerci/Unit Area		
			Mild	Moderate	Heavy
Shoulder	121	100	61	48	12
Neck	98	80.99	67	21	10
Masseter	83	68.03	70	6	7
Thigh	60	49.58	51	2	7
Tongue	15	12.39	7	2	6
Diaphragm	13	10.74	6	4	3
Heart	6	4.95	6	__	__
Total(carcass wise)	121	__	61	48	12

Distribution of *Cysticercus cellulosae* in the Musculature

Observation pertaining to distribution of *Cysticercus cellulosae* cysts in the musculature (Table 1) revealed that, all the 121 cases had cysts in shoulder muscles (100%). Apart from shoulder muscles, the cysts were also commonly encountered in neck (80.99%), masseter (68.03%) and thigh muscles (49.58%). Comparatively lower rate of occurrence was noted in tongue (12.39%), diaphragm (10.74%) and cardiac muscles (4.95%). The attempt was also made to examine the brains by exposing the skull of 25 carcasses; but cysts were not encountered in the central nervous tissues. In the present study the cysts were not encountered in the visceral organs .These findings are in general agreement with the observations of Shinde (1991), Gaurat (2002), and Bhadrige (2010). However, Sharma *et al.* (2005) and Sarma *et al.* (2000) recorded thigh and neck muscles, respectively as most frequent sites for porcine cysticercosis in contradictory with the observations of this study. Predominance of lingual localization of cysticerci suggesting tongue palpation as a reliable method for detection of swine cysticercosis reported by Sato *et al.* (2003), Rajshekhar (2004), Morales *et al.* (2008) and Marcia *et al.* (2012) in Vietnam, Nepal, Mexico and Brazil respectively, has never been the finding of the surveys conducted in India, though mild to moderate rate of occurrence of the cysts in the tongue has been reported by number of workers (Shastri, 1966, Pramanik *et al*., 1986, Pathak and Gaur, 1989; Shinde, 1991; Dhanalakshmi, 2003 and Sharma *et al.*, 2005). In the present study as well, tongue localization of the cysts was encountered in 12.39% carcasses.

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Although the observations on site preferences have been recorded by a number of workers, no uniform pattern of distribution of cysticerci in the musculature unanimously emerges out to give a definite direction to meat inspection. However, the present finding of 100% occurrence of the cysts in shoulder muscles in concordance with the findings of Shinde (1991), Mundhe (1999), Gaurat (2002), Mandakhalikar *et al.* (2009) and Bhadrige (2010) undoubtedly points out incision of shoulder muscles as a reliable method for detection of *Cysticercus cellulosae* during meat inspection. Additional cuts are also recommended in neck, masseter and thigh muscle to improve the efficacy of meat inspection. However, Gracy *et al*. (2009) recommended incision of thigh, pillars of diaphragm, intercostal and cardiac muscle for detection of the cysticerci. Mandakhalikar *et al*. (2009) categorically stated that incision of shoulder and neck muscles for detection of cysticerci is a standardized protocol of meat inspection followed at Mumbai abattoir. The present findings validate the method that is being followed in the slaughter house. The precise reason for location preferences of *Cysticercus cellulosae* in the swine musculature is not available in the literature at this point of time.

Influence of Season, Age and Sex on Prevalence of *Cysticercus cellulosae* in Pigs

In this survey conducted over a period of one year, seasonal prevalence of *Cysticercus cellulosae* was recorded. The occurrence rate of porcine cysticercosis was highest in monsoon (2.05 %) and in the other two seasons it was almost equal *i.e.* 0.87 and 0.85% in winter and summer, respectively (Table 2). D'Souza and Hafeez (1998) also revealed similar trend of higher occurrence rate of pork measles in Andhra Pradesh during northwest monsoon followed by summer, northeast monsoon and winter. In contrast, Borkataki *et al.* (2011) reported highest prevalence of porcine cysticercosis in pre-monsoon and lowest prevalence in monsoon in Assam.

Table 2: Seasonal prevalence of *Cysticercus cellulosae* in pigs slaughtered at Deonar abattoir, Mumbai, during July 2006 to June 2007

Season	No. of Pig Examined	No. Positive Pig (%)	Intensity (No. of Cysts per unit Area)			X^2
			Low (%)	Moderate (%)	Heavy (%)	
Monsoon	3214	66 (2.05)	31 (46.97)	27 (40.91)	8 (12.12)	**72.54**
(July2006 to Sept 2006 and June 2007						
Winter	4617	40 (0.87)	21 (52.50)	15 (37.50)	4 (10.00)	
(Oct 2006 to Jan 2007)						
Summer	1761	15 (0.85)	9 (60.00)	6 (40.00)	0	
(Feb 2007 to May2007)						
Total	9592	121 (1.26)	61 (50.41)	48 (39.67)	12 (9.91)	

Soulsby (1982) described that the cysticerci develop to full grown cysts in the musculature in about ten weeks and subsequently survive in the musculature for about 9-12 months before death and disintegration. Hence, seasonal prevalence has no relevance in this context as it does not essentially indicate the tentative

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time of infection and age of the cysts. However, in the present study application of data of seasonal prevalence to statistical analysis showed significantly higher rate of occurrence of porcine cysticercosis in monsoon as compared to other two seasons.

As regards age-wise occurrence of *Cysticercus cellulosae* (Table 3), it was observed that in adult pigs above two years of age group, the prevalence rate was higher (1.69%) than the pigs ageing between one and two years (1.41%) and pigs below one year (0.80%). However, Borkataki *et al.* (2011) reported exactly opposite trend of higher prevalence of cysticercosis in pigs below one year (11.41%) than the pigs belonging to one to two years age group (7.60 %). In almost every survey conducted in India, the efforts were made to note influence of age on the prevalence of porcine cysticercosis but in majority of the reports the numerical differences in the occurrence of the metacestode were found to be non-significant (Pramanik *et al.*, 1985; Pathak and Gaur, 1989; D'Souza and Hafeez, 1998 and Sharma *et al.*, 2005). However in the present study age-wise difference in the prevalence of *Cysticercus cellulosae* was found to be statistically significant at 1% level. The discrepancy in the age predisposition of porcine cysticercosis cited in the literature could be attributed to the sample size, managemental practices and to some extent presence of immunity. Soulsby (1982) described that the animals already harbouring bladder worms in the body possess concomitant immunity which prevents transformation of migrating oncosphere into the bladder worms. Further the author has also reported passive transfer of protective immunity to young ones which wanes gradually. This could be the reason for less prevalence of *Cysticercus cellulosae* in younger pigs noted in the present study. Further, the author categorically stated that, the protective immune response, active or passive, also exerts its action against heterologous bladder worm infection *viz. Cysticercus tenuicollis* and hydatid cysts and thus have direct bearing on the epidemiology of metacestode infections including porcine cysticercosis.

Table 3: Age- wise prevalence of *Cysticercus cellulosae* in pigs slaughtered at Deonar abattoir, Mumbai

Age Group	No. of Animals Examined	No. of Pigs Found Positive	Percentage	X^2
Up to 12 months	2755	22	0.8	7.06
13 to 24 months	5890	83	1.41	
Above 2 Yrs.	947	16	1.69	
Total	9592	121		

Gender discrimination (Table 4) in the prevalence of pork measles noted in the present study revealed statistically higher infection rate in at 1% level in female pigs (1.74%) as compared to male (0.94%) pigs. Similar trend of higher occurrence of porcine cysticercosis in sow as compared to that in boar was also published by D'Souza and Hafeez (1998), Mandakhalikar *et al.* (2009) and Borkataki *et al.* (2011). This general trend was almost unanimously reported by majority of workers but mostly with statistically significant difference. Although there is no direct justification cited in the literature at this point of time, it

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could be due to break in protective immunity in sows owing to physiological stress of gestation, farrowing and lactation.

Table 4: Sex-wise prevalence of *Cysticercus cellulosae* in pigs slaughtered at Deonar abattoir, Mumbai

Sex	No. of Animals Examined	No. of Pigs Found Positive	Percentage	X^2
Male	5750	54	0.94	11.81
Female	3842	67	1.74	
Total	9592	121	1.26	

Apart from age, sex and seasonal predisposition, the literature also throws light on influence of breed and managemental conditions on the occurrence of porcine cysticercosis in different parts of India. Preponderance of *Cysticercus cellulosae* in indigenous as compare to crossbred pigs and in pigs reared under free range system as compared to those reared under intensive management has been reported extensively in the Indian literature (Pramanik *et al.*, 1985; Pathak and Gaur,1989; D'Souza and Hafeez,1998 and Sharma *et al.*, 2005). The two categories based on genetic makeup (breed) and managemental practices (feeding habits) are interlinked with each other in the sense that indigenous pigs are owned by socio economically backward section of the society particularly in rural areas without proper infrastructural facilities and thus the pigs invariably let loosed throughout the day for the food (human night soil) in the localities/ human dwellings without sanitary facilities of well-constructed close latrines. In contrast, very few (less than 10% of total swine population) scientifically maintained pig farms are available in India, where intensive management is practiced. These farms mostly possess crossbred pigs which show better growth than indigenous animals. Present study, since based on slaughter house observations, did not provide adequate opportunity to confirm this trend.

Although public health role of porcine cysticercosis in causing intestinal taeniosis and neurocysticercosis in humans has been well documented by various authors in India, the economic loss caused due to partial / complete condemnation of carcasses and other administrative charges of meat inspection, processing and disposal has not been estimated on a national scale. Owing to ubiquitous distribution of porcine cysticercosis in different parts of India, the economic losses predicted to be substantial. The economic loss reported by D'souza and Hafeez (1998) and Bhadrige (2010) owing to condemnation of pork may prima facie appear to be meagre in large scale at the level of meat trait, but at grassroots level / ownership level, it may be too big to sustain particularly by economically backward community.

Conclusion

In view of discussion, it is concluded that, although the prevalence rate of *Cysticercus cellulosae* is declining gradually in different parts of India, there is need to monitor the occurrence of the disease

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periodically owing to tremendous zoonotic potential and substantial economic loss until drastic improvement in the pig farming and general sanitary hygiene is achieved.

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