

## CURRENT DIAGNOSTIC PROCEDURES FOR CYSTICERCOSIS IN CATTLE AND PIGS\*

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*SUMMARY: Taeniosis/cysticercosis complex is a significant public health problem worldwide. Control of this zoonotic disease requires a good diagnostic test to identify animals harboring live metacestodes. Meat inspection, which is the only public health measure implemented to control this human infections, is a poorly sensitive method to detect such infected animals. The need for diagnostic tests superior to meat inspection have led to the development of serological tests. Antibody detection diagnostic tests indicate exposure to infection and not necessarily the presence of an established, viable infection. But from the public health point of view only living metacestodes are important. Contrary to meat inspection and antibody detection methods, the monoclonal antibody (MoAb)-based enzyme-linked immunosorbent assays (ELISAs) for the detection of excretory/secretory (ES) products indicate infection with live metacestodes. The MoAb based antigen detection ELISA (Ag-ELISA) is much more sensitive to identify active infections of *T. saginata* and *T. solium* metacestodes.*

**Key words:** cysticercosis, meat inspection, antibody detection methods, ES Ag-ELISA.

### INTRODUCTION

Cysticercosis is a larval tapeworm infection acquired from ingestion of embryonated *Taenia saginata* (cattle) or *Taenia solium* (pigs and humans) eggs excreted with faeces from human carriers who harbour the adult tapeworm in the intestines. The hatched embryos migrate throughout the body and develop into cysticerci (Minozzo *et al.*, 2002; Boa *et al.*, 2002). In humans, the invasion of the central nervous system with *T. solium* cysticerci known as neurocysticercosis (NCC) is one of the emerging diseases worldwide, and the major cause of epileptic seizures in areas of endemicity (Cruz *et al.*,

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Review scientific paper / Pregledni naučni rad

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\*The paper is a part of the research work on the project "Selected biological hazards for safety/quality of food of animal origin and control measures from farm to consumer", file no.31034, financed by the Ministry of Sciences of the Republic of Serbia, from 2011. to 2014.

1999; Doder *et al.* 2004). Moreover, cysticercosis is an important cause of economic losses in pig and cattle production due to downgrading and/or condemnation of carcasses as untreated infected meat is an important source of this zoonosis (Carabin *et al.*, 2006). Meat inspection, which is the only public health measure implemented to control human infections, is a poorly sensitive method and detects mainly heavily infected animals (Wanzala *et al.*, 2003). Detection of cysticerci depends on the expertise of the meat inspector as well as on the stage of development of the cysticerci (Minozzo *et al.*, 2002; Wanzala *et al.*, 2003). The method is more sensitive to detect dead, degenerated, or calcified cysticerci than viable cysts, as the latter they have the same pinkish-red color as the meat (Onyango-Abuje *et al.*, 1996; Wanzala *et al.*, 2003). Moreover, the method detects infection only after slaughter when it is too late to make decision on treatment of animals.

The need for diagnostic tests superior to meat inspection have led to the development of serological tests. Antibody detection diagnostic tests indicate exposure to infection and not necessarily the presence of an established, viable infection. But from the public health point of view only living metacestodes are important. Contrary to meat inspection and antibody detection methods, the monoclonal antibody (MoAb)-based enzyme-linked immunosorbent assays (ELISAs) for the detection of excretory/secretory (ES) products indicate infection with live metacestodes (Harrison *et al.*, 1989; Brandt *et al.*, 1992). The 158C11 and 60H8 MoAb based antigen detection ELISA (Ag-ELISA) is much more sensitive to identify active infections of *T. saginata* and *T. solium* metacestodes (Brandt *et al.*, 1992; Van Kerckhoven *et al.*, 1998; Dorny *et al.*, 2000). The assay is an important tool to detect individual cases or to screen populations for the presence of viable cysticerci. This information is required by public health services in order to make decisions on treatment or control programs (Wanzala *et al.*, 2002; Sikasunge *et al.*, 2008). The assay requires relatively expensive laboratory equipment. The dipstick methods are more applicable in the resource deprived field laboratories of developing countries (Birku *et al.*, 1999). Studies that have used the polystyrene surfaced Nunc-immunoTM dipsticks for the detection of pathogens in food samples demonstrated the usefulness of the sticks for immunological tests (Aldus *et al.*, 2003; Blazkova *et al.*, 2006).

### **Immunodiagnostic tools**

Immunodiagnostic techniques include methods for specific antibodies and for circulating parasite antigen in serum or cerebrospinal fluid. The antigens used in immunoblot and enzyme-linked immunosorbent assay (ELISA) for antibody detection have evolved from crude extracts to highly purified specific fractions and recombinant antigens of the glycoprotein family, increasing both the sensitivity and the specificity of the tests. The application of ELISA for the detection of circulating parasite antigens may present some diagnostic advantages since it demonstrates not only exposure but also active infections. Until now only a few of the current techniques have been standardised and fully validated, making comparisons between studies difficult. In surveys on cysticercosis, antibody detection systems have been useful in identifying the risk factors associated with transmission of *Taenia spp.* High seroprevalence in a community indicates a situation where preventive and control measures should be applied.

## Diagnosis of cysticercosis in cattle

### *Carcass inspection*

Meat inspection of cattle is the only public health measure implemented to prevent *T. saginata* transmission to people and is based on the partial incision and inspection of target organs/muscle groups: heart, masseters, and if necessary tongue, *triceps brachii*, and diaphragm; and careful visual search of *T. saginata* cysts. Studies on naturally infected calves have demonstrated that only 14.1% of the total carcass cysts were found in inspection sites indicated above and that only 5.8% of the total carcass cysts appear on cut surfaces created by meat inspection technique (Wanzala *et al.*, 2003). A higher proportion (34%) of cysts was found in the target organs/muscle groups in experimentally infected calves (Kyvsgaard *et al.*, 1990). Another study found a sensitivity of 38% in carcass dissection positive naturally infected calves. They demonstrated that 27% of animals with one to 10 cysts, 42.9% of animals with 11 to 20 cysts, and 77.8% with more than 20 cysts were revealed by the routine procedure (Walther et Koske, 1980). The lack of precision of the visual identification of specific cysts might overestimate the prevalence through misdiagnosis of other morphological alterations in affected muscles. It is difficult to differentiate between old lesions caused by cysticerci and other lesions. For example, of meat inspection identified *T. saginata* cysticercus lesions only 76.7% of them gave positive PCR result: 91% of 78 viable cysts and 70.7% of 239 dead (degenerating and calcified) cysts (Geysen *et al.*, 2007). In another study PCR confirmed only 52.4% of the cysticercus lesions recovered during routine meat inspection: 80% of 25 viable cysts and 49.6% of 242 dead cysts (Abuseir *et al.*, 2006).

### Enzyme-Linked Immunosorbent Assay

#### *Antibody detection ELISA*

The antibody detection ELISA (Ab-ELISA) for the diagnosis of *T. saginata* cysticercosis detects specific antibodies in serum of infected cattle from three weeks post-infection onwards (Kamanga-Sollo *et al.*, 1987). The diagnostic antigens are either from crude homogenates of *T. saginata* cysticerci, or from cyst fluids and/or crude homogenates of related parasites *T. hydatigena*, *T. crassiceps* and *T. solium* (Craig et Rickard, 1980; Geerts *et al.*, 1981; Kamanga-Sollo *et al.*, 1987; Monteiro *et al.*, 2006). Such crude antigens give cross-reactions with serum from cattle infected with heterologous helminths, such as *Fasciola hepatica*, and *T. hydatigena* (Craig & Rickard, 1980). Since *T. hydatigena* metacestode is not commonly found in cattle, cross reaction may not present a major drawback in practice (Geerts *et al.*, 1981). Such assays are deficient to diagnose lightly infected animals at slaughterhouses (Monteiro *et al.*, 2006). In natural conditions light grade infections are common. For example, an ELISA using hydro-soluble antigens of *T. crassiceps* demonstrated a sensitivity and specificity of 37.5% and 95.7% respectively (Geerts *et al.*, 1981). The ELISA using a recombinant antigen of *T. saginata* oncosphere adhesion protein (Hp6-Tsag) showed 100% sensitivity and a specificity of 93.2% in experimentally infected cattle (Ferrer *et al.*, 2007).

## Enzyme-Linked Immunosorbent Assay

### *Antigen detection ELISA*

The level of antibody titer did not correspond with live cysticerci burden in naturally infected animals (Onyango-Abuje *et al.*, 1996). In slaughterhouse cattle antigen assay was found three times as sensitive as meat inspection. Furthermore, the assay detects live cysticerci which are most likely missed, as they have the same pinkish-red color as the meat (Onyango-Abuje *et al.*, 1996; Wanzala *et al.*, 2003). Two MoAb-based ELISA systems, HP10 and (158C11 and 60H8), were developed for the detection of *T. saginata* cysticercosis (Harrison *et al.*, 1989; Brandt *et al.*, 1992; Van Kerckhoven *et al.*, 1998). Both assays recognized the circulating glycoprotein antigens secreted by the viable metacestodes from four weeks after infection onwards (Harrison *et al.*, 1989; Onyango-Abuje *et al.*, 1996). A mouse monoclonal antibody IgM coded HP10, developed against glycoproteins from surface enriched extract of *T. saginata* cysticerci, was used for the development of a diagnostic ELISA to detect these glycoproteins in the serum of *T. saginata* infected cattle. However, only cattle harboring 200 live 8 to 16 weeks-old cysticerci were consistently detected (Harrison *et al.*, 1989). In a recent study conducted in Kenya the assay detected 75% (n=20) of naturally infected cattle harboring one or more live cysts at carcass dissection. All animals with five and more cysts were Ag-ELISA positive (Wanzala *et al.*, 2007). Another study found a sensitivity of 83% (n=6) for animals with  $\geq 30$  live cysticerci, which dropped to 22% (n=23) for animals with 1-29 live cysts (Onyango-Abuje *et al.*, 1996).

The other MoAb-based antigen detection ELISA system was developed by Brandt *et al.* (1992) and modified by Van Kerckhoven (Van Kerckhoven *et al.* 1998) and Dorny (Dorny *et al.* 2000). The assay yielded a sensitivity of 92% and a specificity of 98.7% in heat treated sera from cattle harbouring more than 50 viable cysts.

### Electroimmunotransfer Blot

There is limited information on the use of the electroimmunotransfer blot (EITB) for the diagnosis *T. saginata* cysticercosis. A hydrophobic fraction, 10 to 18 kDa, isolated from cyst fluid of *T. hydatigena* metacestodes, collected from naturally infected goats, was evaluated in immunoblot and dot blot procedures and detected *T. saginata* infection in calves (Bogh *et al.*, 1995).

### Dipstick-immunoassay

Hayunga (Hayunga *et al.* 1991a) developed a dipstick antibody detection ELISA for the diagnosis of *T. saginata* and *T. solium* cysticercosis using ammonium sulphate-soluble fractions of *T. hydatigena* cyst fluid antigen adsorbed on Immobilon P membrane dipsticks. The assay detected 6 out of 7 (85.7%) cysticercotic cattle three weeks after experimental infection (Hayunga *et al.*, 1991).

### Dot-ELISA

Although considerable progress has been made to develop simple dot-immunoassays for *T. saginata* cysticercosis, the techniques are not standardized (Jiang *et al.*, 1990; Draelants *et al.*, 1995b; Biswas *et al.*, 2004; Agudelo *et al.*, 2005). Draelants

(Draelants *et al.* 1995a) developed an antigen detection dot-ELISA using MoAbs (2H8 and 12G5) of IgM isotype and nitrocellulose membrane as described by Brandt (Brandt *et al.* 1992). The assay gave 87.5% and 93.5% sensitivity and specificity, respectively in cattle with more than 100 viable cysts.

## **Diagnosis of cysticercosis in pigs**

### ***Carcass inspection***

Meat inspection is the only diagnostic method carried out on large scale in slaughterhouses for the post-mortem detection of pig cysticercosis. The method is more sensitive to detect dead, degenerated, or calcified cysticerci; but is most likely to miss quite a number of viable cysticerci, as they have the same pinkish-red color as the meat (Wanzala *et al.*, 2003). The procedure is based on the partial incision and careful observation in the “predilection” sites such are: heart (obligatory), masseters, tongue, and *triceps brachii*(optionaly) (Boa *et al.*, 2002). The technique has demonstrated low sensitivity. Dorny (Dorny *et al.* 2004) estimated a sensitivity of 22.1% and specificity of 100%. Boa (Boa *et al.* 2002) showed that routine meat inspection involving visual inspection of incised and intact surfaces of heart, tongue, external and internal masseter muscles, and *triceps brachii* muscles can only reveal 10.6% of the total carcass cysts. In other words, the inspection can only detect 10.6% of infected animals.

### **Tongue palpation**

Tongue examination for detection of *T. solium* cysts in live pigs by palpation and visual inspection is a low cost ante-mortem diagnostic method of porcine cysticercosis. The technique has a high specificity (100%), but generally low sensitivity (Dorny *et al.*, 2004; Phiri *et al.*, 2006). The sensitivity of the method depends on the level of infection. Approximately, 76 and 78% of positive tongue palpation pigs were found seropositive in ELISA and EITB, respectively (Sato *et al.*, 2003). The diagnostic antigens were isoelectric-focusing purified glycoproteins according to Ito (Ito *et al.* 1998). In an endemic area, the tongue palpation detected up to 70.8% of meat inspection positive pigs (Gonzalez *et al.*, 1990). In comparison to total carcass dissection as low as 16% sensitivity was also recorded (Phiri *et al.*, 2006). Despite the low sensitivity the method is used in epidemiological studies of porcine cysticercosis (Sarti *et al.*, 1992; Mutua *et al.*, 2007; Sikasunge *et al.*, 2008). In a pig population tongue palpation showed prevalence of 10.8% while this was 23.3% by Ag-ELISA (Sikasunge *et al.*, 2008).

## **Enzyme-Linked Immunosorbent Assay**

### ***Antibody detection ELISA***

The assay detects IgG. Antigens used for coating of most ELISAs for the detection of antibodies against *T. solium* cysticercosis in pig serum are from cyst fluid or crude homogenates of the *T. solium* cysticerci, or from the related parasite *T. crassiceps* (Nunes *et al.*, 2000). These crude antigens have shown cross reactions with sera from pigs infected with *T. hydatigena*, *E. granulosus*, *Ascaris suum*, *Fasciolopsis buski*, *Hymenolepis diminuta*, and *Dipylidium caninum* (Kumar et Gaur, 1987; Cheng et Ko, 1991;

Ko et Ng, 1998; Pinto *et al.*, 2000). Fractionation and/or purification of the antigens have improved the specificity of the assay (Ito *et al.*, 1998; Assana *et al.*, 2007). A fraction of 14 kDa antigen purified using an ion exchange column on high performance liquid chromatography from crude cyst fluid of *T. solium* was found specific (Assana *et al.*, 2007). The isoelectric-focusing purified glycoprotein antigens from cyst fluid (Ito *et al.*, 1998) have shown a specificity and sensitivity of 100% in detecting antibodies against *T. solium* metacestodes in pig serum (Ito *et al.*, 1999).

### **Antigen detection ELISA**

The presence of antibodies does not constitute direct evidence of a living parasite within the host (Garcia *et al.*, 1997; Fleury *et al.*, 2007). It may indicate transient antibodies from exposure to infection (Garcia *et al.*, 2001) and/or persisting antibodies of previously established infection after elimination due to immune mechanism and/or drug therapy (Harrison *et al.*, 1989; Garcia *et al.*, 1997). A mouse monoclonal antibody IgM coded HP10, developed against glycoproteins from surface enriched extract of *T. saginata* cysticerci (Harrison *et al.*, 1989), is used for the detection of these glycoproteins in the serum of *T. solium* infected people. The assay displayed 84.8% (n=46) sensitivity and 94% specificity in serum from patients with active infection (Fleury *et al.*, 2007). In another study a similar sensitivity (85%) and specificity (92%) was found (Garcia *et al.*, 2000). The assay is used for serodiagnosis and follow-up of NCC (Garcia *et al.*, 2000; Garcia, 2007).

Another MoAb-based antigen detection ELISA system was developed by Brandt *et al.* (1992) and modified by Van Kerckhoven *et al.* (1998) and Dorny *et al.* (2000). The monoclonal antibody-based ELISA is being used for clinical management and epidemiological surveys of human cysticercosis (Erhart *et al.*, 2002; Prado-Jean *et al.*, 2007). The sharing of antigens between the metacestode and adult tapeworm might influence seropositivity in endemic areas (Draelants *et al.*, 1995a; Correa *et al.*, 1999). In the hamster model of taeniosis, adult antigens have been demonstrated to cross the intestinal epithelium and enter the circulation (Correa *et al.*, 2002).

The detection of viable cysts is achieved through capturing circulating antigens by MoAbs. The two MoAb-based ELISA systems (Harrison *et al.*, 1989; Brandt *et al.*, 1992; Van Kerckhoven *et al.*, 1998) are used for detection of circulating antigens of viable metacestodes in pig serum. The assays could detect antigens in serum of pigs harbouring live cysticerci from four weeks after infection onwards, in contrast no antigen is detected in those containing only dead cysticerci (Nguekam *et al.*, 2003).

### **Electroimmunotransfer Blot**

The EITBs are the most sensitive and specific assays for the detection of antibodies specific to *T. solium* cysticercosis in pigs. The EITB (Tsang *et al.*, 1989) was evaluated on serum samples from naturally infected pigs with *T. solium* and other heterologous infections including echinococcosis. The assay was determined to be 100% sensitive and specific. It detected antibodies in experimentally infected pigs between 5 and 8 weeks post infection (Tsang *et al.*, 1991). This assay was very sensitive (98%) and specific (100%). No sera from *Echinococcus granulosus*/*E. multilocularis* and other heterologous infections recognized the GP bands (Tsang *et al.*, 1989). The assay has been used for epidemiological surveys of human cysticercosis (Garcia *et al.*, 1991).

## Dot ELISA

The performance of antibody detection dot-ELISAs depends on antigens and/or reference tests used. The complete homogenate of *T. solium* cyst antigen dotted on nitrocellulose membrane detected antibodies in 56.5% sera from patients with CT/MRI confirmed NCC. The assay was 92% specific (Biswas *et al.*, 2004). In another studies the assay detected 58.3% of LLGP EITB positive individuals during immunological screening of endemic population (Agudelo *et al.*, 2005).

## CONCLUSIONS

Cysticercosis is a significant public health problem worldwide. Control of this zoonosis requires a good diagnostic test to identify animals harboring live metacestodes. Visual meat inspection, which is the only public health measure implemented to control human infections, is a poorly sensitive method to detect such animals. It may underestimate the prevalence of the disease by a factor 3 to 10.

The need for diagnostic tests superior to meat inspection have led to the development of serological tests. Antibody detection diagnostic tests indicate exposure to infection and not necessarily the presence of an established, viable infection. But from public health point of view only living metacestodes are important. Contrary to meat inspection and antibody detection methods, the monoclonal antibody based enzyme-linked immunosorbent assays (ELISAs) for the detection of excretory/secretory (ES) products indicate infection with live metacestodes. The assay is an important tool to detect individual cases or to screen populations for the presence of viable cysticerci. The assay requires relatively expensive laboratory equipment. The dipstick methods are more applicable in the resource deprived field laboratories of developing countries.

There is limited information on the prevalence of *T. saginata* and *T. solium* cysticercosis in Serbia. Recent studies of neurocysticercosis (Doder *et al.*, 2004) have shown that the prevalence is very low, but cysticercosis is present in pigs and humans.

## REFERENCES

- AGUDELO,P., BOTERO,D. PALACIO,L.G.: Evaluation of the ELISA method for diagnosis of human cysticercosis in an endemic region. *Biomedica*, 25:488-495, 2005.
- ALDUS,C.F., VAN AMERONGEN,A., ARIENS,R.M., PECK,M.W., WICHERS,J.H. WYATT,G.M.: Principles of some novel rapid dipstick methods for detection and characterization of verotoxigenic *Escherichia coli*. *Journal of Applied Microbiology*, 95:380-389, 2003.
- ASSANA,E., KANOBANA,K., TUME,C.B., ZOLI,P.A., NGUEKAM, GEERTS,S., BERKVEN,S., DORNY,P.: Isolation of a 14 kDa antigen from *Taenia solium* cyst fluid by HPLC and its evaluation in enzyme linked immunosorbent assay for diagnosis of porcine cysticercosis. *Research in Veterinary Science*, 82:370-376, 2007.
- BHIGJEE,A.I. SANYIKA,C.: Disseminated cysticercosis. *Journal of Neurology, Neurosurgery & Psychiatry*, 66:545, 1999.
- BIRKU,Y., WELDAY,D., AYELE,D.SHEPHERD,A.: Rapid diagnosis of severe malaria based on the detection of Pf-Hrp-2 antigen. *Ethiopian Medical Journal*, 37:173-179, 1999.

- BISWAS,R., PARIJA,S.C. NARAYAN,S.K.: Dot-ELISA for the diagnosis of neurocysticercosis. *Revista do Instituto de Medicina Tropical de Sao Paulo*, 46:249-252, 2004.
- BLAZKOVA,M., KARAMONOVA,L., GREIFOVA,M., FUKAL,L., HOZA,I., RAUCH,P. WYATT,G.: Development of a rapid, simple paddle-style dipstick dye immunoassay specific for *Listeria monocytogenes*. *European Food Research and Technology*, 223:821-827, 2006.
- BOA,M.E., KASSUKU,A.A., WILLINGHAM III,A.L., KEYYU,J.D., PHIRI,I.K.NANSEN,P.: Distribution and density of cysticerci of *Taenia solium* by muscle groups and organs in naturally infected local finished pigs in Tanzania. *Veterinary Parasitology*, 106:155-164, 2002.
- BOGH,H.O., LIND,P., SONDERBY,B.V., KYVSGAARD, N.C., MAEDA,G.E., HENRIKSEN,S.A.NANSEN,P.: Immunodiagnosis of *Taenia saginata* in cattle using hydrophobic antigens from *T. hydatigena* metacestode cyst fluid. *Applied Parasitology*, 36:226-238, 1995.
- BRANDT,J.R., GEERTS,S., DE DEKEN,R., KUMAR,V., CEULEMANS,F., BRIJS,L. FALLA,N.: A monoclonal antibody-based ELISA for the detection of circulating excretory-secretory antigens in *Taenia saginata* cysticercosis. *International Journal of Parasitology*, 22:471-477, 1992.
- CARABIN,H., KRECEK,R.C., COWAN,L.D., MICHAEL,L., FOYACA-SIBAT,H., NASH,T. WILLINGHAM III,A.L.: Estimation of the cost of *Taenia solium* cysticercosis in Eastern Cape Province, South Africa. *Tropical Medicine and International Health*, 11:906-916,2006.
- CHENG,R.W.;KO,R.C.: Cross-reactions between crude antigens of larval *Taenia solium* (*Cysticercus cellulosae*) and other helminths of pigs. *Veterinary Parasitology*, 39:161-170, 1991.
- CORREA,D., SARTI,E., TAPIA-ROMERO,R., RICO,R., ALCANTARA-ANGUIANO,I., SALGADO,A., VALDEZ,L. FLISSER,A.: Antigens and antibodies in sera from human cases of epilepsy or taeniasis from an area of Mexico where *Taenia solium* cysticercosis is endemic. *Annals of Tropical Medicine and Parasitology*, 93: 69-74, 1999.
- CORREA,D., TAPIA-ROMERO,R., MEZA-LUCAS,A. MATA-RUIZ,O.: Antigen-Based Immunoassays in the Diagnosis of *Taenia solium* Cysticercosis. In: *Taenia Solium Cysticercosis From Basic to Clinical Science*. Singh,G. & Prabhakar,S., editors. CABI Publishing, New York; p. 343-349,2002.
- CRAIG,P.S. RICKARD,M.D.: Evaluation of “crude” antigen prepared from *Taenia saginata* for the serological diagnosis of *T. saginata* cysticercosis in cattle using the enzyme-linked immunosorbent assay (ELISA). *Z Parasitenkd*, 61: 287-297, 1980.
- CRUZ,M.E., SCHANTZ,P.M., CRUZ,I., ESPINOSA,P., PREUX,P.M., CRUZ,A., BENITEZ,W., TSANG,V.C., FERMOSO,J. DUMAS,M.: Epilepsy and neurocysticercosis in an Andean community. *International Journal of Epidemiology*, 28: 799-803, 1999.
- DODER R, MADLE-SAMARDZIJA N, CANAK G, VUKADINOV J, TURKULOV V, SEVIĆ S.: Neurocysticercosis--5 years' experience at the Clinic for Infectious Diseases Med Pregl.,Nov-Dec., 55(11-12),:523-7, 2002.
- DORNY,P. PRAET,N.: *Taenia saginata* in Europe. *Veterinary Parasitology*, 149: 22-24, 2007.
- DORNY,P., BRANDT,J., ZOLI,A. GEERTS,S.: Immunodiagnostic tools for human and



porcine cysticercosis. *Acta Tropica*, 87: 79-86, 2003.

DORNY,P., VERCAMMEN,F., BRANDT,J., VANSTEENKISTE,W., BERKVEN,S., D. GEERTS,S.: Sero-epidemiological study of *Taenia saginata* cysticercosis in Belgian cattle. *Veterinary Parasitology*, 88: 43-49, 2000.

DRAELANTS,E., BRANDT,J.R., KUMAR,V. GEERTS,S.: Characterization of epitopes on excretory-secretory antigens of *Taenia saginata* metacestodes recognized by monoclonal antibodies with immunodiagnostic potential. *Parasite Immunology*, 17: 119-126, 1995°.

DRAELANTS,E., HOFKENS,E., HARDING,E., BRANDT,J. GEERTS,S.: Development of a dot-enzyme immunoassay for the detection of circulating antigen in cattle infected with *Taenia saginata* cysticerci. *Research in Veterinary Science*, 58: 99-100, 1995b.

ERHART,A., DORNY,P., VAN DE,N., VIEN,H.V., THACH,D.C., TOAN,N.D., CONG,L.D., GEERTS,S., SPEYBROECK,N., BERKVEN,S., D. BRANDT,J.: *Taenia solium* cysticercosis in a village in northern Viet Nam: seroprevalence study using an ELISA for detecting circulating antigen. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 96: 270-272., 2002.

FERRER,E., GONZALEZ,L.M., MARTINEZ-ESCRIBANO,J.A., GONZALEZ-BARDERAS,M.E.,CORTEZ,M.M.,DAVILA,I.,HARRISON,L.J.,PARKHOUSE,R.M. GARATE,T.: Evaluation of recombinant HP6-Tsag, an 18 kDa *Taenia saginata* oncospherical adhesion protein, for the diagnosis of cysticercosis. *Parasitology Research*, 101:517-525,2007.

GARCIA,H.H., MARTINEZ,M., GILMAN,R., HERRERA,G., TSANG,V.C., PILCHER,J.B., DIAZ,F., VERASTEGUI,M., GALLO,C., PORRAS,M.: Diagnosis of cysticercosis in endemic regions. The Cysticercosis Working Group in Peru. *Lancet*, 338: 549-551, 1991.

GEERTS,S., KUMAR,V., CEULEMANS,F. MORTELMANS,J.: Serodiagnosis of *Taenia saginata* cysticercosis in experimentally and naturally infected cattle by enzyme linked immunosorbent assay. *Research in Veterinary Science*, 30: 288-293, 1981.

GEYSEN,D., KANOBANA,K., VICTOR,B., RODRIGUEZ-HIDALGO,R., DE BORCHGRAVE,J., BRANDT,J. DORNY,P.: Validation of meat inspection results for *Taenia saginata* cysticercosis by PCR-restriction fragment length polymorphism. *Journal of Food Protection*, 70: 236-240, 2007.

GONZALEZ,A.E., CAMA,V., GILMAN,R.H., TSANG,V.C., PILCHER,J.B., CHAVERA,A., CASTRO,M., MONTENEGRO,T., VERASTEGUI,M., MIRANDA,E.: Prevalence and comparison of serologic assays, necropsy, and tongue examination for the diagnosis of porcine cysticercosis in Peru. *American Journal of Tropical Medicine and Hygiene*, 43: 194-199,1990.

HARRISON,L.J., JOSHUA,G.W., WRIGHT,S.H. PARKHOUSE,R.M.: Specific detection of circulating surface/secreted glycoproteins of viable cysticerci in *Taenia saginata* cysticercosis. *Parasite Immunology* 11: 351-370,1989.

HAYUNGA,E.G., WONG,M.M., SUMNER,M.P. ISENSTEIN,R.S.: Evaluation of a 'dipstick' immunoassay to detect cysticercosis in experimentally infected cattle. *Veterinary Parasitology*, 38: 13-22,1991.

ITO,A., PLANCARTE,A., NAKAO,M., NAKAYA,K., IKEJIMA,T., PIAO,Z.X., KANAZAWA,T. MARGONO,S.S.: ELISA and immunoblot using purified glycoproteins for serodiagnosis of cysticercosis in pigs naturally infected with *Taenia solium*.

- Journal of Helminthology*, 73: 363-365, 1999.
- KAMANGA-SOLLO, E.I., RHOADS, M.L., MURRELL, K.D.: Evaluation of an antigenic fraction of *Taenia hydatigena* metacestode cyst fluid for immunodiagnosis of bovine cysticercosis. *American Journal of Veterinary Research*, 48: 1206-1210, 1987.
- KO, R.C. NG, T.F.: Evaluation of excretory/secretory products of larval *Taenia solium* as diagnostic antigens for porcine and human cysticercosis. *Journal of Helminthology*, 72: 147-154, 1998.
- KUMAR, D.GAUR, S.N.: Serodiagnosis of porcine cysticercosis by enzyme-linked immunosorbent assay (ELISA) using fractionated antigens. *Veterinary Parasitology*, 24: 195-202, 1987.
- KYVSGAARD, N.C., ILSOE, B., HENRIKSEN, S.A. NANSSEN, P.: Distribution of *Taenia saginata* cysts in carcasses of experimentally infected calves and its significance for routine meat inspection. *Research in Veterinary Science*, 49: 29-33, 1990.
- MINOZZO, J.C., GUSSO, R.L.F., CASTRO, E.A., LAGO, O. SOCCOL, V.T.: Experimental bovine infection with *Taenia saginata* eggs: recovery rates and cysticerci location. *Brazilian Archives of Biology and Technology*, 45: 451-455, 2002.
- MONTEIRO, L.L., PINTO, P.S. DIAS, F.S.: Evaluation of the ELISA test for the antibody detection in cattle naturally and experimentally infected with *Cysticercus bovis*. *Veterinary Parasitology* 141: 260-263, 2006.
- MUTUA, F.K., RANDOLPH, T.F., ARIMI, S.M., KITALA, P.M., GITHIGIA, S.M., WILLINGHAM, A.V. NJERUH, F.N.: Palpable lingual cysts, a possible indicator of porcine cysticercosis, in Teso District, Western Kenya. *Journal of Swine Health and Production*, 15: 206-212, 2007.
- NGUEKAM, A., ZOLI, A.P., VONDOU, L., POUEDET, S.M., ASSANA, E., DORNY, P., BRANDT, J., LOSSON, B. GEERTS, S.: Kinetics of circulating antigens in pigs experimentally infected with *Taenia solium* eggs. *Veterinary Parasitology*, 111: 323-332, 2003.
- NUNES, C.M., BIONDI, G.F., HEINEMANN, M.B. RICHTZENHAIN, L.J.: Comparative evaluation of an indirect ELISA test for diagnosis of swine cysticercosis employing antigen from *Taenia solium* and *Taenia crassiceps* metacestodes. *Veterinary Parasitology*, 93: 135-140, 2000.
- ONYANGO-ABUJE, J.A., HUGHES, G., OPICHA, M., NGINYI, K.M., RUGUTT, M.K., WRIGHT, S.H. HARRISON, L.J.: Diagnosis of *Taenia saginata* cysticercosis in Kenyan cattle by antibody and antigen ELISA. *Veterinary Parasitology*, 61: 221-230, 1996.
- PHIRI, I.K., DORNY, P., GABRIEL, S., WILLINGHAM III, A.L., SIKASUNGE, C., SIZIYA, S. VERCROYSE, J.: Assessment of routine inspection methods for porcine cysticercosis in Zambian village pigs. *Journal of Helminthology*, 80: 69-72, 2006.
- PINTO, P.S., VAZ, A.J., GERMANO, P.M. NAKAMURA, P.M.: Performance of the ELISA test for swine cysticercosis using antigens of *Taenia solium* and *Taenia crassiceps* cysticerci. *Veterinary Parasitology*, 88: 127-130, 2000.
- PRADO-JEAN, A., KANOBANA, K., DRUET-CABANAC, M., NSENGYIUMVA, G., DORNY, P., PREUX, P.M. GEERTS, S.: Combined use of an antigen and antibody detection enzyme-linked immunosorbent assay for cysticercosis as tools in an epidemiological study of epilepsy in Burundi. *Tropical Medicine and International Health*, 12: 895-901, 2007.
- SARTI, E., SCHANTZ, P.M., PLANCARTE, A., WILSON, M., GUTIERREZ, I.O., LOPEZ, A.S., ROBERTS, J. FLISSER, A.: Prevalence and risk factors for *Taenia solium*

taeniasis and cysticercosis in humans and pigs in a village in Morelos, Mexico. *American Journal of Tropical Medicine and Hygiene*, 46: 677-685, 1992.

SATO,M.O., YAMASAKI,H., SAKO,Y., NAKAO,M., NAKAYA,K., PLANCARTE,A., KASSUKU,A.A., DORNY,P., GEERTS,S., BENITEZ-ORTIZ,W., HASHIGUCHI,Y. ITO,A.: Evaluation of tongue inspection and serology for diagnosis of *Taenia solium* cysticercosis in swine: usefulness of ELISA using purified glycoproteins and recombinant antigen. *Veterinary Parasitology*, 111: 309-322, 2003.

SIKASUNGE,C.S., PHIRI,I.K., PHIRI,A.M., SIZIYA,S., DORNY,P. WILLINGHAM III,A.L.: Prevalence of *Taenia solium* porcine cysticercosis in the Eastern, Southern and Western provinces of Zambia. *Veterinary Journal*, 176: 240-244, 2008.

VANKERCKHOVEN,I., VANSTEENKISTE,W., CLAES,M., GEERTS,S. BRANDT,J.: Improved detection of circulating antigen in cattle infected with *Taenia saginata* metacestodes. *Veterinary Parasitology*, 76: 269-274, 1998.

WALTHER,M. KOSKE,J.K.: *Taenia saginata* cysticercosis: a comparison of routine meat inspection and carcass dissection results in calves. *Veterinary Record*, 106: 401-402, 1980.

WANZALA,W., KYULE,N.M., ZESSIN,K.H., ONYANGO-ABUJE,A.J., KANG'ETHE,K.E., OCHANDA,H. HARRISON,J.S.: Evaluation of an antigen-ELISA in the diagnosis of bovine cysticercosis in Kenyan cattle. *Parasitology Research*, 100:539-548, 2007.

WANZALA,W., ONYANGO-ABUJE,J.A., KANG'ETHE,E.K., ZESSIN,K.H., KYULE,N.M., BAUMANN,M.P., OCHANDA,H. HARRISON,L.J. Control of *Taenia saginata* by post-mortem examination of carcasses. *African Health Science*, 3: 68-76, 2003.

WANZALA,W., ONYANGO-ABUJE,J.A., KANG'ETHE,E.K., OCHANDA,H. HARRISON,L.J.: Serodiagnosis of bovine cysticercosis by detecting live *Taenia saginata* cysts using a monoclonal antibody-based antigen-ELISA. *Journal of South African Veterinary Association*, 73: 201-206, 2002.

# SAVREMENE DIJAGNOSTIČKE PROCEDURE U DIJAGNOSTICI CISTICERKOZE KOD GOVEDA I SVINJA

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## Izvod

Tenijaza i cisticerkoza predstavljaju značajan javno-zdravstveni problem širom sveta. Kontrola ove zoonotske bolesti zahteva korišćenje zadovoljavajućih laboratorijskih testova koji identifikuju zaražene životinje kao rezervoare infekcije ljudi. Inspekcija mesa je jedina važeća mera prevencije i kontrole humanih infekcija, ali je slabo osetljiv metod za detekciju živih metacestoda kod životinja. Postoji potreba za razvojem savremenih i osetljivijih dijagnostičkih testova. Testovi zasnovani na detekciji antitela ne mogu da utvrde da li su cisticerkusi u muskulaturi vijabilni, što je sa aspekta javnog zdravlja najvažnije. Imunološki testovi zasnovani na detekciji sekretorno/ekskretornih antigena (Ag-ELISA) mogu da dokažu žive metacestode. U radu je dat prikaz svih metoda u dijagnostici cisticerkoze kod goveda i svinja, iako za sada, nema standardizovanih, komercijalnih testova.

**Ključne reči:** cisticerkoza, inspekcija mesa, imunoenzimski testovi, ES Ag-ELISA.

Received / *Primljen*: 06.11.2011.

Accepted / *Prihvaćen*: 28.11.2011.