Short Communication

First report of epidemic prevalence of cerebral coenurosis in ten sheep herds in Iran

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Summary
Coenurosis is a neurological parasitic infection of sheep caused by the larval stage of Taenia multiceps. In spring 2020, several animals were referred from different flocks (10 sheep herds) to the Clinic of Faculty of Veterinary Medicine, Urmia University, Iran with a history of acute neurological dysfunctions associated with increased mortality. Affected animals were 5-8 months years-old from the mixed breed and both sexes. Physical and ophthalmoscopic examinations were performed. The cerebrospinal fluid (CSF) samples were obtained from the lumbosacral region and were examined grossly and microscopically. The CSF examination showed a mixed population of mononuclear cells with a predominance of small lymphocytes and reduced number of monocytes. Neutrophils were also occasionally observed. Dissection of the brain revealed ventricular deformity Coenurus cerebralis with white protoscolices causing the obstruction of the ducts and thus resulting in internal hydrocephalus and lateral ventricles enlargement. This study, as the first report of the epidemic incidence of cerebral coenurosis in sheep from Urmia, Iran, implies a failure of prevention and control measures against a parasitic disease. Thus, regular chemical-prophylactic protocols of dogs and correct disposal of the infected brain upon slaughtering or death of animals to prevent scavenging by dogs can control it.

Keywords: Taenia multiceps, Coenurosis, Sheep, Outbreak, Cerebrospinal fluid

Introduction
Coenurosis is an infectious parasitic disease occurred by the invasion of the brain and spinal cord with Taenia multiceps larvae. Coenurus cerebralis (C. cerebralis) is the metacestode or larval form of the dog tapeworm T. multiceps and the adult worm inhabits the small intestine of dogs and some other carnivores (Mahadevan et al., 2011). Sheep is the usual animal intermediate host, whereas it also has numerous other definitive
and intermediate hosts and, occasionally, humans. Coenurosis is present worldwide, mainly in sheep-farming regions of the world causing a disease known as gid (Sturdy), as the infected sheep shows ataxia and circles around its position. As a consequence, localized, space-occupying lesions by thin, translucent, and large uni- or multilocular cysts are produced in the central nervous system (CNS; Oryan et al., 2014). The cysts contain clear and watery fluid with hundred of white nodules on its inner surface, measuring a few millimeters in diameter (Varcasia et al., 2013). The leptomeninges, brain parenchyma, and ventricles are the preferred sites of cysts. In acute outbreaks, neurological signs of coenurosis rise with various degrees of muscle tremors, excitability, ataxia, blindness, and nystagmus, which in the majority of cases result in the death of the animal, due to starvation after several days (Abera and Wubit, 2016). These clinical signs are caused by an acute inflammatory response than by mechanical action of the cyst. The symptoms are strictly connected with the number of ingested eggs, the immune state of the host, and the localization of the parasites in the CNS (Scala and Varcasia, 2006).

It was previously reported that chronic form of cerebral coenurosis is more frequent than the acute form, although both forms are usually fatal (Alemu et al., 2015). Notably, chronic coenurosis mostly happens in older animals of more than six months of age (Oryan et al., 2014). When the cyst volume increases, the subsequent clinical signs become more evident (Scala and Varcasia, 2006). Because of the local lesion, the infected animal holds its head to one side and turns in a circle (Oryan et al., 2014). However, other clinical symptoms like incoordination, ataxia, head pressing, drowsiness, blindness, and coma commonly lead to the death of the affected animal within several weeks (Abera and Wubit, 2016). In this regard, clinicopathological evaluations are not commonly applied in diagnosis in the suspected animals, and serological assays are not sufficiently specific to be of value. When necropsy is done, thin-walled cysts may be found anywhere in the brain, which is most commonly observed on the external surface of the brain. Many of the infected animals die after some weeks of starvation (Scala and Varcasia, 2006). Scrapie, louping ill, listeriosis, sarcocystosis, nasal bots syndrome, brain abscessation, and cerebrocortical necrosis due to thiamin deficiency should be considered as the differential diagnosis (Oryan et al., 2014).

The most common affected site in the spinal cord is the lumbar region. In this line, local pressure atrophy of nervous tissue is detectable, which may extend to softening of the overlying bone. It is necessary that this should be differentiated from other local space-occupying lesions of the CNS, including abscess, tumor, and hemorrhage. As a matter of decision, it is possible to fatten the infected animal for slaughter, after surgical drainage of the cyst. The control of mature worm infestation in dogs can satisfactorily break the life cycle of tapeworm. Thus, it is believed that a periodic treatment of farm dogs by a tenicide therapy is necessary for prevention of this and other tapeworms. Moreover, it is suggested that the carcasses of the infested livestock with the larva
should not be available to dogs. Also, a previous
study has reported that anthelmintic agents
demonstrate efficacy in treating coenurosis in
naturally affected sheep, as presented by
degeneration of the cysts in the treated animals
(Oryan et al., 2014). As more details, the best
results have been reported with oral albendazole, or
combination of fenbendazole and praziquantel.
Recently, high rates of sheep mortalities with
neurological clinical signs were observed in
several sheep herds in the Urmia region, in the
northwest of Iran. Thus, the present study aimed to
demonstrate the potential role of C. cerebralis in
such sheep mortalities. This study is the first report
of a cerebral coenurosis outbreak in sheep from
Iran.

Materials and methods
In spring 2020, several animals were referred to the
Clinic of Faculty of Veterinary Medicine, Urmia
University, Iran from different flocks (10 sheep
herds) with a history of acute neurological
dysfunctions and with increased mortality. Animals were 5-8 months years-old from the
mixed breed and both sex. Physical and
ophthalmoscopic examinations were performed.
The blood sample was obtained from the right
gular vein. The CSF obtained from the
lumbosacral region and was examined grossly and
microscopically.

Results
Clinical signs
The affected animals presented the typical clinical
neurological signs such as circling behavior,
incoordination, depression, visual defects, poor
appetite, star gazing, head tilt, a tendency to keep
away from other animals in the flock, neck rigidity,
and irregular gait. The absence of menace reflex
with the presence of direct pupillary light reflex
demonstrated a central blindness. Also, a moderate
congestion of retinal venules was indicated in the
ophthalmoscopic examination.

Herd history findings
Examination of the herd's history revealed that
there was an unusual population of dogs (over ten
dogs) in the herd, which had not received any
antiparasitic treatment. Interestingly, the herdsmen
were unaware of the transmissible disease between
dogs and sheep and the necessity of an antiparasite
therapy program for the herd dogs.

Laboratory findings
The analysis of hematology parameters is
presented in Table 1. A neutrophilic reaction with
an increase in total protein and fibrinogen levels
was detected that may be attributed to other
concurrent infectious diseases. The CSF
examination showed a mixed population of
mononuclear cells with the predominance of small
lymphocytes and the low numbers of monocytes.
Neutrophils were also occasionally observed. The
CSF protein concentration was slightly increased.
The biochemical alterations with more details are
shown in Table 2. Calcium level was normal,
whereas that of magnesium showed a slight
increase in the CSF of the affected animals. Other
factors that have not yet been evaluated in sheep
CSF, were compared with the values reported in
cattle. Creatine kinase and lactate dehydrogenase
activity were increased compared to the normal
range of values reported in the references (Kaneko, 2008). The increase in the enzyme activities was very significant. The results of microbial culture for detection of *Listeria monocytogenes* in the brain tissues were negative.

**Table 1.** Hematology values of the infected sheep.

<table>
<thead>
<tr>
<th>Hematology Parameters</th>
<th>Normal range*</th>
<th>Sampled sheep (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCV (%)</td>
<td>24-49</td>
<td>31.1 ± 0.41</td>
</tr>
<tr>
<td>HB (g/dl)</td>
<td>8.0-16</td>
<td>10.3 ± 0.13</td>
</tr>
<tr>
<td>RBC</td>
<td>8.0-15</td>
<td>12.2 ± 0.73</td>
</tr>
<tr>
<td>MCV (fL)</td>
<td>23-48</td>
<td>25.4 ± 0.40</td>
</tr>
<tr>
<td>MCH (pg)</td>
<td>8.0-12</td>
<td>8.4 ± 0.00</td>
</tr>
<tr>
<td>MCHC (g/dl)</td>
<td>31-34</td>
<td>33.1 ± 0.21</td>
</tr>
<tr>
<td>Total WBC (µL)</td>
<td>4000-12000</td>
<td>7600 ± 10.00</td>
</tr>
<tr>
<td>Neutrophil</td>
<td>1000-5000</td>
<td>4940 ± 22.80</td>
</tr>
<tr>
<td>Eosinophil</td>
<td>100-750</td>
<td>152 ± 6.90</td>
</tr>
<tr>
<td>Lymphocyte</td>
<td>2000-9000</td>
<td>2356 ± 43.11</td>
</tr>
<tr>
<td>Monocyte</td>
<td>0-750</td>
<td>152 ± 8.30</td>
</tr>
<tr>
<td>Platelets</td>
<td>3.0-8.0</td>
<td>7.82 ± 0.90</td>
</tr>
<tr>
<td>Total protein(g/dl)</td>
<td>6.0-7.9</td>
<td>9.8 ± 0.51</td>
</tr>
<tr>
<td>Fibrinogen(mg/dl)</td>
<td>100-500</td>
<td>700 ± 0.00</td>
</tr>
</tbody>
</table>

*Normal range for hematology parameters in ruminant adopted from reference indexes (Kaneko, 2008).

**Postmortem findings**

Cysts of various sizes were detected in cerebral hemispheres (figure 1 and 2). Dissection of the brain revealed ventricular deformity *C. cerebralis* with white protoscolices causing the obstruction of the ducts and consequently resulting in internal hydrocephalus and lateral ventricles enlargement.

**Discussion**

Cerebral coenurosis is a serious endemic disease of small ruminants in the world and especially in the Middle Eastern countries that has already been reported from Iran, Oman, Egypt, Turkey, Jordan, and Iraq (El-Neweshy et al., 2019). In this regard, there has been only a little number of scientific reports focusing on the occurrence of coenurosis in sheep in Iran, though the outbreak form has not yet been reported. In the current study, the problem as an outbreak of coenurosis was detected in 10 semi-industrial sheep raising farms. Notably, the affected goats presented non-specific nervous system manifestations. Different clinical signs like ataxia, circling, incoordination, blindness, drowsiness, head pressing, hind leg paralysis, and coma have been indicated in the affected animals as reported in previous studies (Abera and Wubit, 2016; El-Neweshy et al., 2019; Oryan et al., 2014).

**Table 2.** Biochemical characteristics of CSF in the infected sheep.

<table>
<thead>
<tr>
<th>Biochemistry Parameters</th>
<th>Normal range in sheep*</th>
<th>Sampled sheep (Mean)</th>
<th>Normal range in cow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (mg dL-1)</td>
<td>5.6 ±0.3</td>
<td>5.23± 0.30</td>
<td>-</td>
</tr>
<tr>
<td>Magnesium (mg dL-1)</td>
<td>2.88</td>
<td>1.52± 0.01</td>
<td>1.8–2.1</td>
</tr>
<tr>
<td>Sodium (mg dL-1)</td>
<td>-</td>
<td>100.7 ± 0.00</td>
<td>132–142</td>
</tr>
<tr>
<td>Potassium (mEqL-1)</td>
<td>-</td>
<td>3.22± 0.04</td>
<td>2.7–3.2</td>
</tr>
<tr>
<td>Creatine kinase (U/l)</td>
<td>-</td>
<td>64 ± 0.00</td>
<td>2–48</td>
</tr>
<tr>
<td>Lactate dehydrogenase</td>
<td>-</td>
<td>54 ± 0.00</td>
<td>2–25</td>
</tr>
</tbody>
</table>

*Normal range for biochemistry parameters of CSF in ruminant adopted from reference indexes (Kaneko, 2008).
Although, many other differential diagnosis such as sarcocystosis, nasal bots syndrome, brain abscessation, and polioencephalomalacia, thiamin deficiency was considered (Oryan et al., 2014), the post-mortem demonstration of C. cerebralis cyst in necropsy suggests that the coenurosis is the main pathological condition being prevalent and is likely to constitute a significant health problem in sheep herds with noticeable economic loses. In the present study, we reported unique clinical and pathological findings of sheep coenurosis. We found a large number of small cysts in the brain parenchyma with a loose connection to the tissue, which easily separated; interestingly, the number...
and sizes of the recovered cysts were similar to those reported in the literature (Alemu et al., 2015; El-Neweshy et al., 2019; Tavassoli et al., 2011). Here, pathological lesions of the affected brain tissues were more extensive than the focal granulomatous lesions reported in the previous studies (Nourani and Kheirabadi, 2009; Sharma and Chauhan, 2006; Shivasharanappa et al., 2017). This variation of the cyst-induced inflammatory response may be related to the host immune status and parasitic burden. When *C. cerebralis* is posited in the nervous tissues, lead to space-occupying lesions, and the mortality rate may reach 100% (Sharma and Chauhan, 2006). Growing evidence suggests that chemotherapy is ineffective and surgical intervention is only recommended for valued animals (Sharma and Chauhan, 2006). The CSF examination showed a mixed population of mononuclear cells with the predominance of small lymphocytes and the low numbers of monocytes. Neutrophils were also occasionally observed and protein concentration was slightly increased. The presence of a large blood clot on the cerebellum surface represents various migration routes and entrance sites of larva from vessels to the neural tissue and subsequent vessel laceration. As it was anticipated, such severe hemorrhage led to death. It seems that infection propagation is ecology-dependent, as that increased by high moisture, rainfall, and moderate temperature of the region. In these climatic conditions, the parasitic eggs are viable for a longer period and facilitate their incidence (Scala and Varcasia, 2006). On the other hand, a potential possible reason could be the increase in the rainfall and humidity of the study area in the recent year (2020). Following the rainy season, many street dogs have taken refuge to Urmia Mountains and ranges where the affected sheep were grazing.

A seasonal variation has already been reported for occurrence of coenurosis with the highest rates during the spring, in chronic forms and more commonly in lambs (Scala and Varcasia, 2006). Many factors including unhygienic disposal of dead animals, poor management, no guard dogs deworming, and exposure to stray dogs and wild canids could keep the parasite life cycle in such open livestock grazing areas. It was notable that there was not any anti-parasitic program in the herds examined.

**Conclusion**

The present study demonstrates the first outbreak of cerebral coenurosis in sheep from Urmia, based on clinical, postmortem, and laboratory findings. Given the zoonotic implications and economic losses, the current study highlights the importance and necessarily of suitable prevention and control methods of the cerebral coenurosis.

**Acknowledgments**

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**Conflict of interest statement**

There is no conflict of interest.

**Ethical approval**

Not applicable.
Reference


Nourani H. & Kheirabadi K. P. Cerebral coenurosis in a goat: pathological findings and literature review. Comparative Clinical Pathology, 2009, 18, 85-87.


