GUIDELINE for Cytauxzoonosis

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The Cytauxozoonosis guidelines were first published in the Journal of Feline Medicine and Surgery (2015) 17:637–641 by Albert Lloret et al.; the present update has been authorised by Maria Grazia Pennisi.

Key points

- Cytauxzoonosis has been reported worldwide, both in domestic and wild cat species. The parasite is transmitted via ticks, and prevalence is higher in cats with outdoor access and in feral cats.
- At least two distinct *Cytauxzoon (C.)* spp. are known to occur in the domestic cat: *Cytauxzoon felis* in North and South America and *Cytauxzoon* sp. in Europe.
- In the US, cytauxzoonosis by *C. felis* is typically an acute or peracute, severe febrile disease of domestic cats. Non-regenerative haemolytic anaemia is often present, as are neurological signs, followed by death in nearly all cases.
- Cats infected with *Cytauxzoon* sp. have been reported in Europe; the clinical course of acute disease is severe with fatal outcome, but mild forms and asymptomatic carrier cats have been described.
- In practice, suspicion is often obtained from blood smears and in *C. felis* infection fine needle aspirates from the liver, spleen and lymph nodes. Quick Romanowsky-type stains can be used to demonstrate schizonts.
- PCR assays have been developed to confirm the presence of *C. felis* and *Cytauxzoon* sp.
- Current treatment of choice is a combination of atovaquone (15 mg/kg PO q8h) and azithromycin (10 mg/kg PO q 24h), as well as fluids, heparin and supportive care.
- Surviving cats can become chronic carriers.
- Prevention is based on living indoor or use of effective tick treatment in outdoor cats.
- Blood transfusion from healthy carriers can be a source of infection.

Agent properties

Cytauxzoon species are emerging apicomplexan haemoparasites (order Piroplasmida, family Theileriidae) of wild and domestic cats, transmitted by ticks. *Cytauxzoon felis* is the main species of felids found in the Americas and China while in the Old World *Cytauxzoon manul* and closely related species are reported. According to the 18S rDNA sequence-based analysis *Cytauxzoon* sp from felids forms two separate clades of New and Old World isolates (Panait et al., 2021).

Cytauxzoon (C.) felis is the main species in America, with numerous strains or genotypes, and it was also found in China (Brown et al., 2009; Shock et al., 2012; Pollard et al., 2017; Zou et al., 2019) producing infection and severe disease in domestic cats (Haber et al., 2007; Brown et al., 2008), bobcats, lions and tigers (Brown et al., 2010; Reichard et al., 2010; Shock et al., 2011). Wild cats (bobcats, mountain lions, ocelots, spotted cats and jaguars) in North and South America can act as reservoir or incidental hosts (Blouin et al., 1984; Furtado et al., 2017).

Domestic cats can also present with subclinical infections and also act as reservoirs (Haber et al., 2007; Brown et al., 2008; Rizzi et al., 2015). In some endemic areas, the prevalence of subclinical infection in cats can be as high as 30% (Brown et al., 2010). Interestingly, USA and Brazil isolates form two subclades by 18S rDNA sequence-based analysis (Panait et al., 2021).

Tick vectors for *C. felis* in the USA are *Amblyomma americanum* and *Dermacentor variabilis* and transstadial transmission has been demonstrated in ticks (Blouin et al., 1984; Reichard et al., 2010; Shock et al., 2011; Allen et al., 2019). An experimental study demonstrated that the duration of tick attachment needed for transmission to occur is at least 36 hours, and ingestion of ticks is not a likely mode of transmission (Thomas et al., 2017).

European Cytauxzoon species

Cytauxzoon manul infects free-ranging Pallas cats (*Otocolobus manul*) in Mongolia and a closely related species (*Cytauxzoon* sp.) has been documented in Europe since 2004 in domestic (*Felis silvestris catus*) and wild cats (*Felis silvestris silvestris*), the Iberian Lynx (*Lynx pardinus)*, and the Eurasian lynx (*Lynx lynx*) (Criado-Fornelio et al., 2004, 2009; Luaces et al., 2005; Millan et al., 2007, 2009; Meli et al., 2009; Carli et al., 2012, 2014; Veronesi et al., 2016; Gallusova et al., 2016; Nentwig et al., 2018; Diakou et al., 2020). It was therefore supposed that distinct *Cytauxzoon* species or strains exist in different geographic areas and hosts, and the taxonomy of these pathogens has started to be clarified in genetic studies (Panait et al., 2021). Mongolian *C. manul* and European isolates form two subclades by 18S rDNA sequence-based analysis (Panait et al., 2021). Additionally, the diversity of *Cytauxzoon* spp. infecting European wild felids (*Felis silvestris silvestris* and *Lynx lynx*) was better assessed by analyses of two mitochondrial markers, and three separate species have been proposed based on genetic differences: *C. europaeus*, *C. otrantorum*, and *C. banethi* (Panait et al., 2021). Similar genetic evaluation of isolates from domestic cats is currently lacking.

The tick vectors for the European species are unknown, but could be represented by *Dermacentor* spp*., Ixodes* spp., and/or *Rhipicephalus* spp. Recently a case of blood transfusion-transmitted cytauxzoonosis was reported in Switzerland (Nentwig et al., 2018).

Epidemiology

Cytauxzoonosis caused by C*. felis* has been documented in wild felids of Americas including Bobcats, Florida panthers and Texas cougars. The first cases in domestic cats were documented in 1976 (Wagner, 1976). For many years, cytauxzoonosis in domestic cats was reported in North America only (South eastern and central states and mid-Atlantic regions) (Tarigo et al., 2013; Miller and Davis, 2013) but it was also found in South America (Maia et al., 2013) and China (Zou et al., 2019).

In the USA it has been hypothesized that infection in domestic cats was the result of a host species jump from bobcats, where the infection prevalence can be high (Shock et al., 2011). In this country the acute disease shows a seasonal incidence from spring to summer or early fall associated with the peak activity of the tick vectors (Reichard et al., 2008; Miller et al., 2011; Wikander et al., 2020a). There is a significant association between infection and outdoor access, and with feral cats in areas where vector ticks are prevalent (Reichard et al., 2008). According to a case-control retrospective study performed in eastern Kansas (USA), acute cytauxzoonosis was most frequently observed in male owned cats aged $\geq$ 1 years (Wikander et al., 2020a). In the same area a high prevalence (25.8%) was determined by blood PCR in asymptomatic domestic cats, with a higher percentage of positivity in spring and fall (Wikander et al., 2020b).

In China (Yunnan province), a molecular survey found a prevalence of 21.5% in 311 domestic cats and it was significantly higher in stray (51.4%) compared to pet (12.2%) cats (Zou et al., 2019).

A hyperendemic focus can be found within endemic areas but is likely due to tick exposure of cats rather than to cat-to-cat transmission, which has never been proven (Birkenheuer et al., 2006; Woods, 2013).

European Cytauxzoon species

Cytauxzoon infection and disease cases in domestic cats and wild felids have also been documented in Europe and they are caused by *C. manul* or a closely related *Cytauxzoon* species. Rare clinical cases were reported in cats from Spain, France, Italy, Portugal and Switzerland (Criado-Fornelio et al., 2004, 2009; Carli et al., 2012, 2014; Alho et al., 2016; Legroux et al., 2017; Nentwig et al., 2018; Panait et al., 2020). Epidemiological investigations reported a *Cytauxzoon* DNA prevalence of 1.2% in domestic cats from the Madrid area in Spain (Díaz-Regañon et al., 2017). In the latter region, *Cytauxzoon* sp. infection was more frequently detected during the winter season, and in cats living in rural areas. Additionally, an association with FIV infection was reported (Díaz-Regañon et al., 2017).

In the Trieste region (North-Eastern Italy), samples from owned (55) and colony (63) cats showed a 23% prevalence of infection, with a significantly higher prevalence in colony cats or cats with outdoor lifestyle (31%); none of the four indoor cats sampled was found to test positive in this study (Carli et al., 2012). Additionally, no statistical association was found between PCR positivity and breed, age, presence of ticks and/or fleas, clinical status, anemia, FIV and/or FeLV status and mortality rate (Carli et al., 2012).

Conversely, positive samples were not detected in a population of 263 stray cats tested in Milan (Spada et al., 2014), in 112 colony cats and 174 shelter cats from Central Italy (Morganti et al., 2019), nor in cats from Sicily and Calabria (Persichetti et al., 2018).

Chronically infected domestic cats serve as a reservoir, since long-lasting parasitaemia (up to four years) has been documented in asymptomatic individuals (Carli et al., 2012, 2014; Legroux et al., 2017; Hofmann-Lehmann, unpublished data) and accidental transmission following blood transfusion with blood from a healthy carrier was reported (Nentwig et al., 2018). As the number of domestic cats is obviously much higher than those of wild felids (*Iberian lynx*, *Lynx lynx* and wildcats) in anthropized areas, free-roaming cats and particularly those not receiving regular ectoparisiticide treatments against ticks could play a primary role in maintaining endemicity.

Interestingly, among 21 carcasses of wildcats from Northern and Central Italy that were investigated by PCR three cats tested positive (19%) (Veronesi et al., 2016). A retrospective genetic analysis by nested-PCR of 106 carcasses of wild felids (92 *Felis silvestris silvestris* and 14 *Lynx lynx*) from Germany, Romania, Czech Republic and Luxembourg found a very high *Cytauxzoon* spp. overall prevalence (60.4%) (Panait et al., 2021). In this study, in which genetic analysis of 64 positive samples and of 18 additional positive samples from previous investigations (also from Italy, Bosnia and Herzegovina) was performed, the genetic differences found led to the proposal to consider three different species, with *C. europaeus* being most prevalent (80%) and widespread in European wildcats and lynx compared to *C. otrantorum* and *C. banethi* that were found in *Felis silvestris silvestris* carcasses from Romania only (Panait et al., 2021).

Pathogenesis

The life cycle and complex pathogenesis have been well described for *C. felis* infection (Kier et al., 1987). Vector ticks ingest merozoite-infected red blood cells from the natural reservoir host (bobcat, lynx or domestic cats). The parasite initiates a process of sexual replication (gametogenesis) in the tick gut and salivary glands. This leads to the formation of sporozoites, which are the infective form and can be transmitted if the tick attaches to a domestic cat or another susceptible felid. Sporozoites infect endothelial-associated mononuclear cells and undergo asexual replication within the macrophages that become a large structure known as schizonts – large enough to occlude blood vessels, especially in the liver, spleen, lymphnodes and lungs. Widespread dissemination of *C. felis* schizonts results in parasitic thrombosis, circulatory impairment, tissue infection (included uveal tissues) and severe systemic inflammatory response, which can lead to multi-organ dysfunction and failure and death within 3 weeks after infection (Snider et al., 2010; Meekins and Cino-Ozuna, 2018). When schizonts rupture in the circulation, large numbers of merozoites are released infecting red blood cells and additional mononuclear cells. This is the late-stage with erythroparasitaemia (piroplasma structures within red blood cells) which can be readily observed in blood smears and may lead to haemolytic anaemia and erythrophagocytosis.

Two studies evaluated systemic and lung immune responses in cats naturally infected with *C. felis* based on serum concentrations of TNFα, IL-1 β and serum proteins, immunohistochemistry expression of several inflammatory mediators and PCR assay for CD18. Both studies show a marked systemic and lung pro-inflammatory response that can contribute to the pathogenesis of the disease and is even higher in cats that died compared with survivors (Frontera-Acevedo et al., 2013; Frontera-Acevedo and Sakamoto, 2015).

Recovered cats are considered chronic carriers, resistant to reinfection; however, suspected cases of a second acute disease have been reported (Cohn et al., 2020), and a bobcat with a chronic *C. felis* infection was found infected by a second, different strain one year apart (Zieman et al., 2018).

European Cytauxzoon species

Genetic differences between *C. felis* and *Cytauxzoon* sp. detected in European felids could be responsible for the different pathogenicity, but information is very limited (Nentwig et al., 2018). Schizogony has not yet been described at necropsy of the few *Cytauxzoon* sp. infected cats evaluated (Carli et al., 2012). Absence of schizogony might explain the milder disease observed in most *Cytauxzoon* sp. infected cats compared to *C. felis* infected cats.

Clinical signs

Cytauxzoonosis caused by *C. felis* is typically an acute or peracute severe febrile disease. Clinical signs are nonspecific and consist of depression, anorexia, high fever, icterus, dyspnoea, tachycardia, generalized pain and vocalization. Signs of haemolytic anaemia are frequent (pale mucous membranes, pigmenturia, splenomegaly, hepatomegaly). Some cats may present with or evolve to late stages with neurological signs (ataxia, seizures, nystagmus) due to severe ischaemic damage to CNS (Clarke et al., 2017), hypothermia, moribund state and coma. Many cats die within one week after the onset of clinical signs (Hoover et al., 1994; Birkenheuer et al., 2006). Veterinarians practicing in endemic areas must suspect cytauxzoonosis when faced with cat showing acute, severe disease.

Frequent clinicopathological signs include non-regenerative anaemia, leukopenia with toxic changes, thrombocytopenia, hyperbilirubinaemia, bilirubinuria and an increase of liver enzymes. These changes are associated with erythrophagocytosis and systemic inflammatory response syndrome (SIRS). Coagulation times usually are prolonged due to disseminated intravascular coagulation (DIC). Other biochemical abnormalities are hypoalbuminaemia, hyperglycaemia, pre-renal azotaemia and electrolyte and acid-base disturbances associated with the SIRS state (Hoover et al., 1994; Birkenheuer et al., 2006).

Diagnostic imaging reveals nonspecific signs consisting in hepatosplenomegaly on abdominal radiographs and/or ultrasound and a pulmonary interstitial-alveolar pattern in thoracic radiographs.

European Cytauxzoon species

Few clinical cases were reported in Europe (figure 1) with a total number of 12 cats as of December 2020 with clinical signs associated with erythroparasitaemia (Carli et al., 2012, 2014; Alho et al., 2016; Legroux et al., 2017; Nentwig et al., 2018; Panait et al., 2020). Interestingly, five of the cats were kittens (age range 2-7 months) and two groups of siblings were found affected (Carli et al., 2014; Nentwig et al., 2018). The ages of the other seven cats ranged between 1 and 14 years, with two junior, one prime, three mature, and one geriatric cat. All but two cats had outdoor access and the other two had outdoor access up to no more than one year before. Tick infestation or exposure was reported in six cases (Carli et al., 2012, 2014; Nentwig et al., 2018). Two cats had received prednisone for treating dermatitis or stomatitis before the diagnosis (Carli et al., 2012). A severe disease, mostly with acute onset, was reported in seven cases with one or more of the following signs: fever, anorexia and lethargy, pallor, tachycardia, tachypnoea, heart murmur, anaemia, underweight, diarrhoea, vomiting, abdominal pain, subcutaneous haematomas, jaundice, neurologic signs, dyspnoea associated with pleural and peritoneal effusions (Carli et al., 2012; Alho et al., 2016; Legroux et al., 2017; Nentwig et al., 2018). Pancreatitis was suspected in two of these cats (Carli et al., 2012; Nentwig et al., 2018). Mild disease with a favourable outcome was reported in kittens and young cats (Carli et al., 2012; Nentwig et al., 2018). In two young siblings, diarrhoea was the main complaint and one had a corneal lesion (Carli et al., 2014). There were no historical signs reported for two of three positive kitten siblings whilst the third presented with anorexia and lethargy, but clinical examination evidenced pale mucous membranes and tachycardia in all three kittens (Nentwig et al., 2018). Complete blood cell count, biochemical profile, and tests for co-infections were variably performed. Mild to severe anaemia was however the most frequent clinicopathological abnormality reported in nine cats at diagnosis and in one more cat when euthanasia was performed 25 days after diagnosis (Carli et al., 2012, 2014; Alho et al., 2016; Nentwig et al., 2018; Panait et al., 2020). Information about regenerative response is available for seven cases with a marked regeneration in the four cases diagnosed in Switzerland (Nentwig et al., 2018). Interestingly, the anaemic cat infected by blood transfusion was PCR negative at admission and shifted from non-regenerative to regenerative anaemia two weeks after the blood transfusion had been given, when it became parasitaemic and PCR positive. The severe haemolytic anaemia seen in a cat in Italy was non-regenerative (Carli et al., 2012) as well as the mild anaemia of a kitten in Italy (Carli et al., 2014). Fatality was associated with severe anaemia in two of three cats that died or where euthanized (Carli et al., 2012; Alho et al., 2016). The last case reported in Germany was FIV positive and had a recent history of weight loss and anorexia in the previous days (Panait et al., 2020). The clinico-pathological evaluation evidenced a kidney disease and the cat died after five days of supportive therapy (Panait et al., 2020).

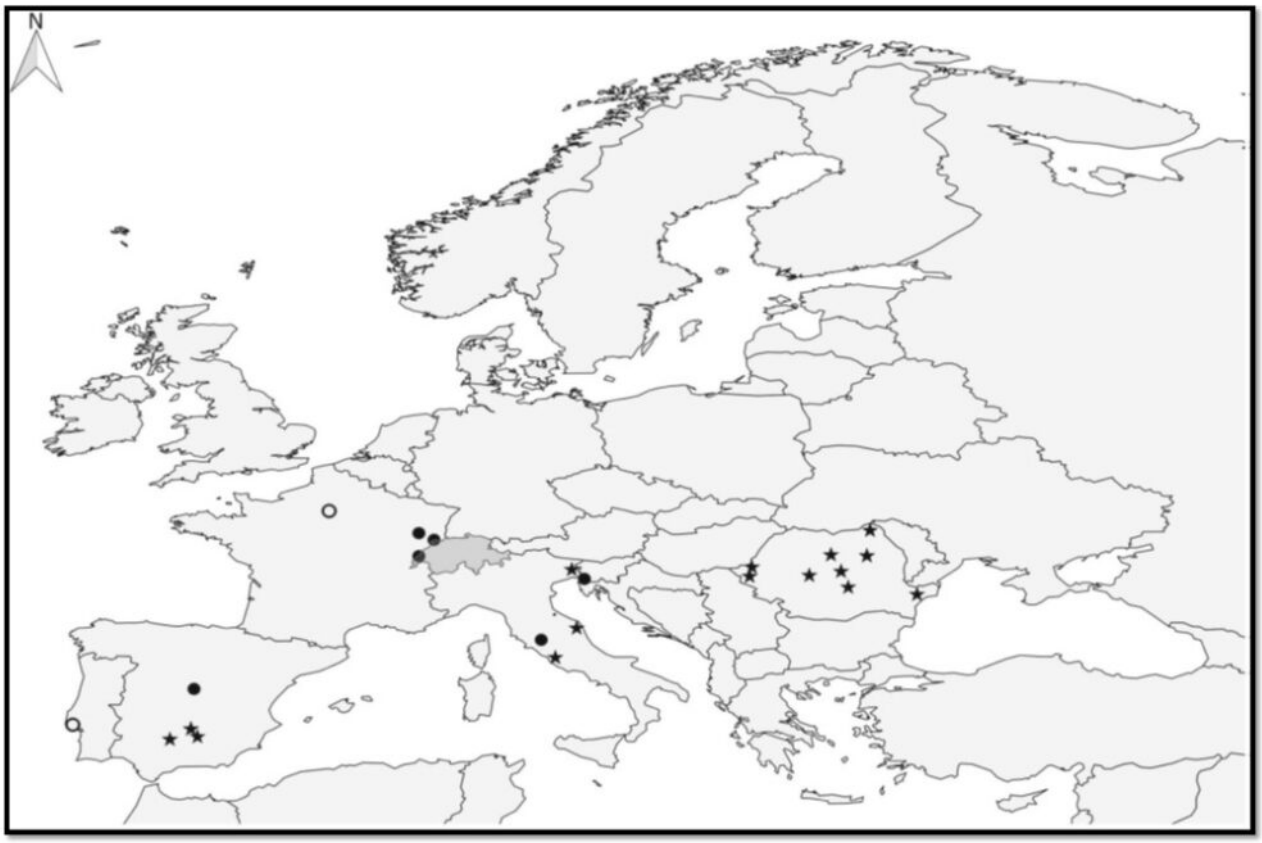

Fig 1. Map of Europe with published Cytauxzoon sp. cases in domestic (dots) and wild (stars) felids. Where the location was not reported in the publication open dots were allocated to the capital of the country (modified from Nentwig et al., 2018).

Diagnosis

In clinical practice, *C. felis* infection is suspected when small piroplasms are observed in blood smears , PCR assays can be used to confirm the diagnosis. Piroplasms are round to oval structures, 1 – 2 µm in diameter, with a dark purple eccentric nucleus within a pale light blue cytoplasm (signet ring shaped), but in some cases may be more elongated with a bipolar nucleus. One to four merozoits within red blood cells can be observed . Distal edges of the blood smears are the best place to look for them. However, accuracy of cytological observation of blood smears is poor for the diagnosis of acute cytauxzoonosis. In fact, merozoites appear late in the course of the disease; so they can be absent or in very low numbers at the onset of clinical signs and blood smears should be repeated daily over the course of the disease. Moreover, observation of merozoites does not confirm acute disease, and can be an incidental finding in cats that survived acute infection or in cats with clinical signs due to another disease. Low levels of parasitaemia can only be detected by PCR assays (Brown et al., 2008). In one clinical trial, parasitaemia was determined by qPCR and was significantly lower in surviving cats *versus* nonsurviving; so qPCR results might be of prognostic value (Meinkoth et al., 2000).

Recognition of schizonts in fine needle aspirates from the liver, spleen and lymph nodes stained with Romanowsky-type stains supports the diagnosis of acute cytauxzoonosis in suspected cases.

Schizonts are seen as very large (50-250 µm diameter), single cells with an eccentric nucleus containing a single prominent nucleus. The cytoplasm contains variable amounts (few to thousands) basophilic particles, which are developing merozoites. These cells may be confused with platelet clumps. PCR assays have been developed to confirm the presence of *C. felis* in both blood and tissue samples (Millán et al., 2007; Birkenheuer et al., 2006; Carli et al., 2012).

European Cytauxzoon sp.

Cytological investigations in clinical cases caused by *Cytauxzoon* sp. found piroplasms in blood smears not morphologically different from those of *C. felis* (figures 2 and 3). However, differently from *C. felis* cases, schizonts were never observed in cytological samples of spleen (Nentwing et al., 2018) and bone marrow (Carli et al., 2012) and at *post mortem* tissue evaluation (Carli et al., 2012; Legroux et al., 2017). It is recommended that samples from suspected cats are submitted to laboratories able to confirm infection by PCR, but so

far not many laboratories offer the PCR assays.

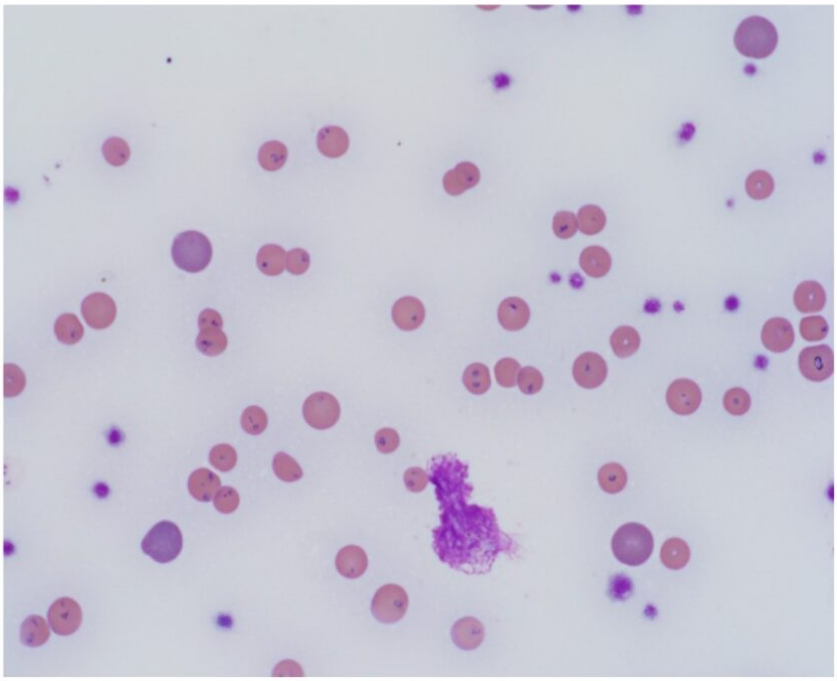

Fig 2. Blood smear of a severely anaemic cat with high parasitaemia of Cytauxzoon sp. One or two round to oval merozoites are in almost all red blood cells. Anisocytosis and polychromasia (MGG stain). © Regina Hofmann-Lehmann, University of Zurich

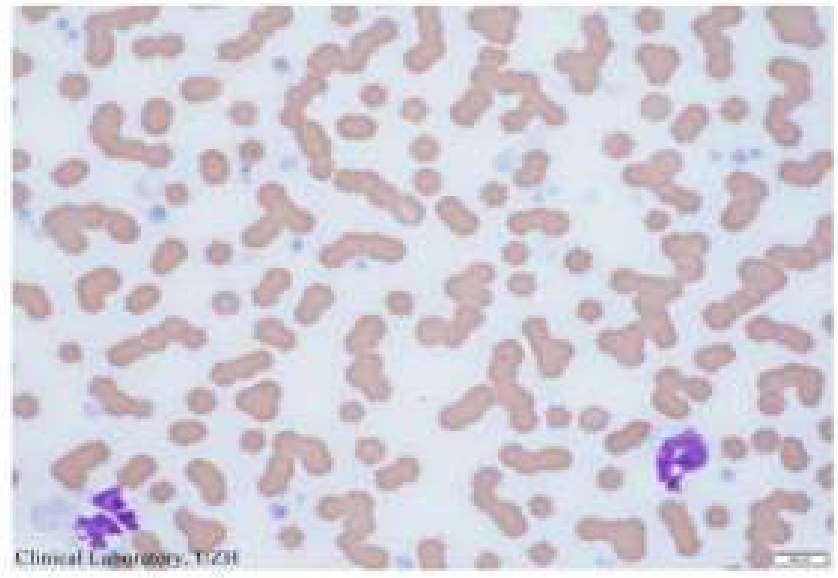

Fig 3. Blood smear of a cat with low grade parasitaemia caused by Cytauxzoon sp. Few red blood cells carrying 1-2 small merozoites (MGG stain). © Regina Hofmann-Lehmann, University of Zurich

Fig 3. Blood smear of a cat with low grade parasitaemia caused by *Cytauxzoon* sp. Few red blood cells carrying 1-2 small merozoites

(MGG stain). © Regina Hofmann-Lehmann, University of Zurich

Treatment

Historically, cytauxzoonosis due to *C. felis* has been considered a fatal disease with mortality close to 100%. Advances in treatment and/or differences in strain pathogenicity, make this statement no longer true, although the prognosis remains guarded (Greene et al., 1999; Meinkoth et al., 2000; Cohn et al., 2011).

Supportive and critical care treatment (intensive fluid and oxygen therapy, anti-thrombus formation drugs like unfractionated heparin 200 U/kg SC q8h, blood products, antibiotics, analgesics) are extremely important to keep the cat alive while the antiprotozoal drugs and immune response take effect. Many cats get worse during the first days and often die, but if they survive, a gradual improvement is seen over the following days (Cohn et al., 2011).

The administration of some antiprotozoal drugs has been reported in case reports or experimental studies (diminazene, imidocarb dipropionate, sodium thiacetarsamide, tetracycline, parvaquone or buparvaquone) but their efficacy has not been proven (Motzel and Wagner, 1990; Greene et al., 1999; Meinkoth et al., 2000).

Imidocarb has been the drug of choice for many years, although it was not known if it provided any advantage over supportive care alone. However, an open-label randomized prospective clinical trial demonstrated better survival rates (60% versus 26%) with the combination of atovaquone (15 mg/kg PO q8h) and azithromycin (10 mg/kg PO q24h) compared to imidocarb (3.5 mg/kg IM once) in 80 cats with acute disease (Cohn et al., 2011). Mortality was high (41/80 cats). Most cats died during the first three days after presentation, only three cats dying after the 3rd day of treatment. Supportive treatment was the same in all cats, including fluids, heparin and supportive care such as tube feeding by means of a naso-oesophageal tube used also to administer oral drugs. This study suggests that this drug combination plus supportive treatment is the current treatment of choice (Cohn et al., 2011). However, atovaquone resistance is possible and linked to parasite cytochrome b mutations. The M128 cytb mutations were found in a cat persistently parasitaemic after repeated atovaquone treatment (Hartley et al., 2020).

Cats surviving the acute infection may become chronic carriers for life with piroplasms within the red blood cells. These cats act as reservoirs and may transmit the infection through tick vectors.

High dosage of diminazene (4 mg/kg IM) for five consecutive days was not effective to eliminate or reduce parasite burden in chronic carrier cats. Moreover, multiple adverse effects appeared, so this treatment is not recommended (Lewis et al., 2014).

European Cytauxzoon species

At present information about efficacy of therapy for cytauxzoonosis diagnosed in Europe is limited and based on the few case reports. Cats with acute cytauxzoonosis were variably treated with drug combinations of azithromycin (10 mg/kg PO q24h), imidocarb (3.5 mg/kg IM twice two weeks apart), or atovaquone (15 mg/kg PO q8h for ten days) (Carli et al., 2102; Alho et al., 2016; Legroux et al., 2017; Nentwig et al., 2018). However, imidocarb and atovaquone are not available in all European countries. In two cases, enrofloxacyn was given in combination with azithromycin or imidocarb and this latter cat subsequently received azithromycin and doxycycline and atovaquone few days before euthanasia (Carli et al., 2012). Blood transfusion was additionally given in two cases (Carli et al., 2012; Nentwig et al., 2018). Prednisolone was given to a cat receiving azithromycin and enrofloxacyn (Carli et al., 2012) and to the cat infected through blood transfusion (Nentwig et al., 2018). In the former case maintenance therapy included prednisolone every two days and doxycycline ten days every month (Carli et al., 2012). The latter case received prednisolone (2 mg/kg q24h) and cyclosporine (5 mg/kg q24h) because immune-mediated disease was suspected to be the cause of initial clinical presentation and Coombs' test was positive (Nentwig et al., 2018).

Prognosis

Prognosis of cytauxzoonosis caused by *C. felis* should be considered guarded to fair, if proper intensive care is provided promptly and atovaquone is available. It has been suggested that different *C. felis* strains may vary in pathogenicity to domestic cats having an influence in survival as some cats have survived after not receiving antiprotozoal drugs (Walker and Cowell, 1995; Meinkoth et al., 2000; Brown et al., 2009). Anyway, it is recommended to treat cats in well-equipped hospitals where the best supportive treatment can be provided.

European Cytauxzoon species

Cytauxzoonosis reported in Europe seems to have a better prognosis: cats may experience subclinical infection or signs of mild disease (anaemia, diarrhoea), possibly unrelated with the infection, but severe and fatal cases have also been documented (Carli et al., 2012, 2014; Alho et al., 2016; Panait et al., 2020).

Prevention

There is currently no vaccine against *C. felis*, although first preliminary studies have being conducted (Tarigo et al., 2013).

Prevention is based on living indoor or use of effective tick treatment in outdoor cats. Efficacy on the prevention of *C. felis* transmission using an acaricide collar (imidacloprid 10% plus flumethrin 4.5%) has been proven in a controlled prospective clinical trial. Two groups of cats (cats with and without collar) were exposed to ticks (*A. americanum*) infected with *C. felis*. None of the cats with collar versus 90% of the cats without collar were infected (Reichard et al., 2013). An experimental study evaluated the preventative efficay of a spot-on formulation (selamectin 6.0 mg/kg plus sarolaner 1.0 mg/kg) against induced infestation by *Amblyomma americanum* adults and the transmission of *C. felis* (Reichard et al., 2019). The topical treatment was >90% effective in reducing *A. americanum* tick counts 72 hours after infestation and significantly prevented transmission of *C. felis* compared to control cats and no treated cats became infected (Reichard et al., 2019).

Testing for the presence of *Cytauxzoon* is advised in feline blood donors. Although inoculation of piroplasms within red blood cells in a blood transfusion does not produce development of schizonts and disease, cats can become chronic carriers and an infection reservoir.

European Cytauxzoon species

The tick vectors for the European species are unknown, but reducing tick exposure by living indoors and effective tick treatment in outdoor cats are potential effective measures for preventing infection with *Cytauxzoon* sp. A case of blood transfusion-transmitted acute cytauxzoonosis was reported in Switzerland (Nentwig et al., 2018), therefore blood donors should be tested by PCR (see http://www.abcdcatsvets.org/blood-transfusion-in-cats/).

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