



# Identification of *Streptococcus suis* in a cat with endomyocarditis

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## Abstract

**Case summary** A 3-year-old neutered male domestic mediumhair cat was evaluated for a 4-month history of a fever that was responsive to pradofloxacin. A grade III/VI left parasternal systolic heart murmur was noted on examination. Findings on thoracic radiography were consistent with left-sided congestive heart failure and findings on echocardiographic examination suggested endomyocarditis. Aerobic blood cultures yielded growth of a *Streptococcus* species that was identified as *Streptococcus suis* using both matrix-associated laser desorption ionization-time of flight mass spectrometry and 16S rRNA gene sequencing. The cat was treated but clinically deteriorated and was euthanized 23 days after diagnosis.

**Relevance and novel information** To our knowledge, this is the first report of *S suis* bacteremia, an emerging pathogen, in association with endomyocarditis in the cat. This case also highlights the role of echocardiography to document progressive hemodynamic changes as a result of valvular erosion in the course of infective endocarditis treatment and the role of blood cultures as a diagnostic tool in cats presenting with fever.

**Keywords:** Endocarditis; bacterial; myocarditis; cardiac infection

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## Case summary

A 3-year-old neutered male domestic mediumhair cat had a 4-month history of fever, weight loss, hyporexia and vomiting. On physical examination at the referring veterinarian, the cat was febrile (104.6°F [40.3°C]), mildly dehydrated and had a grade III/VI left parasternal systolic murmur with no arrhythmia noted. The owner reported that no previous diagnosis of heart murmur had been noted. A feline leukemia virus/feline immunodeficiency virus point-of-care test (SNAP; IDEXX Laboratories) was negative, complete blood count (CBC) showed a slight leukocytosis (20,600/ $\mu$ l; reference interval [RI] 3900–19,000/ $\mu$ l) characterized by a mature neutrophilia (16,707/ $\mu$ l; RI 2620–15,170/ $\mu$ l) and a monocytosis (1566/ $\mu$ l; RI 40–530/ $\mu$ l), and a serum biochemical panel showed hypoalbuminemia (2.5 g/dl; RI 2.6–3.9 g/dl). The cat was treated for 10 days with pradofloxacin (6.9 mg/kg PO q24h [Veraflox; Bayer]) and the clinical signs improved but recurred 1–2 weeks after discontinuation of antimicrobial therapy. The cat was administered an additional 6-week course of pradofloxacin at the same

dose. The clinical signs resolved while on therapy but relapsed shortly after finishing the course. The owner monitored the cat's temperature at home and noted a fever of up to 104°F (40°C). The cat lived with three other cats that were not showing any clinical signs. It frequently went on leashed walks and had not been on any medications before the onset of illness.

The cat was referred to University of California-Davis Veterinary Medical Teaching Hospital (VMTH). On evaluation, the cat was alert, euhydrated, febrile (104.2°F [40.1°C]) and had a body condition score of 4/9 with a

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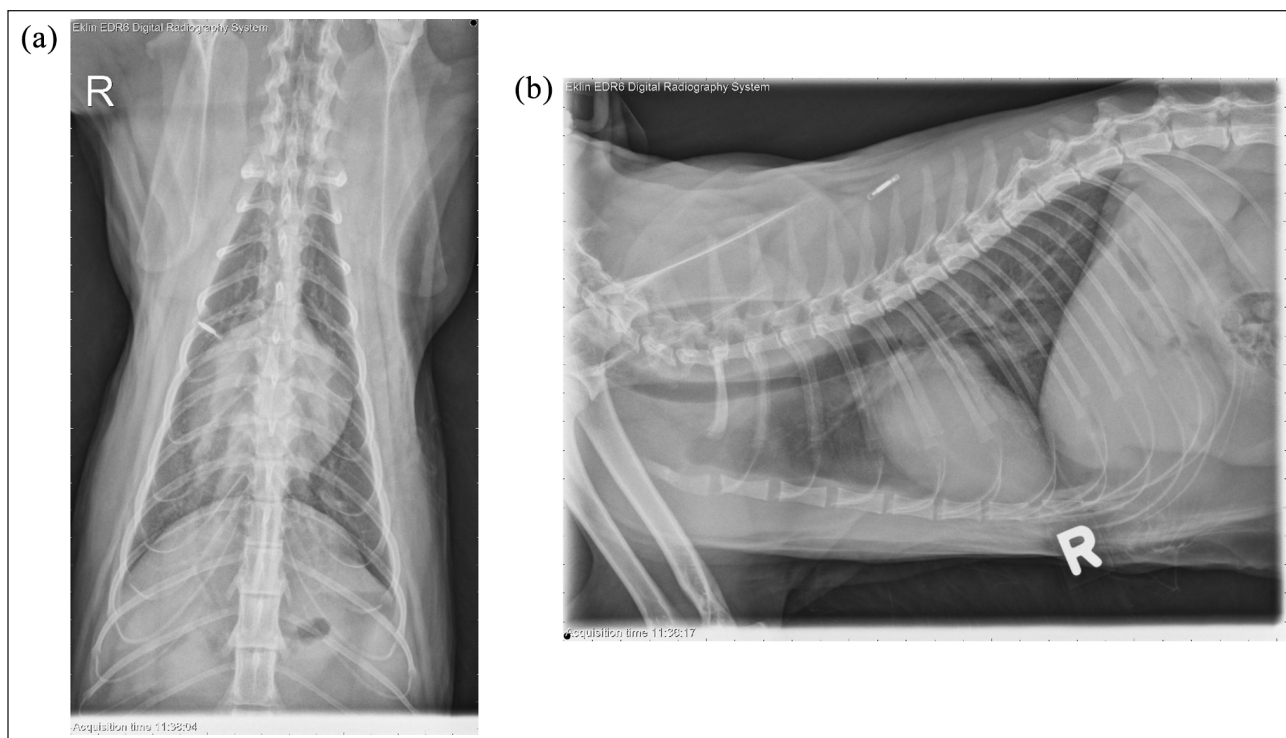
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**Figure 1** Thoracic radiographs. Three-view thoracic radiographs obtained at the initial referral appointment. Enlargement of the cardiac silhouette can be noted on the (a) dorsoventral and (b) right lateral projections (left lateral projection not shown). The caudal right pulmonary artery and vein are mildly distended. A diffuse unstructured interstitial pulmonary pattern is noted with a focal alveolar pattern in the right caudal lung lobe

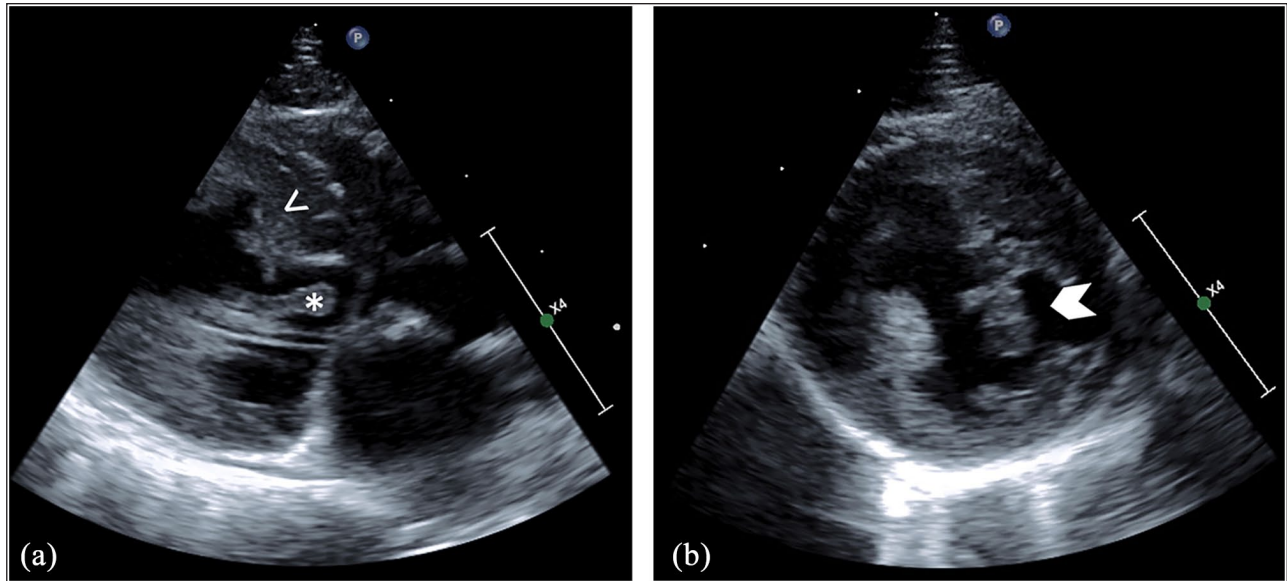
body weight of 5.2 kg. A grade II/VI left parasternal systolic heart murmur with a regular rhythm and slight increase in respiratory effort was also noted. A CBC revealed a mild microcytic (mean cell volume 38.6 fl; RI 42–53 fl), normochromic, non-regenerative anemia (hematocrit 28.9%; RI 30–50%) and a leukocytosis characterized by a left shift (515 bands/ $\mu$ l and 12,870/ $\mu$ l neutrophils; RI 2000–9000/ $\mu$ l) with evidence of toxic change. A chemistry panel did not reveal any abnormalities. Urinalysis revealed a urine specific gravity of 1.029 with 25 mg/dl protein. An aerobic bacterial urine culture was performed to assess for a nidus of infection within the urinary tract and no bacterial growth was noted.

Abdominal ultrasound examination by a board-certified radiologist revealed splenomegaly with a reticulated pattern most consistent with an inflammatory process such as splenitis. Cytologic examination of ultrasound-guided fine-needle aspirates of the spleen revealed lymphoid hyperplasia. Three-view thoracic radiographs revealed generalized cardiomegaly with left atrial (LA) enlargement and a diffuse, mild, unstructured interstitial pulmonary pattern (Figure 1). The caudal right pulmonary artery and vein were mildly distended but were symmetrical and tapered appropriately. The remaining pulmonary vasculature was within normal limits.

An echocardiographic examination by a board-certified cardiologist revealed multiple oscillating lesions associated

with the anterior leaflet of the mitral valve and trace mitral regurgitation (Figure 2). The aortic valve appeared to be normal with no evidence of valvular insufficiency. There was asymmetric thickening of the myocardium with the interventricular septum in diastole measuring 7.1 mm and the left ventricular (LV) posterior wall in diastole measuring 6.7 mm. Within the LV, there were hyperechoic regions associated with the septum and posterior papillary muscle. Arising from the hyperechoic areas there were multiple oscillating lesions suggestive of a vegetative lesion, a thrombus or combination of both. These lesions did not appear to be causing significant LV outflow tract obstruction. The LA was moderately dilated with a short-axis LA to aorta ratio (LA:Ao) of 1.87. The left auricular flow velocity was 37.94 cm/s. These echocardiographic findings were most consistent with endomyocarditis with possible thrombus formation. Serum cardiac troponin I concentration was increased at 74.90 ng/ml (RI 0.00–0.09 ng/ml).

Blood cultures were performed by aseptically collecting 3 ml blood from the right and left medial saphenous veins, and the right lateral saphenous vein over a 75-min period. Blood samples were inoculated into pediatric blood culture bottles (BD Bactec; Becton Dickinson). Cultures from all three vials yielded growth of Gram-positive coccobacilli. Initial identification of the organism was attempted biochemically (API 20 Strep v8.0; bioMerieux) and most significantly



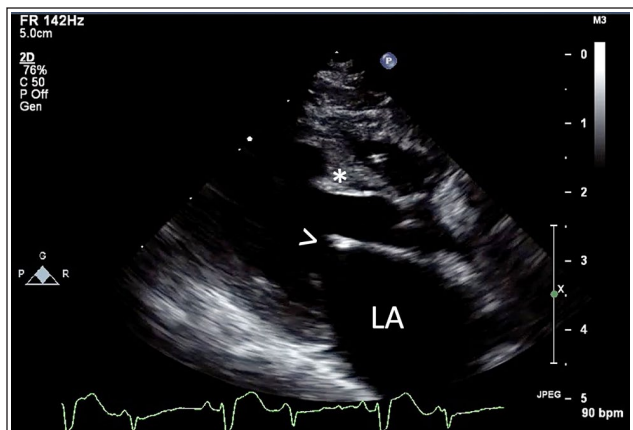
**Figure 2** Initial echocardiogram. (a) Right parasternal long-axis view. There is a large pedunculated lesion arising from the papillary muscle (\*). The endomyocardium in the region of the basilar septum is effaced and replaced by an irregular heterogeneous lesion extending into the left ventricular lumen and the myocardium (^). (b) Right parasternal short-axis view at the level the left ventricular papillary muscles. There is an irregular cauliflower-like lesion (arrow) extending into the left ventricular lumen most consistent with vegetative endocarditis. These lesions represent infectious endomyocarditis

matched with a nutritionally variant *Streptococcus* species. Using matrix-associated laser desorption ionization-time of flight mass spectrometry (MALDI-TOF MS), the organism was identified as *Streptococcus suis*. To confirm the identification, DNA sequencing following PCR amplification of a region of the 16S rRNA gene showed 99% identity with *S suis*. Whole blood was submitted for *Bartonella* testing using BAPGM enrichment cultures followed by PCR (Galaxy Diagnostics) and reported as negative 26 days after first evaluation at the VMTH. Further infectious disease testing, including *Bartonella* serology, was declined by the owners.

Hospitalization and parenteral treatment for endomyocarditis was recommended; however, the owners elected outpatient treatment. Before the results of the blood culture and *Bartonella* testing was available, the cat was treated with pradofloxacin (7.7 mg/kg PO q24h) given the historically favorable response and azithromycin (10 mg/kg PO q24h) given the association between blood culture-negative endocarditis and *Bartonella* infection.<sup>1,2</sup> The cat was also treated with clopidogrel (3.6 mg/kg PO q24h) given the reduced auricular flow velocity. The blood culture results revealed a nutritionally variant *Streptococcus* organism after 48h of incubation; however, the organism was unable to be cultivated for susceptibility testing. The antimicrobial course was continued pending the *Bartonella* testing, as *Streptococcus* species are typically susceptible to fluoroquinolones and azithromycin and the cat had a marked improvement in energy, appetite and attitude. On recheck examination, 6 days after

initial evaluation at the VMTH, an increased respiratory rate (44 breaths/min) and effort were noted. Thoracic radiographs showed persistent cardiomegaly with more severe pulmonary infiltrates than were present on the initial radiographs. The cat was discharged with instructions to administer furosemide (1.2 mg/kg PO q12h), pimobendan (0.24 mg/kg PO q12h) and benazepril (0.29 mg/kg PO q12h). The other medications were continued. On examination 13 days after initial evaluation at the VMTH, pyrexia had resolved (100.9°F [38.3°C]) and the resting respiratory rate was normal (28–32 breaths/min). The serum cardiac troponin I concentration had decreased to 0.31 ng/ml (RI 0.00–0.09 ng/ml).

On day 20 after initial examination at the VMTH, the owner noticed an increased respiratory rate and effort. On examination the cat was normothermic (101.4°F, 38.5°C), with a heart rate of 184 beats/min, an intermittently irregular rhythm and a respiratory rate of 56 breaths/min. Echocardiographic examination revealed a marked reduction in the size of the vegetative lesion on the mitral valve, as well as a reduction in the size of the hyperechoic LV myocardial lesions (Figure 3). There was a persistent, hyperechoic septal bulge, but overall diastolic LV wall measurements had improved (septum 7.6 mm, free wall 4.6 mm). There was moderate mitral regurgitation and severe LA dilation (LA:Ao 2.32), both of which were more severe than on the initial echocardiographic examination and were attributed to severe erosion of the mitral valve. The left auricular flow velocity was slightly improved (velocity 43.17 cm/s), with no spontaneous echo contrast or visible thrombi noted. The progression of the mitral regurgitation and



**Figure 3** Recheck echocardiogram. Right parasternal long-axis view. The previously noted endocarditis lesion has reduced in size with a small hyperechoic region noted at the basilar septum (\*) and hyperechoic lesion on the septal leaflet of the mitral valve (>). There is also progressive left atrial (LA) enlargement

LA size were presumed to be secondary to alteration of valvular structure and function following treatment of the endocarditis.

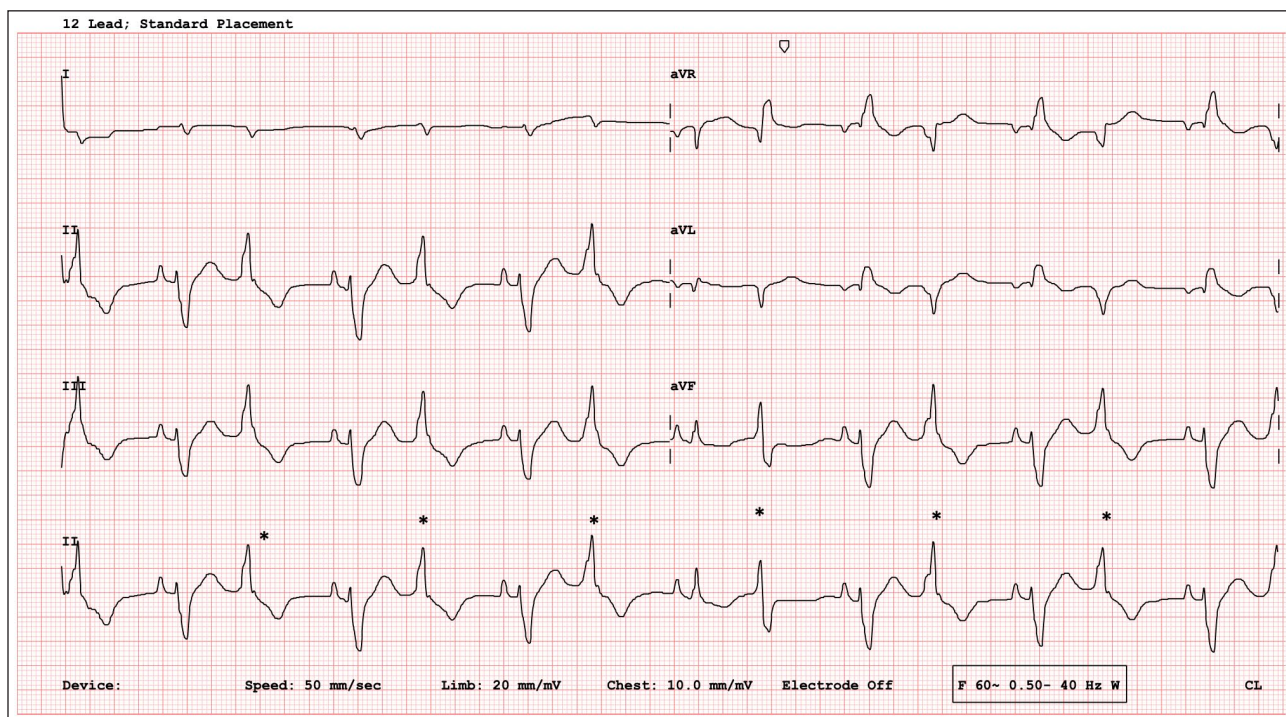
Electrocardiographic examination showed an underlying sinus rhythm, which was intermittently conducted with a right bundle branch block. There was

also frequent, single right-sided (left bundle branch morphology) ventricular ectopy, which at times occurred as periods of ventricular bigeminy (Figure 4). The QRS duration was prolonged (0.08s), consistent with a right bundle branch block. The furosemide dose was increased to 2.27 mg/kg PO in the morning and 1.14 mg/kg PO in the evening.

Despite ongoing therapy, the cat continued to experience a progressive increase respiratory rate and effort and was euthanized 3 days later, 23 days after initial examination at the VMTH. No necropsy was performed.

## Discussion

This case report describes the clinical findings in a cat with *S suis* bacteremia and associated endomyocarditis, which, to our knowledge, has not been previously reported. Infective endocarditis (IE) in the cat is rare, with an estimated prevalence between 0.006% and 0.018%, which is substantially lower than that of dogs (0.04–0.13%).<sup>1</sup> As in dogs,<sup>3</sup> the valves most commonly affected are the mitral and aortic valves,<sup>2,4</sup> although there are rare cases of tricuspid valve endocarditis reported in the cat.<sup>4,5</sup> Clinical signs are often vague, including lethargy, anorexia and weakness, as exhibited by the cat in this report. Cats with IE are more likely to show respiratory distress than dogs with IE.<sup>2,3</sup> This is often a reflection of the high prevalence of congestive heart failure in



**Figure 4** Electrocardiogram (ECG) at the time of arrhythmia diagnosis six-lead ECG paper speed 50 mm/s, amplitude 20 mm/mV. There is an underlying sinus rhythm with ventricular bigeminy. Ventricular ectopy (\*) appears to be right ventricular in origin based on the left bundle branch morphology. The sinus complexes are prolonged, consistent with a right-bundle branch block (QRS duration 0.08s)

cats with IE.<sup>4–7</sup> While the cat reported here had a fever, it is more common for cats with IE to be normothermic.<sup>2,4</sup>

Palerme et al<sup>2</sup> proposed a modification of Duke's criteria for the ante-mortem diagnosis of IE in cats. The cat in this report fulfilled the three major criteria, including three positive blood cultures, vegetative echocardiographic lesions and improvement of the echocardiographic changes with treatment. The cat also fulfilled one minor criterion (fever).

Common organisms associated with IE in dogs at our institution include *Streptococcus* species, Gram-negative bacilli (most commonly *Escherichia coli*) and *Bartonella* species. In one retrospective study performed at our institution, these comprised 37%, 22% and 20% of cases, respectively.<sup>8</sup> The same information is not available for cats. *Bartonella* species infection has been reported in association with feline IE,<sup>4,9–12</sup> and mixed infections with *Bartonella* species and other bacteria can occur. In this case, *Bartonella* species BAPGM culture and PCR were negative, but the results of blood culture confirmed *S suis* bacteremia. *S suis* is a Gram-positive, emerging zoonotic bacterium that is an important cause of arthritis, pneumonia, meningitis, abortions, endocarditis and abortions in swine, and can cause bacteremia and meningitis in people.<sup>13,14</sup> It has been isolated from the tonsils of healthy dogs and cats,<sup>15</sup> and has been documented as the cause of a meningoencephalitis in a cat.<sup>16</sup> The source of infection and route of exposure in this case was unknown. The cat in this report did not have any known exposure to pigs or pig products but had outdoor exposure (on leash walks).

Echocardiographic examination is an important tool for the diagnosis of IE across species, and echocardiographic lesions are a major criterion for the diagnosis of IE. Consequences of IE recognized during echocardiographic examination include changes to the endocardium or myocardium, valvular insufficiency, ventricular and/or atrial dilation and myocardial failure.<sup>17</sup> The cat in this case report had a pronounced echogenic vegetative lesion consistent with an endocarditis lesion and evidence of myocardial involvement consistent with endomyocarditis. This was supported by the elevated serum cardiac troponin I concentration, which markedly improved with antimicrobial therapy. The ventricular ectopy and aberrant conduction that developed was also likely a result of myocardial involvement. This case highlights the value of serial echocardiographic examination, as the lesions noted were markedly improved in size on recheck examination. Progressive mitral insufficiency, suspected to be a consequence of erosion of the valve, was noted along with progressive chamber dilation. There were resolution of fever and the echocardiographic IE lesions, but the resultant hemodynamic consequences were severe, and the cat did not readily respond to standard medical therapy for congestive heart failure.

Antimicrobials are the mainstay of treatment of IE. The initial antimicrobial choice should be made based on the most common etiologic agents in a given region and corresponding antimicrobial susceptibilities, with adjustments made to antimicrobial choice as diagnostic testing results become available. In this case, initial antimicrobial treatment was based on the patient's favorable previous response to pradofloxacin, and azithromycin was used in combination due to initial concerns for bartonellosis while *Bartonella* species PCR and culture were pending. It is recommended that animals be treated with intravenous administration of antimicrobials for at least 7–10 days, which is extrapolated from human guidelines.<sup>18</sup> The owners did not elect for parental therapy in this case, but broad spectrum therapy with coverage for *Bartonella* species would have been indicated.

The most significant limitation of this report is the lack of a necropsy examination. Direct culture and PCR of valve lesions and histopathologic examination could have confirmed streptococcal endomyocarditis (although antimicrobial therapy may have cleared evidence of infection), as well as define the extent of disease with regard to involvement of the myocardium and conduction system. This also would have allowed for investigation of common complications of IE, including other vascular consequences, renal changes or polyarthritis. Despite this, the microbiological and molecular methods used in this case established *S suis* as the causative organism of bacteremia and the echocardiographic findings strongly suggested its association with endomyocarditis.

## Conclusions

This report describes the identification of *S suis* bacteremia in a cat with endomyocarditis. This case also highlights the role of echocardiography and blood cultures as a diagnostic tool in cats presenting with fever.

**Conflict of interest** The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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**Ethical approval** This work involved the use of non-experimental animals only (including owned or unowned animals and data from prospective or retrospective studies). Established internationally recognised high standards ('best practice') of individual veterinary clinical patient care were followed. Ethical approval from a committee was therefore not necessarily required.

**Informed consent** Informed consent (either verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (either experimental or non-experimental animals) for the procedure(s) undertaken (either prospective or retrospective studies). For any animals or humans individually identifiable within this publication,

informed consent (either verbal or written) for their use in the publication was obtained from the people involved.

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