



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Use of computed tomography imaging during long-term follow-up of nine feline tuberculosis cases

Citation for published version:

Major, A, O'halloran, C, Holmes, A, Lalor, S, Littler, R, Spence, S, Schwarz, T & Gunn-moore, D 2018, 'Use of computed tomography imaging during long-term follow-up of nine feline tuberculosis cases' *Journal of Feline Medicine and Surgery*, vol 20, no. 2, 1098612X1769947, pp. 189-199. DOI: 10.1177/1098612X17699476

Digital Object Identifier (DOI):

[10.1177/1098612X17699476](https://doi.org/10.1177/1098612X17699476)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Peer reviewed version

Published In:

Journal of Feline Medicine and Surgery

Publisher Rights Statement:

Authors retain copyright

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.



1 **The Use of Computed Tomography Imaging During Long Term Follow-up of Nine Feline Tuberculosis**

2 **Cases**

3 Alison Major,^{1a} Conor O'Halloran,^{2ab} Andrea Holmes,¹ Stephanie Lalor,³ Rebecca Littler,⁴ Susanna Spence,⁵
4 Tobias Schwarz,^{2c} Daniëlle Gunn-Moore^{2c}

5

6 ¹University of Bristol/Langford Veterinary Services, School of Clinical Veterinary Science, Langford House,
7 Langford, Bristol, BS40 5DU, UK

8 ²Royal (Dick) School of Veterinary Studies and The Roslin Institute, Division of Veterinary Clinical Sciences,
9 The University of Edinburgh, Hospital for Small Animals, Easter Bush Veterinary Centre, Roslin, Midlothian,
10 EH25 9RG, UK

11 ³Willows Veterinary Centre & Referral Service, Highlands Road, Solihull West Midlands, B90 4NH, UK

12 ⁴Northwest Surgeons, Delamere House, Ashville Point, Sutton Weaver, Cheshire, WA7 3FW, UK

13 ⁵Small Animal Hospital, University of Glasgow, Bearsden Road, Glasgow, G61 1QH, UK

14

15 ^aJoint first authors

16 ^bCorresponding author – Conor O'Halloran BVSc, MSc, Royal (Dick) School of Veterinary Studies and The
17 Roslin Institute, Division of Veterinary Clinical Sciences, The University of Edinburgh, Hospital for Small
18 Animals, Easter Bush Veterinary Centre, Roslin, Midlothian, EH25 9RG, UK

19 Email: Conor.O'Halloran@roslin.ed.ac.uk

20 ^cJoint last authors

21

22

23

24 **Abstract:**

25 **Case Series Summary:** Feline tuberculosis is an increasingly recognised potential zoonosis of cats. Treatment
26 is challenging and prognosis can vary greatly between cases. Pulmonary infection requires extended courses of
27 antibiotics, but methodologies for sensitively monitoring response to treatment are currently lacking.

28

29 In this case series we retrospectively examined the serial computed tomography (CT) findings in nine cats that
30 had been diagnosed with tuberculosis. Changes in pathology (where applicable to tuberculosis) were correlated
31 with the clinical presentation of each of the cats, the treatment protocol, plus previous and contemporary
32 diagnostic investigations.

33

34 This study found that changes in CT findings during the medium to long term management of feline tuberculosis
35 were highly variable between cats. The majority of cats had reduced pathology at re-examination during anti-
36 tuberculous therapy, but pathology only resolved in a minority of cases. In some cases reoccurrence of
37 pathology detected by CT imaging preceded clinical relapse, allowing for rapid therapeutic intervention.

38

39 **Relevance and Novel Information:** When considered in combination with clinical findings, CT studies can
40 aid in decision making regarding tapering of antibiotic protocols, or reintroduction of therapy in cases of
41 recurrence or reinfection. These cases also highlight that in some cases, persistent abnormalities can be
42 detected by CT so complete resolution of CT pathology should not always be a goal in the management of
43 feline tuberculosis.

44 **Introduction**

45 Feline tuberculosis is a highly variable and increasingly recognised disease in domestic pet cats in the British
46 Isles.¹⁻³ Infection is assumed to be acquired from bites by prey species sustained during hunting, leading to the
47 most typical clinical presentation of cutaneous lesion/s at “fight and bite sites” with or without regional lymph
48 node involvement.¹⁻³ Disseminated disease can occur, resulting in non-specific signs related to the respiratory
49 and/or alimentary tracts giving rise to variable findings on diagnostic imaging investigations.⁴⁻⁷ Thoracic and/or
50 abdominal pathology can more rarely result from acquisition of disease through inhalation or ingestion.^{1,5} The
51 radiological and computed tomography (CT) abnormalities associated with disseminated mycobacterial
52 infection have previously been described.^{2,4,7}

53 Advocated treatment protocols for feline tuberculosis typically consisted of an initial and a continuation phase.⁸
54 The initial phase combines three antibiotic drugs lasting for two months, while the continuation phase comprises
55 of two drugs for a further four months.⁸ However, it is possible that treating with all three drugs until two
56 months after apparent clinical resolution, which typically results in four to six months of treatment, may result
57 in a better clinical outcome (DGM and COH, unpublished data, 2016).

58 Prognosis varies depending on the species of mycobacterium involved, the extent and severity of disease, and
59 the compliance and tolerance of the patient to medication.^{1,6} While many cases respond favorably to therapy,
60 resulting in apparent cure or long term remission, other patients either fail to respond or go on to develop
61 recurrence of signs following apparently successful treatment.^{1,6}

62

63 In order to assist clinical decision making by veterinary surgeons and owners, a reliable method is needed to
64 monitor the disease at all stages of management. The use of CT has already been shown to be a valuable tool in
65 the initial diagnosis.⁷ In this report, we describe the use of CT during the medium and long term follow-up of
66 tuberculous disease in nine cats between June 2010 and May 2016. Table 1 shows signalment and summary
67 data for all nine cases detailed below.

68

69

70

71

72

73

74

75

76 Table 1: Summary details of the nine case of feline tuberculosis where serial CT images were used as part of clinical follow-up

Case Number	Breed	Age (years)	Gender	Location in UK	Weight (kg) at initial presentation	Haematology & serum biochemistry (reference interval)	FIV / FeLV status	Diagnosis	Impact of CT evaluations
1	Oriental	7	MN	South Scotland	5	Total calcium 3.13mmol/L (1.95-2.83mmol/L) Ionised calcium 1.75mmol/L (1.05-1.45mmol/L)	Negative	<i>M. microti</i>	Early re-instigation of antibiotics following slight clinical deterioration.
2	DSH	11	FN	Central Scotland	3.6	No abnormalities detected	Negative	<i>M. microti</i>	Pulmonary dissemination of tuberculosis diagnosed. Mid-term static appearance of lesion irrespective of antibiotic therapy.
3	Bengal	13	MN	South Scotland	5	No abnormalities detected	Negative	<i>M. microti</i>	Delayed antibiotic tapering due to persistent abnormalities. Early re-instigation of antibiotics following slight clinical deterioration.

4	British Shorthair	10	MN	Cheshire, England	3.8	Hyperglobulinaemia	Negative	<i>M. bovis</i>	Reduction of antibiotics with improvement to detectable abnormalities.
5	DSH	7 months	MN	Bristol, England	2.8	Total calcium 3.95mmol/L (2.30-2.50mmol/L)	Negative	<i>M. microti</i>	Discontinuation of antibiotics with improvement to detectable abnormalities.
6	DSH	3	FN	West Midlands, England	4.1	No abnormalities detected	Negative	Tuberculosis complex	Reduction of antibiotics with early improvement to detectable abnormalities.
7	DSH	7	MN	South Scotland	5	No abnormalities detected	Negative	<i>M. microti</i>	Reduction of antibiotics with improvement to detectable abnormalities.
8	Burmilla	8	ME	South Scotland	4.6	No abnormalities detected	Negative	<i>M. microti</i>	Discontinuation of antibiotics with improvement to detectable abnormalities.
9	DSH	7	MN	Central Scotland	5.7	No abnormalities detected	Negative	<i>M. microti</i>	Continuation of antibiotics with partial improvement to detectable abnormalities.

77 Legend: DSH: domestic short hair, MN: male neutered, FN: female neutered, ME: male entire, FIV: feline immunodeficiency

78 virus, FeLV: feline leukaemia virus.

80 **Case Series Description**

81 **Case 1**

82 Case 1 initially presented with anorexia and weight loss. Mild mandibular lymphadenomegaly and harsh lung
83 sounds were noted on physical examination. Thoracic radiographs revealed a diffuse structured interstitial lung
84 pattern; CT was not performed as the clinic did not have on-site access to CT at this time. The feline interferon
85 gamma (IFN- γ) release assay (IGRA) was performed by Biobest Laboratories, Edinburgh, and indicated
86 infection with *Mycobacterium microti*.⁸ The cat was treated with a triple antibiotic protocol of rifampicin
87 [generic, Mylan, Herts] (10mg/kg) 50mg PO q24h, marbofloxacin [Marfloquin, Virbac] (3mg/kg) 15mg PO
88 q24h, and azithromycin [Zithromax, Pfizer] (6mg/kg) 30mg PO q24h for two months as the induction treatment
89 phase; marbofloxacin was then discontinued and the remaining antibiotics continued for the maintenance phase.
90 After six months, clinical remission from disease was achieved; serum calcium concentration was within the
91 reference interval and repeat radiographs revealed no abnormalities, so antibiotics was stopped.

92 Eleven months after antibiotic treatment had been discontinued, the cat represented with a recurrence of lethargy
93 and anorexia, with normal lung sounds but reduced thoracic compression. Body weight had increased to 6.2kg.
94 A recurrence of hypercalcaemia was noted (ionised calcium 1.75 mmol/l) and serum 25-hydroxyvitamin D
95 concentration was low (46 pg/ml, RI 14.9-61.0ng/ml). Full-body CT was performed using a VetMouseTrap
96 device, revealing mild tracheobronchial, mediastinal and mesenteric lymphadenomegaly and a diffuse,
97 moderate reticulonodular lung pattern (Figure 1a). Recurrence or reinfection of tuberculosis was assumed and
98 triple antibiotic therapy was reinstated (drugs and doses as above, dosed for a 6kg cat). In addition, calcitriol
99 supplementation was given at a dose of 2ng/kg PO q24h. Three months later the cat was reassessed, and clinical
100 examination and whole-body CT were normal (Figure 1b). On the basis of completing three months of triple
101 antibiotic therapy and resolution of clinical signs, treatment was changed to pradofloxacin (Veraflox tablets

102 Bayer) [4mg/kg] 25mg PO q24h, which was given as an antimicrobial monotherapy for six months with
103 calcitriol supplementation as previously described. Two further CT examinations were performed, at four and
104 six months after disease recurrence, and were normal. Eleven months after recurrence, after two months off
105 pradofloxacin, the cat was represented as the owner observed a mildly increased sleeping respiratory rate
106 (21bpm; this cats normal sleeping respiratory rate was <20bpm). Despite a normal clinical examination, a CT
107 scan demonstrated a diffuse mild reticular lung pattern with areas of ground glass opacity (Figure 1c); the serum
108 calcium concentration was increased and serum 25-hydroxyvitamin D concentration was low. Triple antibiotic
109 therapy was restarted (rifampicin and azithromycin, dosed as above, plus pradofloxacin [Veraflox liquid, Bayer]
110 [~5mg/kg] 30mg PO q24h), and calcitriol treatment was restarted at [2ng/kg] 12.5mcg PO q24h (body weight
111 6.5kg). After two-months of treatment repeat CT examination was normal. Due to the history of several episodes
112 of disease it was recommended that the triple antibiotic therapy be continued for a further four months, followed
113 by three months of double antibiotic therapy (azithromycin and pradofloxacin, dosed as above). The cat
114 remained clinically normal throughout this period and treatment was discontinued a total of 20 months after the
115 initial recurrence. Two months later another IGRA returned a negative result and the serum calcium and 25-
116 hydroxyvitamin D concentrations were within normal limits. A further episode of mycobacterial
117 recurrence/reinfection occurred after eight months without treatment. The cat was again re-presented following
118 observation of a mildly increased sleeping respiratory rate (23bpm; body weight 7.1kg). Whole body CT
119 demonstrated mild diffuse thoracic and abdominal lymphadenomegaly, and a diffuse but patchy, mild to
120 moderate reticulonodular lung pattern. A repeated IGRA was positive and consistent with *M. microti* infection.
121 Triple antibiotic therapy was prescribed for three months (rifampicin, pradofloxacin and azithromycin, dosed
122 as above, for a 7kg cat), followed by double antibiotic therapy for a further nine months (pradofloxacin and
123 azithromycin, dosed as immediately above). During this period, the cat remained well, and a further four full-

124 body CT examinations revealed a normal pulmonary parenchymal appearance. Given the normal imaging and
125 clinical findings throughout this period, antibiotics were discontinued as planned, and the cat remains well
126 without recurrence of clinical signs over 17 months later, during this time five CT scans revealed no detectable
127 abnormalities. A timeline of this case is shown in Figure 2.

128 **Case 2**

129 Case 2 was first presented for weight loss and generalised lymphadenomegaly. Radiographs revealed a diffuse
130 interstitial lung pattern (CT was not available at the clinic at that time). Excisional biopsy of the popliteal lymph
131 nodes was performed; histopathology revealed a granulomatous lymphadenitis and Zeihl Neelsen (ZN) staining
132 identified intra-lesional acid-fast bacilli indicative of mycobacterial infection. A triple antibiotic protocol was
133 instigated (rifampicin [11mg/kg] 40mg PO q24h; marbofloxacin [2.7mg/kg] 10mg PO q24h; clarithromycin
134 [11mg/kg] 40mg PO q12h) for two months followed by rifampicin and marbofloxacin (same doses) for four
135 months. Revisits revealed initially static peripheral lymphadenomegaly, which resolved over the four months
136 of maintenance treatment. Repeat thoracic radiography at the end of the maintenance phase revealed no
137 abnormalities and treatment was therefore discontinued. Four months following the end of treatment the cat
138 presented to an emergency clinic with acute respiratory signs. Laryngeal swelling was identified and following
139 stabilisation with corticosteroids, furosemide, chlorphenamine (all at standard doses), plus additional oxygen,
140 the laryngeal swelling resolved. Radiography revealed a thoracic mass consistent with an enlarged cranial
141 mediastinal lymph node. This was confirmed on full body CT examination using a VetMouseTrap device,
142 which also revealed moderate mineralisation within the mass lesion (Figure 3a). Fine needle aspiration (FNA)
143 of the mass yielded a non-diagnostic sample whilst an IGRA was consistent with *M. microti* infection. Given
144 the previous history of mycobacterial lymphadenitis, with an owner who was reticent to restart triple therapy,

145 the cat was started on single antibiotic therapy (pradofloxacin liquid [7mg/kg] 25mg PO q24h) to see if this
146 might reduce the size of the thoracic mass and so give weight to the diagnosis that it may be tuberculous. One
147 month later the cat was clinically well and CT revealed a static appearance to the mass. Antibiotic therapy was
148 discontinued as it did not appear to be effective. Three months later the CT appearance remained unchanged,
149 and a repeat IGRA was inconclusive. The cat represented the next month with hypersalivation and difficulty
150 eating. Physical examination revealed thickening of the caudal aspect of the right mandibular ramus, with
151 loosening of the associated teeth. On CT this lesion was characterised by moderate bone lysis with concurrent
152 proliferation, moderate regional lymphadenomegaly was noted. The thoracic mass remained static in
153 appearance, but the surrounding lung had a mild patchy ground glass appearance (Figure 3b). The appearance
154 of the mandibular lesion was not considered typical for tuberculous osteomyelitis. Biopsy of the mandibular
155 mass and local lymph nodes resulted in a diagnosis of squamous cell carcinoma with reactive lymphoid
156 hyperplasia. The owner opted for palliative therapy with meloxicam (Metacam, Boehringer Ingelheim
157 0.05mg/kg PO q24h), and after three weeks the cat was euthanased. Post mortem examination was performed
158 and histopathology of the enlarged cranial mediastinal lymph node revealed large numbers of acid-fast bacilli
159 within the node and the peri-nodal connective tissue. As indicated by CT, granulomatous inflammatory changes
160 extended into the adjacent pulmonary parenchyma. The lymph node was confirmed to be PCR positive for *M.*
161 *microti* by the Mycobacterial Reference Laboratory, Leeds University Teaching Hospital. A timeline of this
162 case is shown in Figure 4.

163 **Case 3**

164 Case 3 initially presented with mandibular lymphadenomegaly. Sternal lymphadenomegaly was noted on
165 thoracic radiography and abdominal ultrasound revealed marked mesenteric lymphadenomegaly and focal

166 marked circumferential jejunal thickening; FNA of the mandibular and jejunal lymph nodes and the abnormal
167 jejunal wall revealed granulomatous inflammation with acid-fast bacilli indicative of mycobacterial infection.
168 An IGRA was consistent with *M. microti* infection and the cat was started on triple antibiotic therapy (rifampicin
169 [10mg/kg] 50mg PO q24h; azithromycin [8mg/kg] 40mg PO q24h; pradofloxacin tablets [5mg/kg] 25mg PO
170 q24h), plus calcitriol supplementation ([2ng/kg] 10mcg PO q24h). Two months later the cat was clinically well,
171 although the right mandibular lymph node remained slightly enlarged. A conscious full-body CT examination
172 using a VetMouseTrap device was performed, revealing improved but persistent mesenteric
173 lymphadenomegaly. Given the clinical and imaging findings, the triple antibiotic therapy described above was
174 maintained for another four months, giving a total treatment duration of six months, after which the mandibular
175 and mesenteric lymph nodes were palpably normal and antibiotics was discontinued (body weight 6.4kg at this
176 time). Three months later the cat represented with weight loss, lethargy and inappetence (body weight 6.0kg).
177 The peripheral lymph nodes were of normal size but harsh inspiratory lung sounds and multiple palpable
178 abdominal masses were noted. Both abdominal ultrasound and full-body CT were performed, confirming the
179 presence of marked thoracic and abdominal lymphadenomegaly, and focal marked jejunal thickening as had
180 been previously described. A diffuse, mild reticulonodular lung pattern was also noted. A FNA of the mesenteric
181 lymph nodes again revealed granulomatous inflammation with acid fast bacilli. Triple antibiotic therapy was
182 resumed at the dose rates detailed previously, but despite an initially improved demeanour the cat continued to
183 lose weight and after five months of treatment was euthanased. Post mortem examination was not performed.
184 A timeline of this case is shown in Figure 4.

185 **Case 4**

186 Case 4 initially presented with weight loss, dyspnoea and coughing. Physical examination revealed tachypnoea
187 (respiratory rate 40bpm), with increased inspiratory and expiratory effort and noise. Thoracic CT examination
188 revealed a moderate multifocal alveolar pattern with regions of pulmonary cavitation affecting multiple lung
189 lobes, most marked within the right caudal lobe, and a moderate thoracic lymphadenomegaly (Figure 5a). A
190 right caudal lung lobectomy was performed and histopathology revealed necrotising and pyogranulomatous
191 bronchopneumonia; however, no acid fast bacteria were identified. Tissue was submitted for culture and blood
192 for IGRA, and treatment with marbofloxacin ([2mg/kg] 8mg PO q24h) was started. A good clinical response
193 was noted in the initial two-month post-operative period; however, tissue culture and IGRA both confirmed
194 *Mycobacterium bovis* infection, and a standard triple antibiotic protocol was introduced (marbofloxacin
195 [2mg/kg] 8mg PO q24h; azithromycin [10mg/kg] 40mg PO q24h; rifampicin [20mg/kg] 80mg PO q24h –
196 although the dose of rifampicin was high). After two months of triple antibiotic treatment, CT was repeated
197 revealing residual patchy ground glass opacity, with collapsed cavities within the remaining lung lobes, but
198 subjectively normal thoracic lymph nodes. Due to the improved pulmonary appearance and the good clinical
199 condition of the cat, triple antibiotic therapy was reduced to dual therapy (marbofloxacin and rifampicin, dosed
200 as above). After a further four months, the appearance of the lungs on CT examination was unchanged (Figure
201 5b) and a repeat IGRA remained positive. Antibiotic treatment was discontinued, and the cat remained well,
202 with a negative IGRA result obtained six months later. A timeline of this case is shown in Figure 4.

203 **Case 5**

204 Case 5 initially presented with coughing, resting tachypnoea (respiratory rate 55bpm), and exercise intolerance.
205 Body weight and condition score (1.5/5) were low. Thoracic and abdominal CT examination revealed a diffuse
206 marked nodular lung pattern with occasional scattered foci of pulmonary mineralisation (Figure 6a), marked

207 tracheobronchial lymphadenomegaly and mild peripheral and abdominal lymphadenomegaly. A FNA of lung
208 tissue revealed marked pyogranulomatous inflammation with acid-fast bacilli and was PCR positive for
209 *Mycobacterium tuberculosis* complex organisms. The IGRA suggested infection with *M. microti*. A standard
210 antibiotic protocol of two months' triple therapy (pradofloxacin [\sim 5mg/kg] 15mg PO q24h; azithromycin
211 [\sim 10mg/kg] 30mg PO q24h; rifampicin [\sim 10mg/kg] 30mg PO q24h) was followed by ongoing double therapy
212 (azithromycin and rifampicin, dosed as above). At a recheck after eight months of treatment the cat was
213 clinically normal and had an improved body weight and body condition score (4.4kg and 2.5/5). Thorax CT
214 revealed only a mild diffuse reticulonodular lung pattern, but scattered pulmonary mineralisation was more
215 extensive than previously noted (Figure 6b). Antibiotic therapy was discontinued. The cat remained well and
216 the CT abnormalities were seen to be static at a revisit 12 months later. A timeline of this case is shown in
217 Figure 4.

218 **Case 6**

219 Case 6 presented with lethargy, intermittent dyspnoea, weight loss, stridor and nasal discharge. Clinical
220 examination revealed a moderate inspiratory dyspnoea with wheezing on auscultation, bilateral serous nasal
221 discharge, bilateral renomegaly and bilateral popliteal lymphadenomegaly. A CT examination of the head,
222 thorax and abdomen revealed an alveolar lung pattern within the right middle and ventral right caudal lung
223 lobes, with a diffuse moderate reticulonodular pattern, moderate multifocal lymphadenomegaly, mild bone lysis
224 over the nasal bridge and multiple mass lesions in both kidneys. Nasal biopsies confirmed mycobacterial
225 infection by histopathology, and was PCR positive for *Mycobacterium tuberculosis* complex organisms, but the
226 laboratory was unable to further define the species. A standard antibiotic protocol of two months' triple therapy
227 was prescribed (pradofloxacin [\sim 5mg/kg] 20mg PO q24h; azithromycin [\sim 10mg/kg] 40mg PO q24h; rifampicin

228 [~10mg/kg] 40mg PO q24h), followed by ongoing double therapy (pradofloxacin and rifampicin, dosed as
229 above). Two months after the start of antibiotic therapy the cat was clinically well. The CT showed marked
230 improvements, with residual diffuse mild pulmonary ground glass appearance, mild multifocal
231 lymphadenomegaly and partial resolution of the renal mass lesions. Antibiotics were discontinued after a six-
232 month course, and the cat remains clinically well 12 months later. A timeline of this case is shown in Figure 4.

233 **Case 7**

234 Case 7 presented with dysuria due to a well demarcated alopecic skin nodule of 2cm diameter over its prepuce.
235 Physical examination revealed a mildly elevated resting respiratory rate (48 bpm). An incisional biopsy of the
236 preputial lesion revealed granulomatous inflammation and rare acid-fast bacilli indicative of mycobacterial
237 infection. An IGRA was strongly suggestive of an *M. microti* infection. A CT scan, performed using a
238 VetMouseTrap device, revealed a focal region of alveolar pattern in the left cranial lung lobe with a diffuse
239 mild reticulonodular pattern suggestive of pulmonary tuberculosis. The cat was placed on standard triple
240 antibiotic therapy (pradofloxacin tablets [3mg/kg] 15mg PO q24h; azithromycin [6mg/kg] 30mg PO q24h;
241 rifampicin [10mg/kg] 50mg PO q24h) for four months. By re-evaluation, the preputial lesion and dysuria had
242 completely resolved and thoracic CT revealed an improvement in both the focal and diffuse pulmonary changes.
243 The cat was changed to dual antibiotic therapy (rifampicin and azithromycin, dosed as above), and this was
244 discontinued after an additional two months; the cat remains clinically well six months later. A timeline of this
245 case is shown in Figure 4.

246 **Case 8**

247 Case 8 was presented for investigation of dyspnoea (respiratory rate 60bpm), bilateral mandibular
248 lymphadenomegaly and palpable abdominal masses. Abdominal ultrasound showed a diffusely heterogeneous
249 appearance to the spleen and mild generalised abdominal lymphadenomegaly. An exploratory laparotomy was
250 performed to biopsy the abnormal structures. Histopathological analysis of the spleen and medial iliac lymph
251 node revealed granulomatous splenitis and reactive lymphoid hyperplasia consistent with mycobacteriosis
252 although no acid-fast bacteria were seen. Thoracic radiography revealed a severe diffuse mixed bronchial and
253 nodular pattern with multiple foci of mineralisation in the caudodorsal lung fields. No thoracic
254 lymphadenomegaly was evident. An IGRA indicated *M. microti* infection, so triple antibiotic therapy was
255 instigated for six months (marbofloxacin [2mg/kg] 10mg PO q24h; rifampicin [16mg/kg] 75mg PO q24h;
256 clarithromycin [8mg/kg] 35mg PO q12h). Re-evaluation after six months revealed that the initial clinical signs
257 had resolved and a full body CT scan using the VetMouseTrap identified complete resolution of the previously
258 noted lung pattern and abdominal lymphadenomegaly. Several small mineral foci remained visible within the
259 lungs which were predominantly, but not exclusively, airway associated. Antibiotic therapy was discontinued
260 at this point. The cat remained clinically well and at a routine revisit over 33 months later a full body CT was
261 repeated using the VetMouseTrap. This study revealed normal pulmonary parenchyma and there was no
262 evidence of lymphadenomegaly. More extensive and more widely distributed predominantly airway-associated
263 mineralisation was present. A timeline of this case is shown in Figure 4.

264 **Case 9**

265 Case 9 was presented for investigations into stertorous breathing and a rapidly growing inter-ocular skin lesion.
266 The CT examination of the head and thorax revealed a soft tissue mass lesion overlying the frontal and nasal
267 bones with several associated small foci of bone lysis, plus a diffuse but asymmetrical, mixed lung pattern.

268 Moderate bronchial and reticulonodular patterns affected the right lung lobes, partial collapse and an alveolar
269 pattern was noted within the accessory lung lobe, and multiple larger well-defined nodules (some showing
270 internal mineralisation) were present within the left lung lobes, with more normal appearing parenchyma
271 surrounding them. There was moderate sternal and cranial mediastinal and marked tracheobronchial
272 lymphadenomegaly. Histopathology on an incisional biopsy of the soft tissue mass revealed a large mixed
273 inflammatory cell infiltrate including epithelioid macrophages, suggestive of mycobacteriosis; ZN staining
274 revealed large numbers of acid fast bacilli which were identified by PCR as *M. microti*. Triple antibiotic therapy
275 was instigated for nine months (clarithromycin [1 mg/kg] 65mg PO q12h; rifampicin [9mg/kg] 50mg PO q24h;
276 marbofloxacin [1.8mg/kg] 10mg q24h). Within two months the stertor had resolved and the skin lesion had
277 reduced in size; by the end of the nine month course of antibiotics all clinical signs had fully resolved. A CT
278 scan showed improvement but not resolution of the mediastinal and sternal lymphadenopathy and diffuse lung
279 changes. The left lung nodules had mildly more extensive mineralisation than previously. It was decided to
280 continue treatment due to the continued presence of pathology and a timeline of this case is shown in Figure 4.

281 **Discussion**

282 The cases presented here are a cohort of cats with conclusive or strong evidence supporting a diagnosis of feline
283 tuberculosis (culture, PCR and/or IGRA results). In contrast to previously published data on feline tuberculosis,
284 the cases in this series are predominately *M. microti* infections, whereas national culture data shows that while
285 *M. microti* can be cultured from 19% of cases with histopathological changes indicative of mycobacteriosis, *M.*
286 *bovis* can usually be cultured from 15%.² The reason for the lack of *M. bovis* cases is unclear; it may result of
287 our small sample size, the majority of which lived in regions of the UK where *M. microti* is more prevalent², or

288 it could indicate an underlying bias towards owners being more likely to treat cats with *M. microti*-infection
289 rather than *M. bovis*, probably due to the higher zoonotic risk associated with the latter organism⁹.

290 In line with previous studies, the majority of cats with tuberculosis in this study are males;² none were found to
291 be co-infected with the FIV and FeLV, and the median age of cats infected with *M. microti* was seven years
292 (range seven months - 13 years), compared to a previously documented median of eight years.²

293 The cases in this series demonstrated a range of clinical responses following diagnosis and treatment of
294 disseminated feline tuberculosis, and in each case, repeated CT imaging contributed to decision making in
295 ongoing clinical management within the context of contemporaneous investigations. It is recognised that the
296 cases in this study show significant variability both in the use of CT and its timing in relation to treatment. This
297 largely relates to the multi-centre nature of this study, as decision making varied depending on the preferences
298 of the primary clinician.

299 A previous study found a sustained complete remission in only 40% of feline mycobacterial infections;⁶
300 however, that study included many cases that were treated with sub-optimal drug regimens (e.g. short courses
301 of fluoroquinolone monotherapy),^{6,10} as well as including *M. avium* infections which are known to be refractive
302 to treatment due to complex inherent drug resistance patterns.¹¹ Previously advocated treatment protocols for
303 feline tuberculosis typically consisted of an initial and a continuation phase.⁹ However, recent studies regarding
304 multi-drug resistant *M. tuberculosis* (MDR-TB) in humans have suggested that using at least three and ideally
305 four antibiotics given in combination throughout treatment significantly reduces the development of
306 antimicrobial drug resistance.¹²⁻¹⁵ Recommended first line anti-tuberculosis medications for humans consist of
307 rifampicin, isoniazid, dihydrostreptomycin, ethambutol and pyrazinamide.¹⁶ However, the use of these drugs
308 does not readily translate into veterinary medicine; isoniazid has been associated with neurological side effects

309 in small animals,¹⁷ pyrazinamide is ineffective against *M. bovis* infections¹⁸ which comprise approximately
310 15% of feline mycobacterial infections,² and dihydrostreptomycin should be reserved for human use.¹⁹
311 Therefore, small animal anti-tuberculosis therapy, when undertaken, should consist of a triple combination of
312 rifampicin (for its potency and its ability to kill non-replicating [latent] tuberculous Mycobacteria²⁰
313 [recommended doses 10-15mg/kg PO q24h]), a fluoroquinolone (ideally pradofloxacin as it has better efficacy
314 against Mycobacteria than older fluoroquinolones,^{21,22} and a better safety profile in cats²³ [pradofloxacin
315 recommended doses 3-7mg/kg PO q24h]) and a macrolide (such as clarithromycin [7-15mg/kg PO q12h] or
316 azithromycin [5-15mg/kg PO q24h]) for a minimum of three months as standard.^{9,24} It is recommended that
317 treatment should be given for two to three months after apparent clinical resolution, which typically results in
318 four to six months of treatment.^{9,24} The efficacy of combination long-term treatment is supported by the cases
319 in this series, as all were treated with either two or three antibiotics for at least six months; only one of the cats
320 died from tuberculosis, and another was found to have latent tuberculosis after euthanasia for an unrelated
321 disease. This gives a sustained complete remission rate of eight of nine cases (~90% remission), which is much
322 higher than the 40% previously reported.⁶ This is much more in line with our recent experiences, as following
323 the introduction of sustained triple therapy the prognosis for feline tuberculosis appears to be closer to 70-80%
324 success when treating cutaneous and/or pulmonary tuberculosis caused *M. bovis* or *M. microti* (DGM and COH,
325 unpublished data 2016). Prolonged therapy is therefore recommended in all cases, and due care is required
326 when advising clients on discontinuing treatment.

327 The majority of the cases in this series (cases 1, 4, 5, 7 and 8) demonstrated that where improvement in
328 previously detected abnormalities can be identified on the basis of follow-up CT, tapering or cessation of
329 treatment could be undertaken with greater confidence in the context of other clinical findings. However, for

330 some of the cases (6 and 9) significant changes remained at follow-up CT, despite the cats being clinically well,
331 and as a result triple antibiotic therapy was continued.

332 A previous study into the diagnostic and monitoring capacity of standard radiography in feline tuberculosis
333 cases showed that with prolonged antibiotics, detectable pathology is eliminated in the vast majority of cases.⁴
334 By comparison, in this case series some of the abnormalities detectable by CT imaging remained present in the
335 majority of cases, though not all cats underwent repeat imaging following complete cessation of treatment. It is
336 likely that this discrepancy partly results from the greater sensitivity of CT in comparison with radiography for
337 detection of milder changes, highlighting its value. However this must be considered when repeat CT imaging
338 is used to decide whether antibiotic treatment can be discontinued; complete resolution of pulmonary pathology
339 cannot be reliably anticipated, even with extended antibiotics. This highlights the value of ongoing follow up
340 imaging to document the lack of progression of changes, which can then be considered clinically incidental.

341 In some cats undergoing treatment for feline tuberculosis, periods of clinical and/or radiological remission can
342 be followed by recurrence of clinical signs, sometimes on multiple occasions (as seen in cases 1 and 3). It is
343 difficult to determine if this represent recrudescence of disease following subclinical infection (latency) in the
344 intervening periods, or reinfection. For example, cats who are habitual hunters have repeated exposure to a
345 population of infected prey (as is the case for the cat in case 1). The return of clinical disease may be associated
346 with extremely subtle clinical signs (as in case 1). The associated CT abnormalities may be similarly subtle (as
347 in Figure 1c), but when a radiologically normal appearance has been documented during the remission period,
348 these subtle changes can be considered significant, allowing for prompt reintroduction of treatment. This case
349 also demonstrates the importance of careful and dedicated patient observation on the part of the owners;

350 monitoring sleeping respiratory rate is recommended in all cases of feline tuberculosis when undergoing
351 treatment, even when there was initially no respiratory involvement.

352 When repeating diagnostic procedures, it is important to evaluate the potential benefit to the patient, in relation
353 to the costs involved. In the cases in this series we feel that the major benefit is clear; namely that the decision
354 to either reduce/discontinue or restart treatment could be made with greater confidence. With reference to CT
355 examination, a number of costs should be considered. The risk of repeated radiation exposure during scanning
356 is one. We feel that in a population largely consisting of middle-aged cats the risk is minimal, though it should
357 not be entirely discounted, particularly in cases where large numbers of repeated scans are performed. The
358 effect of sedation or general anaesthesia should also be considered. Within a referral hospital the risks of these
359 are low,³⁰ but they may warrant consideration particularly in clinically unstable patients with significant
360 multisystem disease. Finally, the financial cost to the owner should also be considered. In several of the cases
361 in this series, some of the associated costs and risks were reduced by use of a VetMouseTrap device, which
362 allows for full body scanning in a non-sedated patient. Despite a slight reduction in sensitivity arising from a
363 reduction in image resolution, this technique provides a very useful relatively low cost and non-invasive option.
364 Notwithstanding the use of a VetMouseTrap device, in many referral centres the cost to the owner of a CT
365 examination, either thorax in isolation or multiple body regions, does not significantly exceed that of full
366 radiological examination. In addition, as CT becomes more widespread in non-specialist practice, its advantage
367 as far as increased sensitivity over radiology warrants further consideration.

368 **Conclusions**

369 The cases described in this case series demonstrate the value of repeat CT imaging in the management of
370 mycobacterial disease. When considered in combination with clinical findings, CT studies can aid in decision

371 making regarding tapering of antibiotic protocols, or reintroduction of therapy in cases of recurrence or
372 reinfection. These cases also highlight that in some cases, persistent abnormalities can be detected by CT, which
373 may not necessarily indicate an active disease process, and care should be taken in the interpretation of these
374 findings.

375

376 **Acknowledgments**

377 The authors would like to acknowledge all staff involved in the care, diagnosis and management of the cats
378 included in the study.

379

380 This research received no specific grant from any funding agency in the public, commercial, or not-for-profit
381 sectors.

382

383 The authors do not have any potential conflict of interest to declare.

384

385 **References**

386 1. Gunn-Moore DA, Dean R and Shaw, S. Mycobacterial infections in cats. *In Practice* 2014; 32: 444-
387 452.

388 2. Gunn-Moore DA, McFarland S, Brewer J, et al. Mycobacterial disease in cats in Great Britain I:
389 Bacterial species, geographical distribution and clinical presentation of 399 cases. *Journal of Feline*
390 *Medicine and Surgery* 2011; 13: 934-944.

- 391 3. Gunn-Moore DA, Gaunt C and Shaw DJ. Incidence of Mycobacterial Infections in Cats In Great
392 Britain: Estimate from Feline Tissue Samples Submitted to Diagnostic Laboratories *Transboundary*
393 *Emerging Disease* 2013; 60 (4): 338-344.
- 394 4. Bennett A, Lalor S, Schwarz T, et al. Radiographic findings in cats with mycobacterial infections.
395 *Journal of Feline Medicine and Surgery*. 2011; 13 (10): 718-724.
- 396 5. Jennings AR. The distribution of tuberculous lesions in the dog and cat, with reference to pathogenesis
397 *Veterinary Record* 1949; 27: 380-384.
- 398 6. Gunn-Moore DA, McFarland SE, Schock A, et al. Mycobacterial disease in a population of 339 cats
399 in Great Britain: II. Histopathology of 225 cases, and treatment and outcome of 184 cases. *Journal of*
400 *Feline Medicine and Surgery*. 2011; 13 (12): 945-952.
- 401 7. Major A, Holmes A, Warren-Smith C, et al. Computed tomographic findings in cats with
402 mycobacterial infections. *Journal of Feline Medicine and Surgery*. 2015; 18 (6): 510-517.
- 403 8. Rhodes SG, Gunn-Moore DA, Boschioli L, et al. Comparative study of IFN γ and antibody tests for
404 feline tuberculosis. *Veterinary Immunology and Immunopathology* 144: 129-134.
- 405 9. Greene CE and Gunn-Moore DA Mycobacterial Infections *Infectious Diseases of the Dog and Cat* Ed.
406 Greene CE. 4th Edition. Saunders 2012 p. 495-510.
- 407 10. Devasia RA, Blackman A, Gebretsadik T, et al. Fluoroquinolone resistance in Mycobacterium
408 tuberculosis: The effect of duration and timing of fluoroquinolone exposure. *American Journal of*
409 *Respiratory and Critical Care Medicine*. 2009; 180(4): 365-70.
- 410 11. Jordan HL, Cohn LA, Armstrong PJ. Disseminated Mycobacterium avium complex infection in three
411 Siamese cats. *Journal of the American Veterinary Medicine Association*. 1994; 204(1):90-3.

- 412 12. Yin J, Yuan J, Hu Y, Wei X. Association between directly observed therapy and treatment outcomes
413 in multidrug-resistant tuberculosis: A systematic review and meta-analysis *PLoS ONE* 2016; 11 (3):
414 art. no. e0150511
- 415 13. Pantel A, Petrella S, Veziris N, et al. Extending the definition of the GyrB quinolone resistance-
416 determining region in Mycobacterium tuberculosis DNA gyrase for assessing fluoroquinolone
417 resistance in M. tuberculosis. *Antimicrobial Agents and Chemotherapy*. 2012; 56 (4): 1990-1996.
- 418 14. Liu CH, Yang N, Wang Q, et al. Risk factors associated with fluoroquinolone-resistant tuberculosis in
419 a Beijing tuberculosis referral hospital. *Respirology*. 2011; 16 (6): 918-925.
- 420 15. Jeon D, Kim D, Kang H, et al. Acquired drug resistance during standardized treatment with first-line
421 drugs in patients with multidrug-resistant tuberculosis. *Tuberculosis and Respiratory Diseases*. 2009;
422 66 (3) pp198-204.
- 423 16. Schaberg T, Bauer T, Castell S, et al. Recommendations for therapy, chemoprevention and
424 chemoprophylaxis of tuberculosis in adults and children. German Central Committee against
425 Tuberculosis (DZK), German Respiratory Society (DGP) *Pneumologie* 2012; 66: 133-171.
- 426 17. Haburjak J and Spangler W. Isoniazid-induced seizures with secondary rhabdomyolysis and associated
427 acute renal failure in a dog. *Journal of Small Animal Practice*. 2002; 43 (4): 182-186.
- 428 18. De Jong BC, Onipede A, Pym AS, et al. Does resistance to pyrazinamide accurately indicate the
429 presence of Mycobacterium bovis? *Journal of Clinical Microbiology* 2005; 43: 3530-3532.
- 430 19. World Health Organisation. Global Tuberculosis Report 2015. 20th Ed. WHO, Geneva.
- 431 20. Ahmad S. New approaches in the diagnosis and treatment of latent tuberculosis infection. *Respiratory*
432 *Research* 2010;11:169.

- 433 21. Govendir M, Norris JM, Hansen T, et al. Susceptibility of rapidly growing mycobacteria and Nocardia
434 isolates from cats and dogs to pradofloxacin. *Veterinary Microbiology*. 2011; 153 (3-4): 240-245.
- 435 22. Govendir M, Hansen T, Kimble B, et al. Susceptibility of rapidly growing mycobacteria isolated from
436 cats and dogs, to ciprofloxacin, enrofloxacin and moxifloxacin. *Veterinary Microbiology*. 2011; 147(1-
437 2):113-118.
- 438 23. Messias A, Gekeler F, Wegener A et al. Retinal safety of a new fluoroquinolone, pradofloxacin, in
439 cats: Assessment with electroretinography. *Documenta Ophthalmologica*. 2008; 116 (3): 177-191.
- 440 24. Gunn-Moore DA. Feline mycobacterial infections. *Veterinary Journal*. 2014; 201(2): 230-238.
- 441 25. Lalor S, Mellanby R, Friend E, et al. Domesticated Cats with Active Mycobacteria Infections have
442 Low Serum Vitamin D (25(OH)D) Concentrations *Transboundary and Emerging Diseases*. 2011; 59
443 (3): 279-281.
- 444 26. Yuvaraj B, Sridhar M, Kumar S, et al. Association of serum Vitamin D levels with bacterial load in
445 pulmonary tuberculosis patients. *Tuberculosis and Respiratory Diseases*. 2016; 79 (3):153-157.
- 446 27. Grobler L, Nagpal S, Sudarsanam T, et al. Nutritional supplements for people being treated for active
447 tuberculosis. *Cochrane Database of Systematic Reviews*. 2016; (6): art. no. CD006086.
- 448 28. Zittermann A, Pilz S, Hoffmann H, et al. Vitamin D and airway infections: A European perspective.
449 *European Journal of Medical Research*. 2016; 21 (1): art. no. 14.
- 450 29. Martineau A, Timms P, Bothamley GH, et al. High-dose vitamin D₃ during intensive-phase
451 antimicrobial treatment of pulmonary tuberculosis: A double-blind randomised controlled trial. *The*
452 *Lancet*. 2011; 377 (9761): 242-250.
- 453 30. Bille C, Auvigne V, Libermann S, et al. Risk of anaesthetic mortality in dogs and cats: An
454 observational cohort study of 3546 cases *Veterinary Anaesthesia and Analgesia*. 2012; 39 (1): 59-68.

455

456

457 **Figure captions:**

458

459 **Figure 1.** The CT appearance of lung parenchyma in case 1 at the level of the accessory lung lobe on three
460 different occasions. (a) Diffuse, moderate reticulonodular pattern identified on the first occasion of disease
461 recurrence following eleven months of clinical remission. (b) Normal pulmonary appearance three months
462 later following triple antibiotic therapy and calcitriol supplementation. (c) Diffuse, mild reticular pattern
463 noted concurrent with an increased sleeping respiratory rate but normal clinical examination, indicative of
464 probable tuberculosis recurrence/relapse eleven months after image a.

465

466 **Figure 2.** A timeline of diagnostic investigations and treatment for case 1; a seven year old male neutered
467 Oriental cat with pulmonary TB caused by *Mycobacterium microti*.

468 Rad – radiograph; TB – tuberculous changes; NAD – no abnormalities detected; mn – months; T –
469 treatment; R – rifampicin; A – azithromycin; M – marbofloxacin; V – vitamin D; P – pradofloxacin; TB?
470 – potentially tuberculous changes.

471

472 **Figure 3.** The CT images at the level of the third sternebra from case 2 on two different occasions. (a)
473 Image acquired four months after cessation of antibiotic therapy for disseminated tuberculosis showing an
474 enlarged cranial mediastinal lymph node (*). (b) Image acquired five months later, showing a static
475 appearance of the lymph node but a mild ground glass appearance of the adjacent lung parenchyma (arrow)

476 indicative of regional extension of disease. The cat was concurrently diagnosed with a mandibular
477 squamous cell carcinoma.

478

479 **Figure 4.** A timeline of diagnostic investigations and treatments for cases 2-9.

480 Rad – radiograph; US – ultrasound; TB – tuberculous changes; NAD – no abnormalities detected; mn –
481 months; T – treatment; R – rifampicin; A – azithromycin; M – marbofloxacin; C - clarithromycin V –
482 vitamin D; P – pradofloxacin; TB? – potentially tuberculous changes; Euth – euthanasia; SCC – squamous
483 cell carcinoma; No – no treatment given; Sx – surgery; MN – male neutered; FN – female neutered; DSH
484 – domestic short haired; BSH – British short haired.

485

486 **Figure 5.** The CT appearance of the lung parenchyma in case 4 at the level of the accessory lung lobe on
487 two different occasions. (a) Multifocal regions of alveolar pattern with associated pulmonary cavitation (*)
488 identified at initial presentation. (b) Follow up imaging after right caudal lung lobectomy and eight months
489 of antibiotic treatment shows residual patchy ground glass appearance and collapsed pulmonary cavities
490 (arrow). An additional CT study performed four months' post surgery (not shown) showed very similar
491 residual changes.

492

493 **Figure 6.** The CT appearance of the lung parenchyma in case 5 at the level of the accessory lung lobe on
494 two different occasions. (a) Marked, diffuse nodular lung pattern with occasional foci of mineralisation
495 (arrows) identified at initial presentation. (b) Follow up imaging after eight months of treatment shows a

496 persistent mild reticulonodular pattern with mildly more extensive parenchymal mineralisation (arrow).
497 Treatment was discontinued and a static appearance was recorded 12 months later, indicating these
498 persistent changes do not reflect active disease.



Figure 1. CT appearance of lung parenchyma in case 1 at the level of the accessory lung lobe on three different occasions. (a) Diffuse, moderate reticulonodular pattern identified on the first occasion of disease recurrence following eleven months of clinical remission. (b) Normal pulmonary appearance three months later following triple antibiotic therapy and calcitriol supplementation. (c) Diffuse, mild reticular pattern noted concurrent with an increased sleeping respiratory rate but normal clinical examination, indicative of probable tuberculosis recurrence/relapse eleven months after image a.

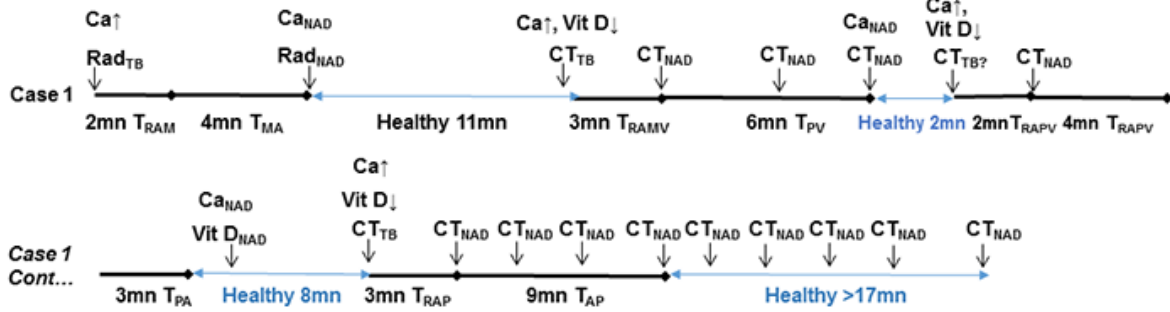


Figure 2. A timeline of diagnostic investigations and treatment for case 1; a seven year old male neutered Oriental cat with pulmonary TB caused by *Mycobacterium microti*.

Rad – radiograph; TB – tuberculous changes; NAD – no abnormalities detected; mn – months; T – treatment; R – rifampicin; A – azithromycin; M – marbofloxacin; V – vitamin D; P – pradofloxacin; TB? – potentially tuberculous changes.

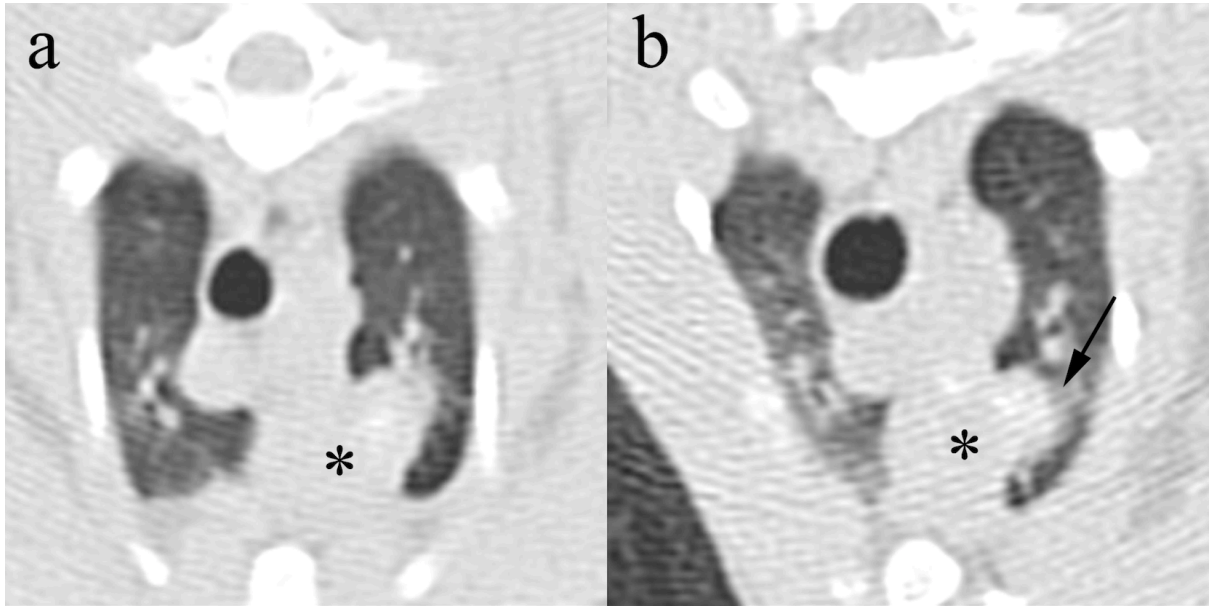


Figure 3. CT images at the level of the third sternebra from case 2 on two different occasions. (a) Image acquired four months after cessation of antibiotic therapy for disseminated tuberculosis showing an enlarged cranial mediastinal lymph node (*). (b) Image acquired five months later, showing a static appearance of the lymph node but a mild ground glass appearance of the adjacent lung parenchyma (arrow) indicative of regional extension of disease. The cat was concurrently diagnosed with a mandibular squamous cell carcinoma.

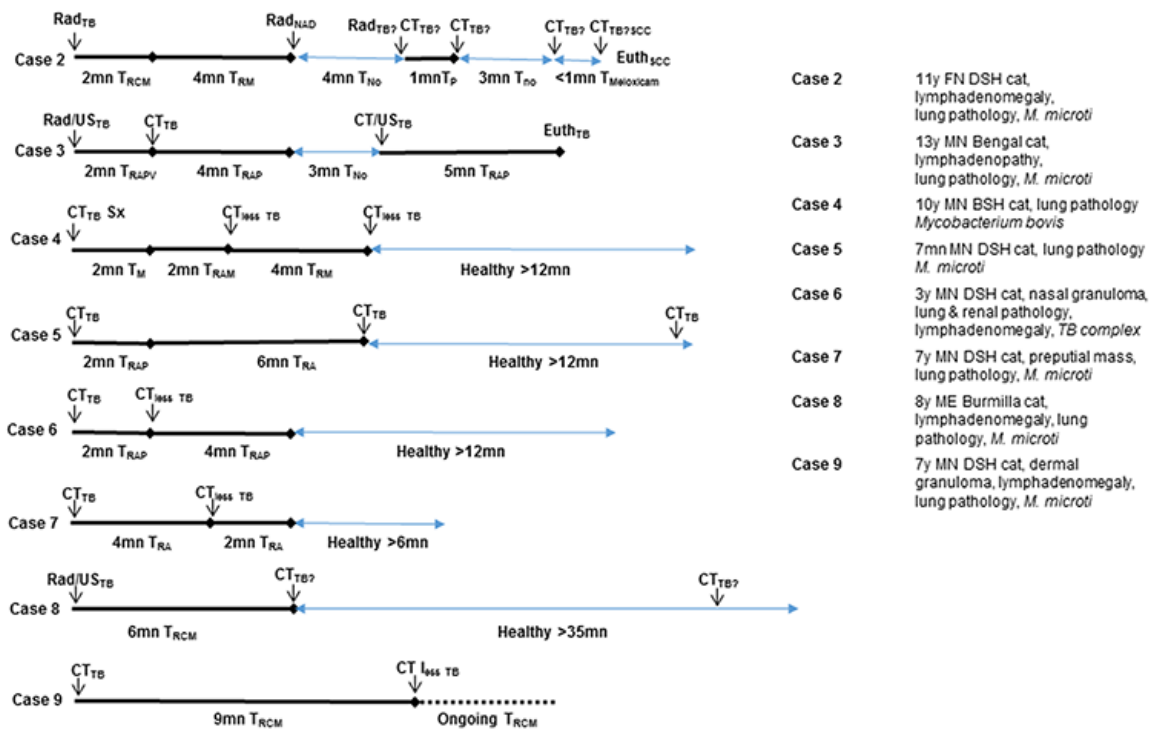


Figure 4. A timeline of diagnostic investigations and treatments for cases 2-9.

Rad – radiograph; US – ultrasound; TB – tuberculous changes; NAD – no abnormalities detected; mn – months; T – treatment; R – rifampicin; A – azithromycin; M – marbofloxacin; C - clarithromycin V – vitamin D; P – pradofloxacin; TB? – potentially tuberculous changes; Euth – euthanasia; SCC – squamous cell carcinoma; No – no treatment given; Sx – surgery; MN – male neutered; FN – female neutered; DSH – domestic short haired; BSH – British short haired.

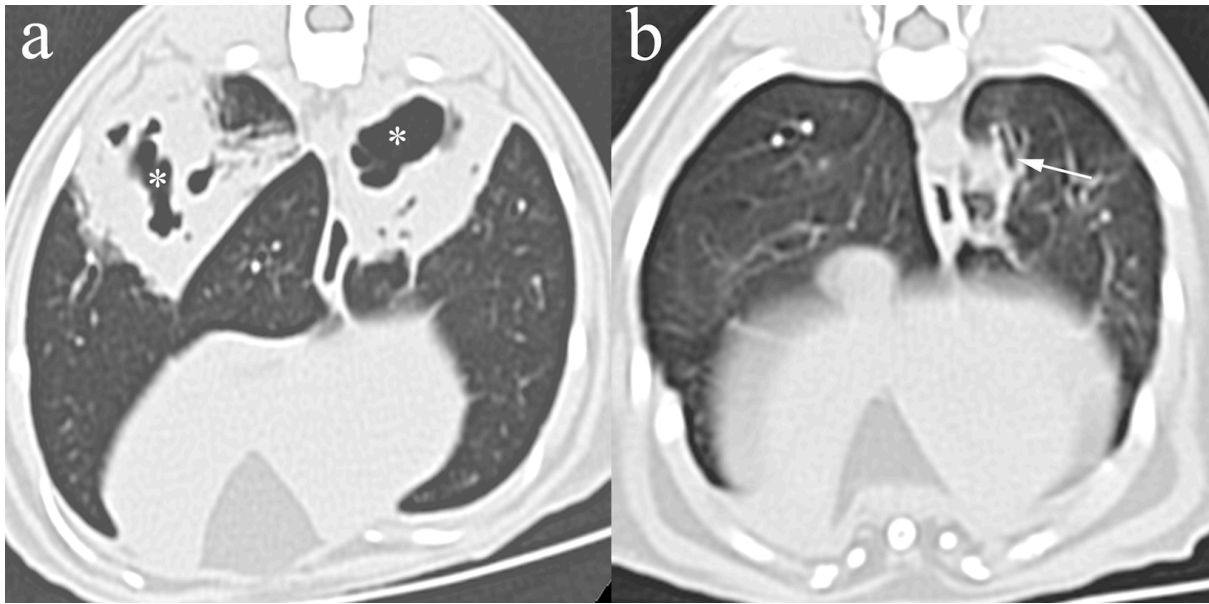


Figure 5. CT appearance of the lung parenchyma in case 4 at the level of the accessory lung lobe on two different occasions. (a) Multifocal regions of alveolar pattern with associated pulmonary cavitation (*) identified at initial presentation. (b) Follow up imaging after right caudal lung lobectomy and eight months of antibiotic treatment shows residual patchy ground glass appearance and collapsed pulmonary cavities (arrow). An additional CT study performed four months' post surgery (not shown) showed very similar residual changes.

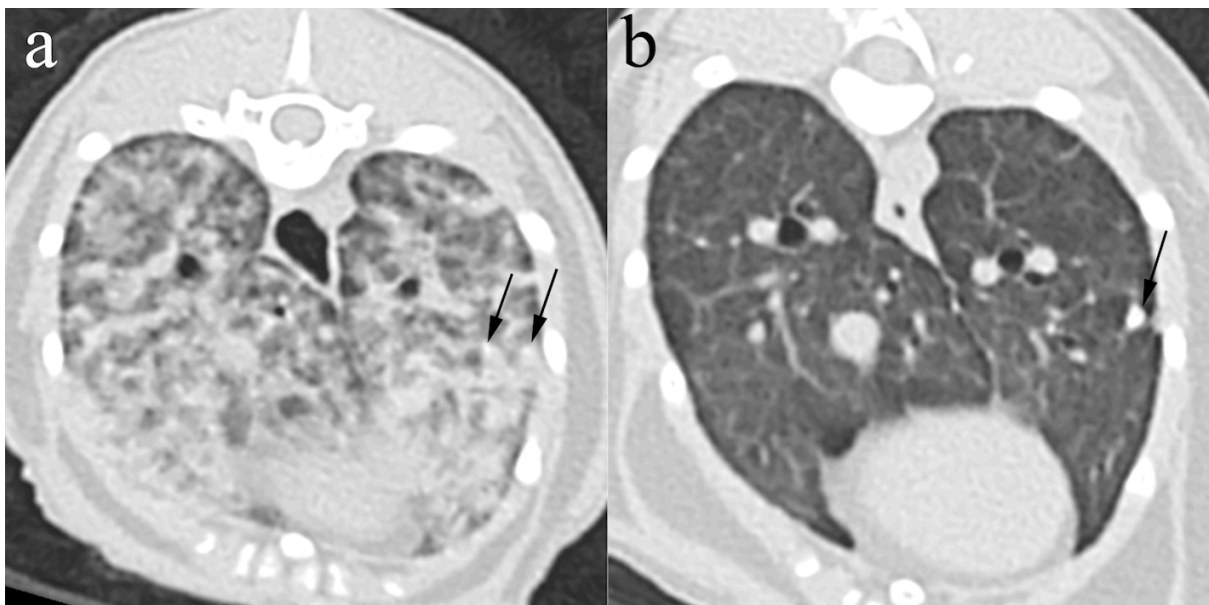


Figure 6. CT appearance of the lung parenchyma in case 5 at the level of the accessory lung lobe on two different occasions. (a) Marked, diffuse nodular lung pattern with occasional foci of mineralisation (arrows) identified at initial presentation. (b) Follow up imaging after eight months of treatment shows a persistent mild reticulonodular pattern with mildly more extensive parenchymal mineralisation (arrow). Treatment was discontinued and a static appearance was recorded 12 months later, indicating these persistent changes do not reflect active disease.