

## Case Report

# Gross and Histopathological Characterisation of Pulmonary Abscessation Associated with *Staphylococcus aureus* and *Escherichia coli* in a Collared Mangabey (*Cercocebus torquatus*): A Case Report

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**Abstract:** Bacterial lower respiratory tract infections (LRTIs) can result in severe and fatal diseases in non-human primates (NHPs), and the disease process of pulmonary abscessation in the Collared Mangabey (*Cercocebus torquatus*), an endangered West and Central African cercopithecoid, has been underreported. A gross and histopathological evaluation of a 12-year-old captive female *C. torquatus* that had a 14-month history of intermittent coughing and had a polymicrobial co-infection with *Staphylococcus aureus* and *Escherichia coli* is presented. At post-mortem examination, bilateral fibrinous to fibrous pleuritis with pleural adhesions to the thoracic wall and pericardium were noted. The left lung was very enlarged, fluctuant and distorted to a spherical or irregularly ovoid shape. On cut section, a large proportion of the lung substance was replaced with a central cavity filled with semi-solid to pasty, yellow to off-white debris, which was largely necrotic and included purulent exudate; similar necrotic material was seen in the bronchi of the contralateral lung. The histopathological features confirmed multifocal colonies of coccoid bacteria in perivascular spaces of pulmonary vessels, interstitial thickening and a discrete focus of suppurative inflammation circumscribed by the zone of fibrous connective tissue and proliferating fibroblasts, which is characteristic of abscess encapsulation. Foreign bodies were also found in alveolar spaces, suggesting chronic exposure to particulate in the environment as a possible contributing factor. Aerobic culture results were positive for *S. aureus* and *E. coli*, and antimicrobial susceptibility testing revealed *in vitro* activity against *S. aureus* and *E. coli* for chloramphenicol and tigecycline. To the authors' knowledge, based on the available literature, it is the first time that pulmonary abscessation has been documented in *C. torquatus*, and in other cercopithecoids, the authors have never observed this condition; so far, it has been the only baseline for the lesions associated with respiratory disease in an endangered species, *C. torquatus*, in captivity.

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## 1. Introduction

Pneumonia is one of the most clinically important respiratory diseases of both captive and wild non-human primates (NHPs) and can lead to complications such as pulmonary abscessation [1, 2]. Respiratory diseases that have been reported in NHPs include tuberculosis, nocardiosis, paragonimiasis, pulmonary acariasis, pneumococcal infection, and severe acute respiratory syndrome (SARS) [2]. Mortality is generally high in pulmonary infections, especially for younger and older animals, and there can be seasonal fluctuations in disease prevalence in certain facilities [1]. Respiratory infections in NHPs are often polymicrobial and involve a variety of opportunistic and pathogenic bacteria that colonize the lower respiratory tract [1, 2].

*Staphylococcus aureus* and *Escherichia coli* are among the most common bacterial causes of primate pulmonary infections, with a prevalence of 43.1% and 34.9% of pneumonia cases, respectively, and are frequently identified as co-infections [1,3]. Severe suppurative pneumonia and multisystemic abscessation are also seen with other pathogens in NHPs, such as *Klebsiella pneumoniae* [4], *Streptococcus spp.* [5–7]. However, *S. aureus* and *E. coli* are still important differential diagnoses in clinical veterinary primatology [1].

Pulmonary abscesses are a type of liquefactive necrosis that consists of circumscribed areas of pus in the lung parenchyma that can be primary (from processes directly involving the pulmonary tissue) or secondary (from conditions affecting the surrounding structures) [8–10]. One of the possible aetiological factors is the aspiration of oropharyngeal secretions, which can originate from inflammatory processes (septic or non-septic) or from the disturbance of normal mechanical clearance [9]. Pulmonary abscesses usually occur in primates in association with suppurative bronchopneumonia or septic emboli [2]. Macroscopically, these lesions are characterised by the presence of purulent exudate in the lung parenchyma and may have secondary complications such as pleuritis, pulmonary thrombosis, and fibrous adhesions [5, 11]. Histopathologically, lesions are usually characterised as single to multiple foci of suppurative inflammation, liquefactive necrosis, leukocytic infiltration, fibrin deposition and haemorrhage, with fibrous encapsulation and emphysematous change occurring in adjacent alveolar spaces [8].

The Collared Mangabey (*Cercocebus torquatus*) is a terrestrial cercopithecoid species of the genus *Cercocebus*, which includes seven recognised species [12] (Bio Explorer, 2026). *C. torquatus* is an endangered species of West Africa and the Democratic Republic of Congo coastal forest areas with a unique red cap, noticeable white eyelids, and a white collar of fur around the chest, shoulders, and cheeks [12] (Bio Explorer, 2026). The species has a significant biomedical value: It has been suggested that it could be used as an animal model for leprosy because its symptoms are similar to those of humans with leprosy [13, 14] and because it is susceptible to it. It has also been used in acquired immunodeficiency syndrome (AIDS) research because of the genetic similarity between its Simian Immunodeficiency Virus and the Human Immunodeficiency Virus [15, 16]. While bacterial pneumonia is well documented in other cercopithecoids such as *Macaca spp.* and *Papio spp.*, there are no specific reports regarding pulmonary abscessation in *C. torquatus*. Such cases must be documented to help guide diagnosis and treatment for this species in managed care.

A gross and histopathological description of pulmonary abscessation due to a combination of bacterial infection with *S. aureus* and *E. coli* in a Collared Mangabey is presented in this case report. The report provides a detailed description of the pathological findings of these co-infecting pathogens in this particular host, helps to further understand primate respiratory pathology and aids in the improved clinical management of opportunistic bacterial infections in cercopithecoids.

## 2. Case Description

A female Collared Mangabey, which had been in captivity for about 12 years at the University of Ibadan Zoological Garden, had a history of chronic intermittent cough for one year and 2 months (14 months). The animal was said to be a juvenile at the time of acquisition. The animal showed no signs of behavioural abnormalities, had a normal appetite, moderate body condition, and activity throughout this period. A pen mate was housed with the mangabey, and normal social interactions were observed. The companion animal was clinically normal and had no other signs of respiratory disease.

The carcass was in moderate body nutritional condition, with a body condition score of 3/5. The oral and ocular mucous membranes were markedly pale. The perineum was blood-stained. The pleural membranes were bilaterally thickened, dull, and firmly adhered to the thoracic wall and the pericardial surface of the heart, consistent with chronic fibrinous to fibrous pleuritis (Figure 1).

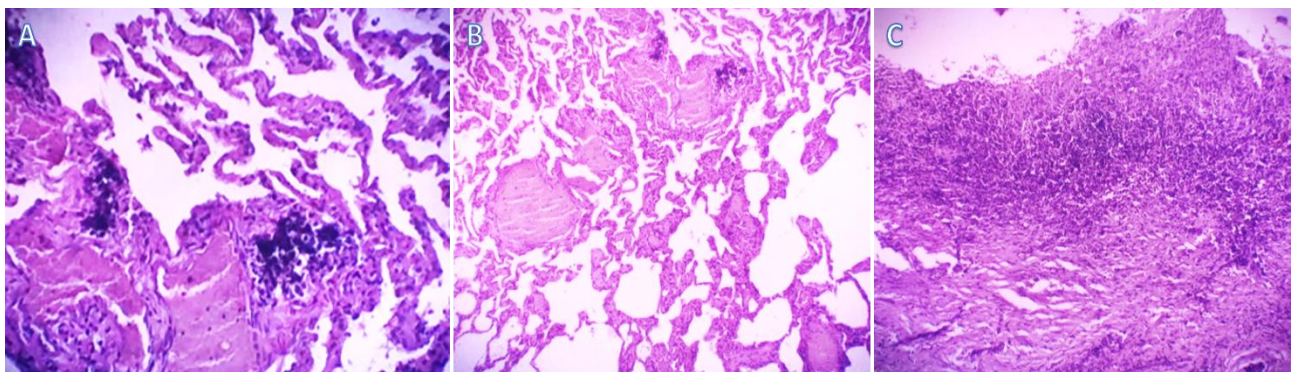
The left lung was markedly and diffusely enlarged, fluctuant on palpation, and distorted from its normal lobular architecture to a spherical to irregularly ovoid form. On cut section, the parenchyma was largely replaced by a central cavity containing semi-solid to pasty material ranging in colour from yellow to off-white, consistent with liquefactive necrotic debris admixed with purulent exudate. Necrotic debris of similar morphology was also identified within the bronchi of the contralateral (right) lung (Figure 1). No additional gross lesions were identified in other organ systems.

Morphological diagnosis: Lung (left): severe, chronic, locally extensive necrosuppurative pneumonia with pulmonary abscess formation and marked fibrous encapsulation. Pleura: severe, chronic fibrinous and fibrous pleuritis.



**Figure 1.** Gross findings in a Collared Mangabey with pulmonary abscessation. (A) Full body view of the carcass on the necropsy table (B) The species' distinctive white eyelids. (C) Intact pluck with the left lung completely encapsulated by fibrous tissue, obliterating normal lobular architecture. (D) Cut surface of the lungs revealing complete replacement of the left pulmonary parenchyma by necropurulent exudate; inspissated necrotic debris is evident within the tracheal lumen, with smaller foci of necrotic material extending into the airways of the right lung.

Microscopic examination of the left lung revealed multifocal colonies of coccoid bacteria within the perivascular spaces of pulmonary vessels, associated with marked interstitial thickening (Figure 2). A discrete focus of neutrophilic infiltration was present, demarcated from the adjacent viable parenchyma by a zone of fibrous connective tissue and proliferating fibroblasts, consistent with abscess encapsulation. A Morphological diagnosis of Multifocal, subacute to chronic, suppurative pneumonia with intralesional bacterial colonies, interstitial fibrosis, and fibrous abscess encapsulation.



**Figure 2.** Histopathological findings in the left lung of a Collared Mangabey with pulmonary abscessation. Multifocal large colonies of coccoid bacteria are present within the pulmonary interstitium and alveolar spaces, accompanied by marked interstitial thickening and mild oedema (A). Most pulmonary vessels are markedly congested, and a proportion are occluded by thrombi. Interstitial macrophages are predominantly laden with black carbonaceous material (anthracosis). Focal aggregates of neutrophils are observed within both the alveolar spaces and the interstitium (B). Dense infiltrates of intact and degenerate neutrophils markedly thicken the pleura. Most alveoli are obliterated by the combined effects of inflammatory exudation and fibrosis (C). Sections stained with hematoxylin and eosin (H&E), examined at 100× and 400× magnification. Scale bar = 0.5 µm.

Lung abscess material was submitted to the Veterinary Microbiology Laboratory of the University of Ibadan within 30 minutes of collection and cultured aerobically on blood agar for 24 hours, yielding heavy growth of *S. aureus* and moderate growth of *E. coli*. Presumptive identification was confirmed using an Analytical Profile Index (API) kit, and antimicrobial susceptibility was assessed on Mueller–Hinton agar using the Kirby-Bauer disk diffusion method. The *S. aureus* isolate was susceptible to gentamicin (120 µg), meropenem (10 µg), erythromycin (15 µg), chloramphenicol (30 µg), and tigecycline (30 µg) by antimicrobial susceptibility testing. The *E. coli* isolate was found to be sensitive to chloramphenicol (30 µg), ertapenem (10 µg), and tigecycline (30 µg).

### 3. Discussion

In this case of the Collared Mangabey, the pathological changes observed emphasize the importance of polymicrobial bacterial infections in the origin of severe pulmonary lesions in this species of primate. Both *S. aureus* and *E. coli* were identified in the pulmonary abscesses, and this is in line with the general epidemiology of pathogens in captive NHP colonies, which include *S. aureus* and *E. coli* among the most common and co-occurring pathogens [1]. The gross appearance of the lungs, with extensive purulent exudate and parenchymal destruction (Figure 1), is similar to the suppurative processes reported in other cercopithecids, such as baboons and macaques [13].

Given the advanced age of the mangabey, its age at the time of the condition was about 12 years in captivity, it is quite possible that the condition developed as a combination of predisposing factors. As people and animals age, the efficacy of their innate and adaptive immune system declines, making it easier for organisms normally found as commensal members of the respiratory tract to cause opportunistic colonization [2, 17]. A unilateral distribution of the abscess is indicative of a dominant pulmonary abscessation process, which is usually caused by aspiration of oropharyngeal secretions or localised immunosuppression, rather than a haematogenously disseminated process [9, 18]. Staphylococcal pneumonia is believed to occur rarely in NHPs, however, there is an exception for immunocompromised individuals, such as those infected with Simian Immunodeficiency Virus (SIV) [2], a condition which is thought to be endemic in African primates of the genus *Cercocebus* [16]. That this clinical course was chronic (lasting more than one year) and that it was marked by intermittent coughing also suggests a possible case of prolonged, progressive immunological decline and not an acute infectious event. Furthermore, the urban environment of the subject might have been a factor in their being vulnerable to respiratory diseases. This is hinged on the high likelihood of chronic exposure to inorganic particulates, such as heavy metals, carbon particles, dust, microplastics and chemical fumes. Exposure to these agents has been shown to contribute to chronic airway inflammation and to compromise mucociliary defence [19]; Pigment-laden macrophages within the alveolar spaces are consistent with anthracosis (carbon deposition, Figure 2); however, as polarized light microscopy and special stains for particulate material were not performed, this finding is suggestive of, but not definitively confirmed as, anthracotic pigment.

*S. aureus* is a characterised pyogenic pathogen that can produce a large amount of tissue necrosis and abscess formation by secreting toxins, enzymes, and proinflammatory mediators that are responsible for the recruitment of neutrophils to the infection site [10]. As the neutrophilic activity continues, the infected parenchymal cells and the bacteria-bearing phagocytes undergo necrosis, and the liquefaction of these cells yields sequestered debris that is encapsulated in a fibrous wall, the hallmark of the established abscess [10]. *E. coli* is a natural commensal of the gastrointestinal tract, but acts as a powerful opportunistic respiratory pathogen in the absence of host defences or in the presence of concurrent infection, resulting in the breakdown of normal mucosal barriers [1]. The synergy between these two organisms, whereby *S. aureus* causes structural damage and *E. coli* takes advantage of this, is probably responsible for the severity of the pulmonary lesions seen in this case. Histopathology observation reveals the presence of suppurative necrosis, neutrophilic infiltration, fibrous encapsulation, and intravascular bacterial colonies, which are typical tissue changes following a combination of pyogenic insults [6, 8].

The lesions in this Collared Mangabey are similar to those seen in other aggressive pathogens, such as *Klebsiella pneumoniae*-associated pneumonia and multisystemic abscessation in African Green Monkeys, and bacterial pneumonias in Howler monkeys, and *Streptococcus spp.*-associated bacterial pneumonias in baboons [5, 7, 20].

Other differential diagnoses include Nocardiosis, a common opportunistic pathogen and frequent isolate from NHPs, associated with suppurative and granulomatous nodular lesions and microabscesses,

whose location varies with the route of exposure [21]. Nocardiosis is also typically misdiagnosed as actinomycosis, as Gram-positive microorganisms cause both conditions with a filamentous appearance under microscopy with routine stains, and have similar gross presentation [22,23]. The two aforementioned conditions may account for the gross lesions if the typical suppurative nodules were to coalesce to form a single, cavitating sac; however, the filamentous growths associated with both were not observed at histology, though it must be noted that special stains were not used, and as such the involvement of either cannot be completely ruled out.

Tuberculosis, caused by the *Mycobacterium tuberculosis* complex, is another differential diagnosis that is characterised by chronic respiratory debilitation but is, however, grossly characterised by multifocal areas of firm, caseous, nodular lesions that are not restricted to the respiratory system [24]. The histological presentation consists of the classically associated granulomas, with varying degrees of mineralization [24], rather than suppurative lesions seen in the mangabey necropsied. Also, it was deemed unlikely that the cause was aspiration or foreign-body, since neither plant, food, or other exogenous particulate material nor foreign-body giant cell reaction was seen in the affected parenchyma by histopathological examination. Fungal infection was also ruled out because there were no fungal hyphae or spores seen on the histopathology, and there was no granulomatous inflammation that is usually seen in a mycotic process. An embolic source was also considered unlikely since the distribution of the lesions was unilateral and localized instead of multifocal and bilateral, the distribution pattern typical of hematogenous embolization.

So far, most of the NHP pathology investigations have focused on species that are frequently employed in biomedical research, including the Rhesus Macaque, and little work has been done on the characterisation of disease in non-model cercopithecids [1, 3]. The present case implies that Collared Mangabeys are similarly susceptible to potentially common opportunistic bacteria when they are physiologically compromised and that the manifestation of the susceptibility is not significantly divergent from that of better-studied congeners. This case thus provides a valuable contribution and serves as a reference case for further pathological studies in this species of endangered nature.

A major drawback of this report was that it is a single case ( $n = 1$ ), and therefore not inferential of the incidence or disease trajectory of pulmonary abscessation in *C. torquatus* at the population level. The retrospective study design limits the ability to completely define the temporal association between the onset of infection, potential predisposing stressors, and disease development. The difficulty of post-mortem bacteriology must also be noted; that is, the possibility that gastrointestinal or oropharyngeal flora may have been translocated at the time of death or immediately after and culture alone is insufficient in the determination of the origin and role of the isolates obtained as primary pathogens as opposed to being opportunists or post-mortem contaminants, but it is believed that the strong histopathological relationships between the lesions observed and the organisms isolated indicate that gastrointestinal organisms were the most likely to be primary aetiological agents rather than accidental contamination. Additionally, no ancillary techniques (e.g., Gram staining, immunohistochemistry, fluorescence in situ hybridization, or PCR) were performed to directly demonstrate either organism within the lesions. Histologically, only coccoid bacterial morphology was observed; the absence of visualized bacilli does not exclude *E. coli*, which may represent a secondary colonizer of a lesion primarily established by *S. aureus*.

#### 4. Conclusions

To the authors' knowledge, based on the published literature, this is the first detailed gross and histopathological description of pulmonary abscessation in a Collared Mangabey associated with the isolation of *S. aureus* and *E. coli* bacteria. In summary, the unilocular abscess, the suppurative liquefactive necrosis with fibrous encapsulation on histology, and the microbiological profile are consistent with a presumed primary pulmonary abscessation in a host susceptible due to advanced age. These proposed mechanisms are speculative and not directly demonstrated by the available histopathological or clinical data; further studies would be needed to confirm an immunosenescence-related pathogenesis. The results demonstrate the ability of these opportunistic pathogens to cause severe parenchymal damage in cercopithecids and emphasise the importance of combined gross, histological, and microbiological examination for the diagnosis of the suppurative nature of lesions and the histopathology of the pulmonary lesions to differentiate bacterial abscessation from other pulmonary diseases. These findings highlight the need for careful clinical monitoring of the respiratory tract in older animals, particularly those presenting with chronic cough.

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