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Atrial Fibrillation in Eight New World Camelids

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Background: There is limited information on the incidence of clinical signs, concurrent illness and treatment options for atrial fibrillation (AF) in New World Camelids (NWC).

Objective: Describe clinical signs and outcome of AF in NWC.

Animals: Eight New World Camelids admitted with AF.

Methods: A retrospective observational study of camelids diagnosed with AF based on characteristic findings on electrocardiogram (ECG).

Results: All animals had an irregularly irregular heart rhythm detected on physical examination and 4 cases had obtunded mentation on admission. Three camelids were diagnosed with AF secondary to oleander intoxication, 3 animals had underlying cardiovascular disease, 1 was diagnosed with lone AF and 1 had AF diagnosed on examination for a urethral obstruction. Five of eight animals survived to discharge and nonsurvivors consisted of animals which died or were euthanized as a result of cardiovascular disease (2/8) or extra-cardiac disease unrelated to the AF (1/8).

Conclusions and Clinical Importance: Atrial fibrillation occurs in NWC in association with cardiovascular disease, extra-cardiac disease or as lone AF. Amiodarone and transthoracic cardioversion were attempted in one llama with lone AF, but were unsuccessful. Atrial fibrillation was recorded in 0.1% of admissions.

Key words: Alpaca; Arrhythmia; Cardiac; Llama.

Atrial fibrillation is the most common atrial arrhythmia in domestic animal species. Atrial fibrillation is usually associated with underlying cardiac disease in dogs and cats[1] and with gastrointestinal disorders in cattle, but can be associated with no underlying cause, termed "lone" AF.[2]

The incidence of arrhythmias in llamas has been reported to be 0.78–1.2%, as documented in 2 retrospective studies evaluating ECGs from 2,167 and 663 llamas, respectively.[3,4] Reported rhythm abnormalities included atrial premature contractions, AF, sinus arrhythmia, sinus bradycardia, sinus tachycardia, ventricular premature contractions, ventricular tachycardia, abnormal cardiac conduction (unspecified), and second-degree atrio-ventricular (AV) block. Only one of the animals in each of those reports had atrial fibrillation. Similar to horses, there is clinical evidence that some healthy camelids can demonstrate second-degree AV block at rest.[4]

Abbreviations:

ECG	electrocardiogram
AF	atrial fibrillation
AV	atrioventricular
CBC	complete blood count
CK	creatine kinase
VSD	ventricular septal defect
ASD	atrial septal defect
TVEC	transvenous electrical cardioversion

The clinical features, treatment, and prognosis of AF have not been well described in New World Camelids. The objectives of this retrospective study were to describe the clinical features of AF in camelids, including the incidence in a referral hospital population.

Medical records for camelids presented to the William R. Pritchard Veterinary Medical Teaching Hospital, University of California, Davis over a 28-year period (1986–2014) were reviewed. Inclusion criteria were animals with AF diagnosed by ECG analysis. The ECG recordings were obtained using a base-apex system as used in horses. Data collected included signalment, historical complaint, physical examination (including heart rate) and clinicopathologic findings, concurrent illness, treatment, duration of hospitalization, and outcome.

Eight animals met the criteria for entry into the study: 3 alpacas and 5 llamas. This represented 0.5% of hospital visits of camelids during this same time period. The median age was 10 years (range, 2–11 years). The age of 1 llama was not recorded. Five camelids were female, 2 were intact males and 1 was a castrated male. Presenting complaints included inappetance (4/8), lethargy (5/8), exercise intolerance (2/8), colic (2/8), respiratory distress (1/8), and recumbency (1/8). One llama was presented for inability to urinate, and 1 llama was

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Table 1. The most common complete blood count and serum biochemical abnormalities detected in the 8 camelids diagnosed with atrial fibrillation at the William R. Pritchard Veterinary Medical Teaching Hospital, University of California, Davis over a 28-year period (1986–2014).

Abnormality	Prevalence	Mean ± SD	Reference Range
Lymphopenia	3/8	1,075 ± 871 cells/μL	689–4,848 cells/μL
Anemia	3/8	30 ± 8%	27–45%
Hypoalbuminemia	8/8	2.96 ± 0.63 g/dL	4.7–7.3 g/dL
Hyperglycemia	6/8	261 ± 106 mg/dL	71–149 mg/dL
Azotemia	5/8		
Creatinine		4.6 ± 3.5 mg/dL	1.1–3.2 mg/dL
BUN		55 ± 46 mg/dL	9–34 mg/dL
Hyponatremia	5/8	144.9 ± 7.5 mmol/L	148–158 mmol/L
Hypokalemia	3/8	3.83 ± 0.79 mmol/L	3.7–6.2 mmol/L
Increased creatine kinase (CK)	4/8	424 ± 456 IU/L	14–238 IU/L
Increased gamma-glutamyl transferase (GGT)	4/8	49 ± 44 IU/L	6–29 IU/L

hospitalized with her cria and developed AF during hospitalization, which was noted on a routine daily examination without overt clinical signs.

The most common clinical signs were an irregularly irregular heart rhythm noted on auscultation (8/8), obtundation (4/8), heart murmur (2/8), and increased bronchovesicular sounds (3/8). Tachycardia (>110 bpm) was only noted in one llama.

A complete blood count (CBC) and serum biochemical profile were available for all 8 cases. The most common CBC and serum biochemical abnormalities are reported in Table 1. Additional minor abnormalities were recorded in individual cases associated with their underlying condition.

Three animals were treated for oleander toxicity (two confirmed with positive serum liquid chromatography-mass spectrometry, one case was suspected) and 3 animals had underlying cardiovascular disease (one with a VSD, one with suspected atrial septal defect (ASD; diagnosed by echocardiography but not easily delineated), and one with congestive heart failure (CHF). One animal had a urethral obstruction and one was diagnosed with lone AF.

Diagnosis in all 8 cases was based on ECG findings consistent with AF. These findings included absence of P waves, presence of *f* waves (oscillation of the baseline), irregularly irregular R–R intervals, and normal to narrow QRS complexes of varied amplitude. Echocardiography was performed on 4 animals. Three of the 4 camelids had underlying structural cardiac disease (one with atrial enlargement and suspected ASD, one with VSD, and one with CHF). One animal had no echocardiographic abnormalities and was diagnosed with lone AF.

The most common therapies included intravenous administration of isotonic fluids (4/8), partial parenteral nutrition (2/8), antimicrobials (2/8), and intracompartmental administration of charcoal for oleander toxicity (2/8). Two animals were treated for heart failure and associated pulmonary edema with furosemide and one of these was also treated by oral administration of digoxin. Cardioversion was attempted in the single llama with lone AF using amiodarone (7 mg/kg IV, diluted and administered over 30 minutes; repeated at 3 mg/kg the following day). This was unsuccessful and was followed by transthoracic biphasic defibrillation up to 200 J under general inhalational anesthesia. No adverse effects of these treatments were noted in this animal, although he did not convert to sinus rhythm.

Duration of hospitalization ranged from 0 to 28 days, and 6/8 of cases were discharged within a week of admission. Three animals did not survive. One animal was euthanized because of complications associated with CHF, 1 animal died from oleander intoxication, and 1 animal was euthanized after discharge because of urethral necrosis and fibrosis with stricture formation after urethral obstruction.

Of the five surviving camelids, one animal converted to sinus rhythm with resolution of the underlying condition (oleander intoxication). Four animals were discharged with persistent AF. These included one camelid each with ASD, VSD, oleander intoxication, and lone atrial fibrillation. The 6-year old llama with lone atrial fibrillation was reported to be doing well approximately 6 months after discharge.

Atrial Fibrillation was rarely detected in New World Camelids in this hospital population (0.1%). This is similar to the reported incidence of only 1 case in a population of 2,167 (0.05%) llamas obtained from the Veterinary Medical Database at Purdue University from participating universities from 1986–1993.[3] This might be because AF is rare in these species, or that it is intermittent and self-resolving; or it might be more common in the general population than reflected in these studies if the animals are subclinical and the dysrhythmia goes undetected. The majority of cases in this retrospective study had AF associated with either cardiovascular or systemic disease and only 1 case was diagnosed with

"lone AF". One case converted to sinus rhythm with treatment of its oleander intoxication, but all other discharged cases had persistent AF.

Based on the results of this study, it appears that camelids might develop AF in the face of cardiac disease, other systemic diseases (urethral obstruction), as well as with no other predisposing factors, similar to lone AF in horses. Lone AF in camelids might be more rarely diagnosed compared to horses because of differences in their care and management practices.

Although heart rates recorded for each individual were variable, they generally remained within the reference range (50–110 bpm). Tachycardia was only noted in one llama with a VSD and in this case the maximum-recorded heart rate was 127 bpm. It appears that tachycardia is not a common complication as reported in small animals that often develop AF secondary to atrial dilatation. The 2 llamas noted to have atrial enlargement did indeed have higher heart rates than the other animals. Hence, heart rate might be more a reflection of the underlying disease causing the AF rather than associated with the AF itself.

Clinicopathological abnormalities were associated with the underlying disease process in the animals in this study. Hypokalemia was present in 3/8 camelids, which is hypothesized to be one of the risk factors for development of AF in horses. The llama diagnosed with lone AF had no relevant clinicopathological abnormalities.

Quinidine is the drug of choice to convert AF to sinus rhythm in horses and cattle. Quinidine sulfate was used in an attempt to convert one llama with lone AF to sinus rhythm, but proved unsuccessful.[3] Despite lack of conversion to sinus rhythm, the llama of that report continued to do well clinically, as is often the case in horses with lone atrial fibrillation that fail to convert and are not asked to maximally exercise.[3] The failure to convert to sinus rhythm in this case might have been caused by poor oral bioavailability of quinidine sulfate in camelids. Intravenous quinidine gluconate might have better success in these species, however, the pharmacokinetics and safety require study.

Attempts at both chemical and electrical cardioversion in the llama with lone AF of our report were also unsuccessful. Pharmacokinetics of amiodarone in camelids have not been studied, therefore, the amiodarone doses administered (7 mg/kg followed by 3 mg/kg the following day) might have not been appropriate for successful conversion. There are no reports of successful cardioversion in camelids in the literature, and it is clear that pharmacokinetics and safety studies of antiarrhythmic drugs are warranted in these species.

Electrical cardioversion is an established technique in addition to pharmacological cardioversion for the restoration of sinus rhythm in humans and dogs with AF.[5] Transthoracic cardioversion has been described in horses but is considered rarely successful.[6] Transvenous electrical cardioversion (TVEC) has been reported to be of higher efficacy than transthoracic cardioversion in humans and requires substantially lower energy levels. Successful TVEC using a conventional biphasic defibrillator has been described in horses but has not been reported in camelids.[6–8] Transthoracic electrical cardioversion was attempted in the llama diagnosed with lone AF in this study (up to 200 J) but was also unsuccessful in restoring sinus rhythm.

The prognosis for cattle with AF is generally considered good if the underlying condition has been treated and the AF has converted to normal sinus rhythm. After conversion, an improvement in appetite and milk production is often noted and recurrence of AF is unusual unless underlying heart disease is present. The prognosis for cattle that do not respond to quinidine treatment is poor.[2] Horses with no underlying cardiac disease, normal heart rates, and lone AF of relative short duration have a good prognosis for conversion and return to previous performance level.[9,10] Horses with atrial enlargement or sustained AF for longer than 4 months before treatment have a higher recurrence rate and higher incidence of adverse effects of quinidine treatment. Atrial fibrillation-induced atrial contractile dysfunction gradually improves in the weeks after cardioversion, but even at 7 weeks postcardioversion, significant differences remain compared to healthy horses.[11] Attempts should be made to treat any underlying cardiac disease, electrolyte abnormalities, or other underlying causes in cases where these are identified.[2] Based on this report, the prognosis for camelids appears to be primarily associated with the underlying disease process, if present. Animals with lone AF are likely to have a good prognosis even without conversion, provided they are not put under high exercise demands requiring maximal cardiac output.

Cardiac output at rest in most horses with AF is normal, however, maximal cardiac output during exercise is limited because the atrial contribution to ventricular filling is more important at higher heart rates; hence, the most common clinical sign is exercise intolerance in high level performance horses.[12] The involvement of a larger proportion of horses and cattle in high intensity practices (such as racing or eventing in horses; peak lactation in cattle) is likely to make detection of AF more likely. This could explain the reason for the higher incidence of AF reported in these species. The llama that was presented for signs of exercise intolerance in this study was diagnosed with lone AF similar to that in horses. That llama was used for packing at high altitude, which would be expected to require increased cardiac output. The one additional previously reported case of AF in a camelid also appeared to be "lone AF", and that llama was also noted to do well despite failure to achieve cardioversion.[3]

Atrial fibrillation appears to be rare in New World Camelids and is most commonly associated with underlying cardiac or systemic disease. Lone AF might have a good prognosis except for exertional or high altitude exercise. Further studies on safety and pharmacokinetics of quinidine and other antiarrhythmic medications, as well as the use of electrical cardioversion, are warranted in these species to allow for successful conversion when indicated.

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Off-label Antimicrobial Declaration: Authors declare no off-label use of antimicrobials.

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