ECG of the Month

A 31-year-old 397-g (0.87-lb) female African grey parrot (Psittacus erithacus) was evaluated at the University of Florida Veterinary Medical Center because of vision concerns. The owner reported that the parrot had deterioration in near vision and a history of a so-called weak heart; there were no available veterinary records. The bird had previously lived in Europe and had been under the care of the current owner in Florida for the past year.

At the initial evaluation, the bird was bright, alert, and responsive and had a body condition score of 2.5/5. On physical examination, mild nuclear sclerosis and serosanguinous ocular discharge were evident bilaterally. Thoracic auscultation revealed normal heart sounds, a regular heart rhythm with a rate > 400 beats/min, and normal lung sounds. The bird was anesthetized by inhalation of isoflurane prior to performing diagnostic assessments including a CBC, serum biochemical analyses, radiography, ECG, and echocardiography. Clinicopathologic variables were within reference ranges. Via whole-body radiography, no abnormalities were detected and heart size and shape appeared normal. Echocardiography (2-dimensional and Doppler) was performed from a ventromedian approach, and findings were within normal limits. Electrocardiography was performed by placing the bird in ventrodorsal recumbency and attaching alligator-clip ECG leads to the base of the wings (equivalent to left and right forelimbs in a quadruped) and the base of the legs (equivalent to left and right hind limbs in a quadruped).

ECG Interpretation

A 6-lead ECG and 2-lead rhythm strip were obtained from the bird (Figures 1 and 2). Electrocardiographic measurements were compared with reported reference values for African grey parrots. The appearance of each waveform (P, QRS, and T) was considered normal. Waveform features were as follows: P-wave duration, 0.02 seconds (reference range, 0.012 to 0.018 seconds); P-wave amplitude, 0.2 mV (reference range, 0.25 to 0.55 mV); PR interval duration, 0.06 seconds (reference range, 0.040 to 0.055 seconds); QRS complex duration, 0.02 seconds (reference range, 0.010 to 0.016 seconds); R-wave amplitude, 0.0 mV (reference range, 0.0 to 0.2 mV); S-wave amplitude, 2.0 mV (reference range, 0.90 to 2.20 mV); QT interval duration, 0.08 seconds (reference range, 0.06 to 0.08 seconds).
ence range, 0.048 to 0.070 seconds); and T-wave amplitude, 0.3 to 0.5 mV (reference range, 0.18 to 0.60 mV). The P waves were visible only during periods of slower intrinsic heart rates and were superimposed on the preceding T waves during faster intrinsic heart rates; hence, the mean T-wave amplitude was greater than the upper reference limit. The mean electrical axis was –70°, which was considered clinically normal albeit not within reference range for most avian species (reference range, –70° to –103°). The measurements of waveform duration, amplitude, and intervals were evaluated on an ECG that was recorded at a paper speed of 50 mm/s. It has been suggested that the paper speed should ideally be at least 100 mm/s to more accurately inspect and measure waveforms in an ECG trace obtained from birds because of their typically rapid heart rate. The electrocardiograph used to evaluate the bird of this report had a maximal paper speed of 50 mm/s, and consequently, resultant values were less precise than previously reported reference values. Considering this limitation, ECG measurements from the bird of this report appeared to be within reference limits.

On the basis of the ECG findings, a diagnosis of sinus arrhythmia was made. The intrinsic heart rate varied regularly from 400 beats/min during exhalation to 500 beats/min during inhalation (reference range, 340 to 600 beats/min). This rate variation resulted in a change in T-wave morphology such that the waves were taller when the heart rate was faster because of P-wave superimposition (P-on-T phenomenon). A partial fusion of the P and T waves results in a taller than normal T wave (arrow). Paper speed = 50 mm/s; 1 cm = 1 mV.

Discussion

The sinus arrhythmia at such a high heart rate identified via ECG in the bird of this report is of interest. Sinus arrhythmia is defined as a patterned, irregular sinus rhythm with alternate slowing and acceleration of the heart rate. This can be seen on an ECG tracing as shortening and prolongation of the R-R or S-S interval, which was evident in the ECG recordings obtained from the parrot. Respiratory sinus arrhythmia is associated with a similar trace pattern; the heart rate slows with exhalation and accelerates with inhalation. Respiratory sinus arrhythmia is modulated by several cardiovascular reflexes that alter sympathetic and parasympathetic tone. During inhalation, intrathoracic pressure decreases, which increases venous return to the right side of the heart and results in an increase in heart rate. This heart rate increase is mediated by atrial stretch through the Bainbridge reflex and causes an increase in cardiac output. The resulting increase in systemic arterial pressure is detected by baroreceptors, which stimulate vagal outpouring to slow the heart rate during exhalation. Stretch receptors in the lungs and thoracic wall also have a role in autonomic control of heart rate; activation of the stretch receptors causes an increase in heart rate during inhalation by inhibiting vagal outflow. Additionally, the CNS is known to modulate sinus arrhythmia, possibly through direct links between cardiac centers that regulate vagal efferent activity and respiratory centers in the brainstem or possibly through central changes in baroreceptor sensitivity.

Characteristically, respiratory sinus arrhythmia is associated with slow heart rate and high vagal tone and may facilitate more efficient pulmonary gas exchange by suppressing unnecessary heartbeats during expiration when oxygen exchange is not occurring. In humans, 10% of the total blood volume is located in the lungs, and 10% of that volume is the pulmonary capillary blood volume that participates in gas exchange, which can be compared with the stroke volume of the heart. Each heart beat circulates blood for gas exchange in the capillaries; capillary blood volume is then replaced with the next heartbeat. This synchrony of cardiovascular and respiratory systems is vital for optimal pulmonary gas exchange and has been identified in mammals, fish, and birds.

In dogs, there is a predominance of vagal stimulation in the thorax during respiration. Respiratory sinus arrhythmia is typically identified in dogs with heart rates < 150 beats/min and can also be enhanced in disease conditions that cause an increase in intrathoracic pressure or force of inhalation, which consequently increases parasympathetic activity. In their study of ECG variables in African grey and Amazon parrots, Nap et al identified sinus arrhythmia in 2 of 19 unanesthetized birds and 6 of 63 anesthetized birds that had heart rates similar to that of the bird of this report. Although isoflurane anesthesia may have affected the autonomic balance in this bird, either by directly reducing sympathetic flow (as determined experimentally) or by reflexly increasing sympathetic flow, the phenomenon of sinus arrhythmia at a high heart rate has also been detected in unanesthetized birds. Other ECG investigations have identified sinus arrhythmia as a normal finding in birds; sinus arrhythmia was detected in 48 of 79 (60.7%) free-living birds, and respiratory sinus arrhythmia was detected in 13 of 41 (32%) macaws and 7 of 31 (23%) cockatoos. Presumably, this rhythm in birds is also mediated by...
fluctuations in autonomic tone; however, it is not known whether this might be attributable to changes in sympathetic tone, parasympathetic tone, or both.

Unfortunately, the respiratory pattern of the bird of this report was not recorded at the time of the ECG; therefore, we cannot be certain that the sinus arrhythmia was modulated by cardiorespiratory reflexes. In newly hatched chickens, a role for both respiratory and nonrespiratory influences on sinus arrhythmia has been identified through simultaneously studying breathing activity and oscillatory patterns of instantaneous heart rate changes.20

The P-on-T phenomenon identified in the ECG recordings obtained from the bird of this report has been previously detected in African grey parrots and other avian species.16,17,21,22 This partial fusion of the P and T waves results in a taller than normal T wave, which is evident during inhalation when the intrinsic heart rate is >500 beats/min. At this heart rate, the interval between completion of ventricular repolarization and atrial depolarization is shortened, thereby causing the fusion.21,22

The negative mean electrical axis in the ECG obtained from the bird of this report has been detected in other avian ECG studies.10,12,21 In birds, a so-called flash pattern has been used to describe the activation of the ventricular myocardium.21 The Purkinje fibers of the avian heart penetrate into subendocardial, intramural, and subepicardial layers, resulting in multiple excitatory foci of depolarization that rapidly spread in all directions, with the basilar portion of the septum being activated last.21,22 This ventricular depolarization pattern is in contrast to the class A ventricular activation pattern of certain mammals (e.g., dogs, humans, monkeys, and cats) in which a subendocardial Purkinje system accommodates a caudoventral wave front of ventricular depolarization and results in a positive QRS deflection in lead II.21 The negative QRS complex of birds is similar to mammals with class B ventricular activation patterns (e.g., hoofed mammals).21 Those mammals have a more deeply penetrating and diffuse Purkinje network that results in a primarily negative QRS complex because of explosive depolarization of most of the ventricles, with a final wave front directed towards the vertebral column.21 Compared with mammals of a similar size, birds have a higher heart mass-to-body mass ratio, and it has been suggested that the deeply permeating Purkinje fiber system that results in the multifocal flash pattern of ventricular depolarization is an adaptation that allows birds to maintain a short cardiac cycle length (high heart rate) despite a relatively large heart mass.21 Rapid excitation correlates to shortened contraction times that allows for the extremely high heart rates necessary to meet the metabolic demands of flying and egg laying without compromising diastolic filling.

Although sinus arrhythmia is usually associated with slow heart rates in dogs, the ECG obtained from the bird of this report highlights the counterintuitive, yet normal, finding of sinus arrhythmia at a rapid heart rate in an isoflurane-anesthetized African grey parrot.

References


