AVIAN ATHEROSCLEROSIS: PARROTS AND BEYOND

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Abstract

Atherosclerotic lesions are prevalent in companion psittacine species. Parrots account for much of the veterinary scientific information on avian atherosclerosis, but the lesions have been described in virtually all avian orders. This review presents a synthesis of the epidemiologic, clinical, diagnostic, and therapeutic information known in psittaciformes, at this time, which may help in the veterinary management of atherosclerotic diseases. The article further expands on nondomestic avian species for which information is restricted to pathologic and prevalence studies. A thorough knowledge of atherosclerosis is of the upmost importance for avian clinicians as the disease is common, affects most species of birds, and seems to be associated with captive lifestyles characterized by decreased activity and nonnative diets. Therefore, avian veterinarians are expected to be largely exposed to this chronic medical condition through patient presentation and should be prepared to properly manage this disease. Copyright 2013 Elsevier Inc. All rights reserved.

Key words: atherosclerosis; avian; cholesterol; psittacine; vascular disease

The prevalence of atherosclerosis in avian species has been documented in multiple sources and ranges from 1.9% to 91.8% (Table 1).1-17 The range of reported prevalence of avian atherosclerosis is wide and is likely owing to reports varying in inclusion criteria, lesion severities, geographical areas, demographics, captive conditions of the studied population, psittacine species included, and the retrospective or prospective nature of the work. Most of these studies reported raw prevalence with poorly defined inclusion criteria and without controlling for confounding factors and covariables, such as age and sex. Moreover, reporting the prevalence of pathologic lesions including early and mild lesions that seldom lead to clinical signs is of little clinical use, especially as it can be expected to vary significantly with age groups. In a study where a relatively high number of psittacine cases were included, after review of the original database, the population was found to be composed primarily of neonates and juvenile birds.3 In another prospective study, with all types/stages of atherosclerotic lesions included, the prevalence calculation led to the highest reported prevalence of atherosclerosis in the literature (91.8%).5 A recent large, multicenter study that reviewed cases of more than 7600 psittacine birds gave a clearer picture of the epidemiology of atherosclerosis with the prevalence reported as a function of age, gender, and species (Fig. 1).12 This investigation focused more on the prevalence of clinically important atherosclerotic lesions susceptible to induce disease (type IV to VI atherosclerotic lesions) and interpreted the prevalence in the context of population demographics and statistical precision (Fig. 1).

Several suggested risk factors may promote the development of atherosclerosis in psittacine birds and include age, gender, species, increased plasma total cholesterol and triglyceride levels, high-energy and high-fat diet, physical inactivity, thyroid disease, and coinfection with Chlamydophila psittaci.1-3,5,7,8,12,18 Unfortunately, a clear demonstration of a statistically significant effect from any of these variables controlling for potential confounding factors, such as age, gender, or species, was often not done or not performed on a large representative sample. A higher
prevalence or severity of atherosclerotic lesions was frequently reported in older birds, but a clear quantification of the magnitude regarding age effect on prevalence was not available until published in recent articles.1,2,5,7-9,12 From the literature, conflicting information was present on the influence of gender as a risk factor with some studies reporting a male predisposition,13,16 others a female predisposition,2 and others no difference between genders.5,7,8 Recently, female gender and age were definitely confirmed to be important risk factors for atherosclerotic diseases in a large multivariable model (Fig. 1).12 It is interesting to note that psittacine birds exhibit a reversed sex effect from mammals in which males experience higher prevalence of atherosclerosis. In female birds, estrogens have tremendous physiologic effects on lipid, protein, and calcium metabolism related to reproduction and egg formation. In reproductively active females, estrogens induce an increase in plasma total calcium level, protein levels, cholesterol and triglyceride levels, and hepatic synthesis of 2 specific lipoproteins, vitellogenin and very low-density lipoprotein (yolk labeled [VLDLy]), which target the developing oocyte and are protected against the normal action of plasma lipoprotein lipase.19 Increased plasma cholesterol, VLDL, VLDL remnants, and nonhigh-density lipoprotein (HDL) cholesterol levels promote atherogenesis, providing a plausible explanation for the enhanced predisposition found in female psittacine birds.12 Reproductive diseases were found to be significantly associated with increased prevalence of atherosclerotic lesions and may be a target for prevention.12 African grey parrots (Psittacus erithacus) and Amazon parrots (Amazona spp.) usually show a higher prevalence of lesions than other psittacine species but the confounding effects of age and sex were usually not considered in previous research investigations.1,5,8 However, it was demonstrated that African grey parrots, Amazon parrots, and cockatiels (Nymphicus hollandicus) appeared to be atherosclerosis prone, whereas cockatoos (Cacatua spp.) and macaws (Ara spp.) were determined to be somewhat atherosclerosis resistant.12 The reasons for the species predisposition differences in captivity are speculative and could be associated with different captive lifestyles, stress levels, dietary requirements, and genetic factors. In another large retrospective study on more than 5600 plasma samples, genus-specific differences in plasma total cholesterol values were found to mirror these identified trends in the prevalence (high correlation, 0.93) of clinically important atherosclerotic lesions (Beaufrère, unpublished). This suggests that the differences observed in prevalence between psittacine genera may partially be explained by differences in plasma total cholesterol levels. Psittacine species have evolved with different dietary habits that have changed drastically in captivity, and some species may be better equipped to metabolize dietary lipids than others.20,21 A possible association between Chlamydia pneumoniae infection and atherosclerosis has been investigated in multiple human studies but remains controversial.22-24 As avian chlamydiosis is a common infection in psittacine species, this hypothesis was also explored in representative

### TABLE 1. Prevalence of atherosclerosis in Psittaciformes as reported in the literature sorted by year of publication (methods, inclusion criteria, and population demographics varied substantially between reports; %: raw prevalence, N: total number of birds investigated)

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avian species but the research investigations generated conflicting results. A scientific study using polymerase chain reaction (PCR) and immunohistochemistry on arterial tissues did not find a positive association between atherosclerosis and avian chlamydiosis in psittacine birds. Conversely, a case-control study on 31 parrots reported a significant association between atherosclerosis and positive immunohistochemical reaction for C. psittaci using specific anti-C. psittaci monoclonal antibodies in arterial tissues. However, antichlamydial antibodies, including monoclonal antibodies used in immunohistochemistry, are known to cross-react with atherosclerotic plaque constituents in human samples such as ceroids. Poor correlation has been observed between immunohistochemistry, tissue PCR, and culture, with the former usually leading to a higher detection rate. For immunohistochemistry involving chlamydial antigens, it is recommended to carefully select negative control tissues, use at least 2 negative control antibodies, and only interpret intracytoplasmic staining of macrophages, endothelial cells, and smooth muscle cells in a granular pattern as true positive. In this psittacine study, negative control tissues were avian tissues and blood vessels. However, negative control antibodies were not used to assess background staining of atherosclerotic tissues and extracellular staining in lipid and necrotic pools were interpreted as positive, thus increasing the likelihood of obtaining false-positive test results. Alternatively, C. psittaci PCR-negative psittacine atherosclerotic tissue could have been used as negative control tissues. In addition, pathologic surveys rarely identified lesions consistent with avian chlamydiosis concurrently with atherosclerosis. In a study on 525 advanced atherosclerotic cases, only a single case was found to be concurrently diagnosed with avian chlamydiosis.

Dyslipidemic changes, notably hypercholesterolemia, are thought to be a predisposing factor to the development of atherosclerotic lesions in birds as in other animal species. Avian species predisposed to atherosclerosis tend to have a higher plasma cholesterol levels than other psittacines (Beaufrère, unpublished). In a case-control study on 22 birds, parrots with atherosclerotic lesions had a significantly higher median (range) plasma cholesterol based on their medical records at 421 (233 to 906) mg/dL than control birds at 223 (144 to 250) mg/dL. In a large retrospective study on plasma samples, species determined to have a high prevalence of atherosclerosis were found to have significantly higher total and HDL cholesterol level than other psittacine species (Beaufrère, unpublished). The reasons for the trend observed in HDL levels are unknown as high LDL level but not HDL cholesterol level is typically associated with higher risks of developing atherosclerotic diseases. The contrary, experimental diet-induced atherosclerosis was associated with increased plasma total cholesterol level in budgerigars (Melopsittacus undulatus) and quaker parrots (Myiopsitta monachus) and also with increased LDL cholesterol level in quaker parrots. In quaker parrots, total plasma cholesterol level was also found to
correlate with the severity of atherosclerotic lesions.29

THE LESIONS OF ATHEROSCLEROSIS

Psittacine atherosclerotic lesions consist of the progressive accumulation of inflammatory cells, cholesterol, fat, and cellular debris in the intima and luminal side of the vascular media and are classified into 7 lesion types. In advanced lesions, such as those responsible for clinical signs, there is formation of a lipid core (atheroma, type IV lesion) covered by a fibrous cap (fibroatheroma, type V), and complications such as fissures, hematomas, and thrombosis (type VI) may occur (Fig. 2). In parrots, atherosclerotic lesions are central and most commonly found in the great arteries at the base of the heart, brachiocephalic arteries, ascending aorta, and pulmonary arteries (Fig. 3).1,2,6,12,18,31-34 Lesions in the abdominal aorta and peripheral arteries appear less frequently. However, peripheral lesions have been documented in the abdominal aorta, carotid, and coronary arteries in the parrot species.3,11,14,30,35-38 Complications and clinical signs are usually because of either severe stenosis from the continuously growing atheromatous plaque (Fig. 4) or thrombosis and hemorrhage caused by plaque disruption that can decrease or interrupt blood flow or provoke emboli. Atherosclerotic lesions are silent and subclinical until such complications arise. Stenosis secondary to atherosclerotic lesions is common in birds but atherothrombosis and emboli are rare and, in a postmortem study, were found in only 1.9% of atherosclerotic cases.12

The occurrence of histologic lesions in other organ systems in association with atherosclerosis has been reported.2,5,12 A scientific study identified a correlation between atherosclerosis of the ascending aorta and organ alterations, such as myocardial hypertrophy, myocardial fibrosis, pulmonary congestion, and fibrosis.5 Another report documented a significant association between advanced atherosclerosis and reproductive diseases, hepatic diseases, and myocardial fibrosis.12 The association with myocardial lesions found in 2 studies suggests that atherosclerotic lesions may induce cardiac pathologic changes that could result in overt clinical disease (e.g., myocardial dysfunction and cardiac arrhythmia).

CLINICAL SIGNS

Clinical signs are rarely reported in psittacine patients that are presented with atherosclerosis but, when present, consist of sudden death, congestive heart failure, dyspnea, neurologic signs, respiratory signs, exercise intolerance, and ataxia.1,3,5,11,31,33,36,38-41 Most clinical signs reported in parrots are associated with flow-limiting stenosis of the major arteries or the carotid arteries. However, unlike human cases of atherosclerosis, clinical signs of thrombosis and thromboemboli are rare in similarly affected avian species (or underdiagnosed) (Fig. 4). In humans,
Atherothrombotic lesions are the main cause of death through fibrous cap rupture, thrombosis, emboli, and acute arterial obstruction. Only 1.9% (10/525) of birds displayed atherothrombotic lesions in a pathologic survey and lesion complications could not be experimentally induced in budgerigars and quaker parrots despite 6 to 8 months of cholesterol feeding. This may have been due to the relative small size of birds, which may show different hemodynamic characteristics, and the different thrombogenic properties observed between avian thrombocytes and mammalian platelets. Avian thrombocytes seem less capable of forming shear-resistant arterial thrombi and do not usually form 3-dimensional aggregates as was demonstrated in chickens and budgerigars. Furthermore, the different pattern of coronary circulation in the avian heart with the predominance of intramyocardial arteries and presumably more collateral circulation than humans may be responsible for the rarity of acute myocardial ischemia. Consequently, in psittacine birds, clinical signs of atherosclerosis appear to be primarily associated with chronic stenotic advanced lesions as reported in retrospective studies and in multiple published case reports. It is not known how much occlusion is required of the vascular lumen to induce clinical disease signs in parrots. In humans, the degree of luminal narrowing is correlated with sudden death and clinical signs and >75% of luminal narrowing is common in fatal cases.

Intermittent claudication, a clinical manifestation of peripheral arterial disease, was reported in an Amazon parrot with severe atherosclerotic lesions of the abdominal aorta and ischiatic arteries. Likewise, cases of atherosclerosis have been described in conjunction with pelvic limb ataxia and clinical signs compatible with intermittent claudication and peripheral arterial disease in parrots, especially in Amazon parrots. A yellow-collared macaw (Ara auricollis) developed dry gangrene of the legs while suffering with a concurrent generalized atherosclerosis condition. Atherosclerosis was also suspected as the cause of distal extremity necrosis in several other zoo birds.

Congestive heart failure and valvular insufficiency have been reported in several parrots diagnosed with atherosclerosis. The pathogenesis is unclear but chronic myocardial
onset of disease signs may be a result of a relative presentation of clinical atherosclerosis. The acute acknowledged to be the most common nonspecific distending pressures caused by the pulsatile cardiac expansion of the arterial wall over a range of elastic arteries, leading to limited and constant because of their lower compliance than healthy suspected to form in atherosclerotic arteries. In budgerigars, but the presence of atherosclerosis could not be confirmed antemortem in this patient.41 A hemorrhagic stroke and brain infarct, diagnosed on MRI and confirmed on histopathology, caused severe vestibular signs in a blue-and-gold macaw (Ara ararauna), which was also diagnosed with advanced atherosclerosis.50 Hemorrhagic strokes have also been reported in an Amazon parrot and in budgerigars, but the presence of atherosclerosis could not be confirmed or was not mentioned.37,51 In addition, carotid atherosclerosis was associated with seizures in an African grey parrot and an aurallike behavior with altered consciousness in an Amazon parrot.3,37 A recent study showed an 8 x increase in odds for birds with atherosclerosis to present with neurologic signs, but this association was not statistically significant.7 A coronary aneurysm developed secondary to coronary atherosclerosis in an umbrella cockatoo (Cacatua alba).36 An aortic aneurysm with severe atherosclerosis was reported in an Alexandrine parakeet (Psittacula eupatria).11 Aneurysms are suspected to form in atherosclerotic arteries because of their lower compliance than healthy elastic arteries, leading to limited and constant expansion of the arterial wall over a range of distending pressures caused by the pulsatile cardiac output.52 Exercise intolerance and nonspecific respiratory signs are frequently reported in companion avian species and may be linked to impaired cardiac function secondary to atherosclerotic lesions.3,5 Sudden death or nonspecific clinical signs are generally acknowledged to be the most common presentation of clinical atherosclerosis. The acute onset of disease signs may be a result of a relative

DIAGNOSIS

Atherosclerosis is difficult to diagnose antemortem in birds with the veterinary medical information currently published on this subject. There are severe limitations in the knowledge and resolution of imaging equipment that seriously impair the visualization of lesions, the detection of their ischemic consequences, and the identification of avian patients at increased risks. Nevertheless, a general diagnostic understanding can be derived from reported clinical signs and consequences, confirmed and suspected risk factors, and diagnostic testing methods used in psittacine birds (Fig. 5).

The lack of characterized clinical pathology markers, the incomplete knowledge of risk factors in birds, and the extreme changes in blood lipid and lipoprotein levels occurring during the female reproductive cycle have prevented the identification of susceptible birds and the implementation of risk factor-targeted management thus far. Although avian models of atherosclerosis have consistently shown an increased blood cholesterol and LDL level, the dyslipidemia is artificially induced by high cholesterol feeding and it is unknown whether similar dyslipidemic changes occur in patients with spontaneous atherosclerosis. As previously mentioned, in a case-control study on 31 parrots, a total cholesterol median twice as high as identified in control parrots was found in birds exhibiting atherosclerotic lesions.7 Predisposed psittacine species also had higher plasma total cholesterol values (Beaufrère, unpublished). Moreover, C-reactive protein, an acute-phase protein that has diagnostic and prognostic value in human coronary artery disease does not seem to be a major acute-phase protein in birds (Carolyn Cray, written communication, April 2012).

Blood pressure measurements can be useful in psittacine patients to detect chronic hypertension, which is a risk factor for atherosclerosis in mammals and a means to diagnose certain clinical entities such as intermittent claudication (e.g., ankle brachial index). Unfortunately, indirect blood pressure measurement methods, such as the
Oscillometric and the Doppler probe techniques, are not reliable in parrots and direct arterial blood pressure measurement is invasive and not clinically practical. Electrocardiographic changes have not been well characterized with atherosclerosis but are expected to occur in some cases owing to cardiac consequences and ischemia.

At this time, diagnostic imaging appears to be a promising method to assess the avian cardiovascular system. Antemortem diagnosis of atherosclerosis is primarily obtained in advanced cases, with severe calcification of the arteries, or in association with congestive heart failure. Atherosclerosis targets the major arteries in birds and, fortunately, these arteries are most accessible to diagnostic imaging. The 2 brachiocephalic arteries, pulmonary arteries, and ascending and abdominal aorta can be visualized on plain radiographs and advanced imaging techniques. Smaller arteries such as the carotid arteries, visceral arteries, and branches of the brachiocephalic arteries can also be evaluated on computed tomography (CT) images. Several authors claim that enlargement and opacification of the arteries (i.e., suggestive of atherosclerotic changes) can be detected on digital radiographic images. Considering the variability in x-ray exposure, the fast heart rate of birds, and arterial motion artifacts that are likely present on radiographic images, in addition to the subjectivity in interpreting such changes, it is doubtful that this approach would have any diagnostic benefit. Severe atherosclerosis may also be present in the absence of vascular radiographic signs as documented in several case reports. Thus, radiographs should be considered an insensitive method of detecting vascular diseases. Conversely, arterial calcification is fairly specific to advanced atherosclerotic lesions and can be detected on radiographic and CT images when severe (Fig. 6).

As flow-limiting stenosis is the main mechanism leading to clinical signs of atherosclerosis in psittacine birds, angiography could be useful to assess arterial luminal narrowing. Angiographic procedures have been described using fluoroscopy, digital subtraction fluoroscopy, and CT imaging. Arteriography can be expected to provide valuable information on arterial luminal patency. There is a report of an angiography procedure that successfully diagnosed a coronary aneurysm in a cockatoo.

Cardiac manifestations of atherosclerosis (e.g., congestive heart failure and valvular insufficiency) can be diagnosed with transcoelomic and transesophageal echocardiography, but their association with atherosclerotic lesions is not possible using these techniques.
root can be imaged and measured by ultrasound and the outflow aortic velocity estimated using spectral Doppler, with reference intervals having been reported for aortic measurements. Furthermore, transesophageal echocardiography allows M-mode imaging of the aortic root. Hyperechoic areas on the base of the aorta are occasionally observed in echocardiographic images. Likewise, cerebral complications such as ischemic and hemorrhagic strokes can be imaged using CT or MRI, but concurrent atherosclerosis cannot be detected when calcification of the lesions is not significant. Organ perfusion imaging and radionucleotide-labeled atherosclerotic markers have not been investigated in psittacine birds. Finally, endoscopy, a more invasive diagnostic imaging modality, using an interclavicular approach, allows good and direct visualization of the base of the heart and the major arteries. This endoscopic approach is impaired in obese birds by the fat deposits located in this area. Using high-quality angiographic techniques to either diagnose arterial luminal stenosis or detect atheromatous plaques are likely to become the diagnostic tests of choice when limitations in resolution and motion artifacts are resolved through technological advances.

**MEDICAL MANAGEMENT AND PREVENTION**

In the absence of well-characterized risk factors to target for prevention and pharmacologic information to be used for therapeutics, the medical management and preventive approach are largely empirical and based on information derived from the human literature. However, the recent identification of a significant female susceptibility and association with reproductive disorders may indicate that prevention and management of reproductive dysfunction in captive female parrots may show some benefit in lowering the prevalence of avian atherosclerosis. Although it can be expected that humans and parrots may share major lifestyle and dietary risk factors, this remains to be confirmed and psittacine birds may have specific risk factors that need to be explored for a more adapted approach. The treatment of atherosclerosis can be divided into the reduction of risk factors and the treatment of cardiovascular and ischemic consequences.

Lifestyle changes that could be implemented for companion avian species include increasing physical activity by providing more opportunities for locomotion and foraging behaviors and decreasing the stress level in their captive environment. Limiting dietary excess and obesity also seem to be a reasonable strategy, but species-specific dietary needs should be considered. Statins are employed in parrots but their use is controversial because no pharmacologic information is available and target levels of blood cholesterol and LDL that would reduce atherosclerotic risks are unknown in psittacine birds. Atorvastatin is the most commonly used statin in avian veterinary medicine. It has a long half-life in humans (15 to 30 hours), but it undergoes extensive hepatic biotransformation and shows some pharmacologic interaction with itraconazole, an antifungal drug frequently used in psittacine birds. However, rosuvastatin has a similar half-life, is not extensively metabolized by the liver, and does not display problematic pharmacologic interactions. Other statins (e.g., lovastatin, simvastatin, and pravastatin) have short half-lives (1 to 4 hours). However, an oral pharmacokinetic study on 10-25 mg/kg of rosuvastatin in Hispaniolan Amazon parrots failed to achieve consistent therapeutic plasma concentration (Beaufrère, unpublished).

Clinical signs of peripheral arterial disease have been treated with pentoxifylline or isoxsuprine in Amazon parrots. Despite the lack of evidence for efficacy in humans, isoxsuprine relieved signs of hind limb weakness in an Amazon parrot but atherosclerotic disease was not confirmed. Likewise, the use of antihypertensive medications, such as angiotensin-converting enzyme inhibitors and β-blockers, is not yet applicable in birds when there is no accurate evidence.
and repeatable means of measuring the arterial blood pressure in clinical cases for diagnosis and follow-up evaluation of treatment response or lack thereof. Antithrombotic agents have not been investigated in psittacine birds but atherothrombotic complications are rare. Medical management of congestive heart failure should also be implemented in such cases where this therapeutic protocol is required.

ATHEROESCLEROSIS IN NONDOMESTIC AVIAN SPECIES

Atherosclerosis has been described in almost all orders of birds. Three large retrospective studies reported the prevalence of atherosclerosis in multiple avian orders on 9949, 7689, and 919 birds (Table 2). Most lesions occurred in the major arteries, but also in the carotid and coronary arteries. However, the prevalence in these studies should be interpreted with caution as it is likely that not all organs were reviewed in all cases (i.e., biopsy cases were included in the calculation of the prevalence with the methods and inclusion criteria being different). In addition, avian taxonomy is constantly changing and some taxonomic classification used at the time of those particular research studies may be inaccurate with today’s classification. For instance, the prevalence reported in falconiformes included species from the orders falconiformes and accipitriformes, cases belonging to coraciiformes included birds from the orders coraciiformes and bucerotiformes, and struthioniformes may only have accounted for ostriches.

A report from the Oklahoma City Zoo documented a prevalence of 90% (65/72) of exotic birds with atherosclerosis, with the most advanced lesions described in galliformes and ciconiiformes. A survey of captive birds of prey in the United Kingdom identified 7.6% (5/66) of diurnal birds of prey with atherosclerosis; it was considered the cause of death in 2 Bonelli’s eagles (Aquila fasciata). A review of 57 penguin pathology records over 5 years at SeaWorld identified 25 (44%) birds with atherosclerosis; it was considered the primary cause of death in 4 cases. In a large raptor collection in France (le parc du Puy du fou), a group of 50 black kites

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(Milvus migrans) experienced severe loss due to atherosclerosis of the great vessels that primarily manifested as acute deaths (Charles Facon and Hugues Beaufrère, unpublished).

Myocardial infarction in association with advanced atherosclerosis was diagnosed in several birds including a bald eagle (Haliaeetus leucocephalus), a white-backed vulture (Gyps africanus), a Javan fishing owl (Scotopelia spp.), a concave-casqued hornbill (Buceros bicornis), 3 pelicans (Pelecanus spp.), a tawny frogmouth (Podargus strigoides) (arterial thrombus as well), and an Edward’s pheasant (Lophura edwardsi). An ischemic cardiomyopathy due to atherosclerosis was reported in a red-tailed hawk (Buteo jamaicensis). A ruptured aortic aneurysm due to atherosclerosis has been diagnosed in a Slaters’s crowned pigeon (Goura scheepmakeri), an Egyptian plover (Pluvianus aegyptius), a grey-winged trumpeter (Psophia crepitans), a crowned hawk-eagle (Stephanoaetus coronatus), and a maned goose (Chenonetta jubata). A ruptured aortic aneurysm, along with advanced atherosclerotic lesions, was also considered the primary cause of death in a flamingo (Garner, written communication, May 2012). Likewise, several cases of aortic ruptures with atherosclerosis were reported in Antarctic penguins. Most cases of dissecting aortic aneurysms in ostriches and turkeys are not due to atherosclerosis but have been associated with copper deficiencies.

Furthermore, atherosclerosis is diagnosed with some frequency in wild birds. Out of 97 free-living birds examined in the United Kingdom and East Africa, 32 (33%) had evidence of atherosclerotic lesions and 4 (4%) had evidence of advanced aortic lesions. An investigation on 157 wild male turkeys collected by hunters in the United States found atherosclerosis in 77 (49.5%) of arteries evaluated, with the greatest prevalence of lesions found in the ischiatic artery and aorta. A report from Iraq found 10% of a sample of 100 free-living pigeons with atherosclerotic lesions. A retrospective survey from Northern California found 1.5% (6/409) of free-living raptors diagnosed with atherosclerosis, a lower frequency than usually reported for these species when maintained in a captive setting. In addition, atherosclerotic lesions were also found in a population of free-living Egyptian vultures (Neophron percnopterus).

Although much emphasis has been placed on psittacine atherosclerosis, it is also evident that atherosclerosis is a major problem of other avian orders commonly treated by veterinarians, especially falconiformes and accipitriformes. Some authors mention that atherosclerosis is uncommon in carnivorous animals, but this does not seem to hold in Aves, as birds of prey show a high prevalence of lesions in captivity. Risk factors for atherosclerosis in nonpsittacine species are speculative and currently there has been little epidemiological investigation into this subject. The common practice of feeding day-old chicks, which have a large yolk sac rich in cholesterol, may potentiate atherosclerosis in susceptible raptorial species (e.g., insectivorous raptors and falcons). An example of this predisposing factor for atherosclerosis involves a large retrospective study in humans, whereby consumption of egg yolk was strongly associated with an increased atherosclerotic burden in the carotid arteries.

REFERENCES


