REVIEW

ARTERIAL CATHETERIZATION, INTERPRETATION, AND TREATMENT OF ARTERIAL BLOOD PRESSURES AND BLOOD GASES IN BIRDS

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Abstract

Blood pressure monitoring of patients has become increasingly common in companion animal veterinary hospitals, especially during anesthesia, surgical procedures, critical care, and general health assessments. Determining an animal's blood pressure has become a standard part of the routine diagnostic evaluation for monitoring hypertension in geriatric patients or patients affected with renal insufficiency, cardiac disease, vision loss, or endocrine disorders. To increase the standard of care in exotic and zoological medicine, new diagnostic techniques must be identified and implemented. Blood pressure measurements in avian species are more challenging because only direct blood pressure techniques have been reported to be accurate. Arterial catheterization and interpretation can be daunting without the knowledge of avian physiology and anatomy; however, techniques for placing arterial catheters are not difficult once clinicians have gained sufficient experience. This article describes the techniques, anatomy, and appropriate interpretation of blood pressure results obtained through arterial catheterization in birds.

Key words: anesthesia; arterial catheterization; avian; blood pressure; monitoring

Blood pressure assessment is a crucial component of patient care during anesthesia, surgery, critical care, and general health assessments. Determining a patient's blood pressure has become a standard procedure in companion animal medicine for monitoring hypertension in geriatric patients or animals affected with renal insufficiency, cardiac disease, vision loss, or endocrine disorders. In addition, monitoring a patient's blood pressure has become part of standard protocol during anesthetic procedures and ideally should be performed for every patient.[1]

Avian blood pressure monitoring is a useful diagnostic tool in the assessment and treatment of hypertensive and hypotensive diseases in psittacine patients. Multiple retrospective studies involving psittacine species have shown a high prevalence of atherosclerosis. One study in Amazon and African gray parrots described lesions in more than 91% of the birds evaluated.[2] Another study in psittacine birds showed a high prevalence of atherosclerosis that increased with age and female sex. In human medicine, studies have established a relationship between systemic hypertension and the development of atherosclerosis.[3,4] Detection of hypertension in animals could provide clinical

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insight into an animal's cardiovascular condition and establish risk factors and management protocols for atherosclerosis in birds.

Monitoring blood pressure has many advantages when treating critically ill psittacines as well as those that are high-risk candidates for general anesthesia. Accurate blood pressure monitoring may be extremely helpful in assessing the progress of fluid resuscitation and inotropic or pressor therapy in patients with hypovolemic or septic shock. Arterial catheters can be used for periodic assessment of blood gases, which can be especially beneficial in patients with respiratory disease or acid-base disorders.[5]

Currently, routine blood pressure monitoring is rarely used in avian patients owing to their unique physiology and anatomy and the difficulty of catheter placement. In veterinary medicine, there are typically 2 techniques available for measuring blood pressure: invasive and noninvasive methods. Invasive techniques require an arterial catheter. Noninvasive techniques include Doppler, photoplethysmographic/photoacoustic probes with a sphygmomanometer, and oscillometric monitors.[5]

In previous studies, noninvasive techniques have been reported to be inaccurate in measuring blood pressure in psittacines when compared with invasive blood pressure monitoring. A study performed on anesthetized Hispaniolan Amazon parrots, *Amazona ventralis*, showed low agreement between noninvasive blood pressure measurement using the pectoral limb and hindlimb when compared with direct arterial blood pressures.[6] Several factors can affect the accuracy of noninvasive blood pressure measurement in any species. These include the type of blood pressure monitor used, cuff size in relation to the limb being measured, site of cuff placement, and the patient's blood pressure.[7,8] The inconsistency of measurements between limbs observed in the aforementioned study may have been because of differences in avian anatomy. In the pectoral limb, birds have a propatagium (a web of skin), muscles, and tendons that connect the scapulohumeral joint to the radiocarpal joint of the pectoral limb. This protopatagium could potentially interfere with appropriate occlusion of the ulnar artery, leading to an inaccurate noninvasive blood pressure.[9] Moreover, birds normally have higher heart rates and blood pressures than most domestic animals, which may also influence the accuracy of noninvasive blood pressure results, in that indirect monitors may not be adequately calibrated to measure the higher values.[10]

Accurate determination of blood pressure is critical in any species. Invasive (direct) blood pressure measurement is considered the gold standard and has been shown to correlate well with systemic blood pressure.[11] Unfortunately, invasive blood pressure measurements can be adversely affected by numerous factors. The regional insertion of an arterial catheter affects blood pressure measurements. As a result of Ohm's law, the flow of blood between 2 points is equal to the pressure difference divided by the resistance offered by the blood vessel; therefore, blood pressure measurements are often higher in smaller peripheral arteries when compared with that of larger central vessels. Similarly, impedance, the pressure exerted by blood against the vascular walls, also increases with a reduction in vessel diameter. Thus, the farther an artery is from the aorta, the higher the recorded blood pressure. Compounding accurate measurement further, high resistance distal to the site of arterial pressure measurement may also lead to inaccurate readings owing to reflections of the pulse waves erroneously raising direct systolic pressures. Differences in compliance of the catheter wall, small iatrogenic air bubbles within the line or catheter, and partial occlusion of the system also cause false alterations in blood pressure measurements. The size of the catheter can also affect the accuracy, whereby inappropriate dampening of the arterial pulse signal can occur owing to the differences in the length and diameter of different arterial catheters.[12]

Avian physiology may also affect the interpretation of a patient's blood pressures. Avian vascular anatomy differs from that of mammals and reptiles. Bird arteries have a higher resilience, which may affect how quickly vessels respond to changes in cardiac output and resultant blood pressures.[13] A study in turkeys described arterial resilience between 85% and 87%, which was higher than values reported in most mammals.[14] In addition, unlike mammals, bird's arterial lamellar units in the tunica media do not form complete cylinders. Rather, their lamellae consist of a series of rigid and elastic components, which allows the arterial wall to have greater distention.[15] Owing to this increase in compliance, avian blood vessels often have much thicker walls when compared with mammalian vessels of the same diameter. Because of these adaptations, birds are inclined to have a lower total peripheral resistance and higher arterial pressure than mammals.[16] Birds frequently have larger hearts, higher stroke volumes, and lower heart rates than mammals of