ULTRASONOGRAPHIC FEATURES OF THE KIDNEYS IN APPARENTLY HEALTHY OSTRICHES (*Struthio camelus*) RAISED IN CAPTIVITY

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ABSTRACT

Ten apparently healthy captive-bred ostriches (*Struthio camelus*), four adult females, three adult males and three juveniles, were examined to evaluate the ultrasonographic appearance and echo mean values of the kidneys using an ultrasound machine equipped with a 3.5 MHz convex array scanner. The scanner was placed in the mid-dorso-lateral area, between the rib cage and the pelvic area. Only the cranial lobe and the cranial part of the middle lobe of the kidneys were observed. The kidneys appeared as a non-homogeneous structure with hypoechoic and hyperechoic sections surrounded by a thick hyperechoic capsule. There was no distinct junction between the cortex and the medulla. The kidneys of the adult females and juveniles were more visible than those of the adult males. In female and juvenile ostriches, the left kidney was more visible than the right kidney. In juveniles, the left kidney appeared to be wider than the right kidney. In all groups, the cortex had greater echo mean values than the medulla. The transcutaneous lateral approach where the transducer was directed caudo-dorsally against the flank was shown to be an appropriate acoustic window for examining the cranial lobe and cranial part of the middle lobe of the kidneys of ostriches.

Keywords: echo mean, kidney, ostrich, ultrasound

INTRODUCTION

The ostrich industry changed dramatically over the past 20 years, expanding into different areas of the world where the bird is not originally raised. This intensification had exposed these ostriches into many management and nutrition-related problems, as well as to new infectious agents (Perelman, 1999). The increased concern about commercially farmed ostriches in few countries like the United Kingdom, Denmark, Sweden and the Netherlands resulted in the development of proposals for the health and welfare guidelines and standards strictly monitored by specialist veterinarians (Deeming, 1999). Preventive medicine, welfare of ostriches as farm animals and public health are the most important issues in the future development of the ostrich industry (Perelman, 1999).

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Only a few published systematic investigations of avian ultrasonography exist (Steinmetz *et al*., 2006). This is due to the interferences in the anatomical features of avian, specially the smaller birds where the kidneys are usually detected when the pathological conditions caused their enlargement. But in larger avian patient, like ostriches, the examination of the kidneys is possible but with great difficulty (Samour and Naldo, 2007).

Several studies have been performed to improve the use of ultrasonography in birds (Krautwald-Junghanns and Enders, 1994; Carrani *et al.* and Pees *et al*. as cited by Samour and Naldo, 2007). However, the presence of the vertebral column and the pelvic bones interfere with the use of sufficient acoustic window and limit visualization of the organs. Ultrasonography in birds is considered an essential diagnostic tool. This is useful in daily practice which allows detection of the various alterations in the different organs. By studying the normal ultrasonographic features of kidneys such as echogenicity, texture, size and shape, one would be able to differentiate the normal organ from the pathological one.

More studies are needed to create a standard set of reference avian ultrasonic images and to relate them to clinical and laboratory findings (Samour and Naldo, 2007). Due to the limited data on the ultrasonographic features of the ostriches' kidneys, this study was conducted to describe and compare the ultrasonographic features of the kidneys in apparently healthy ostriches *(Struthio camelus)* raised in captivity.

MATERIALS AND METHODS

Ten apparently healthy ostriches (*Struthio camelus*) selected randomly from a total population of 25 birds raised in captivity at Zoobic Safari, Subic, Zambales, Philippines were used in this study. The health of each bird was evaluated based on medical history, behavioral observation and clinical examination. The animals were distributed into three groups: adult females (4 birds), adult males (3 birds) and juvenile females (3 birds). Birds less than one year old were considered as juveniles while those more than 1 year old were classified as adults. The ostriches were subjected to standard management procedures. The sex of each ostrich was determined via the color of their plumage according to the description of Cramp *et al*. (1977) and Brown *et al*. as cited by Deeming (1999). The adult male ostriches were mainly black with white wing primaries and tail feathers and a grey neck, while the female adults were dull brown-grey all over with light grey to white wing primaries and tail feathers. The juvenile birds resembled the plumage of the female adults but were smaller.

The ostriches were free-ranged, enclosed in a wide open area and were not fasted prior to examination. The enclosure was entered slowly, skilled attendants assisted in the proper handling of the animals to avoid self-inflicted damage to the ostriches. No sedatives, tranquilizers or other chemicals were administered to the ostriches prior to and during the examination. The ostriches were restrained by handling the whole body, especially the back. The female adult and female juvenile ostriches were examined in sitting position while the male adult ostriches were examined in standing position due to the difficulty of restraining. Gentle handling was applied to juvenile ostriches to avoid bruises, wounds and fractures in the animals. The ostriches were hooded to cover the eyes and head of the birds, making them calm during the examination.

An ultrasound machine (Aloka Ultrasound Equipment, Aloka® SSD-500, Aloka Co. Ltd., Tokyo, Japan) equipped with a 3.5 MHz convex array scanner was utilized in the study. Fixed ultrasonographic settings (time gain compensation, gain, contrast, brightness and dynamic range) were maintained during the examination of the kidneys of the ten ostriches. The machine power output and time gain compensation were set at near gain of fifteen decibels (15 dB), far gain of three decibels (3 dB) and main gain at eighty decibels (80 dB).

Profuse amount of ultrasound transmission gel was applied to the scanner and on the examination area where feathers were absent (apteria) to ensure proper contact between the scanner and the skin. The feathers on the examination site were parted to make room for the scanner. Removal and plucking of the feathers were not performed. A lateral approach for examination, where the scanner was placed directly caudal to the last rib and directed caudo-dorsally against the flank, was applied. The cranial edge of the pelvic bones and the caudal edge of the ribs of the ostrich were located and palpated first. The scanner was placed in this area to view the kidneys (Figure 1). Multiple longitudinal scans of the kidneys were obtained

Figure 1. Ultrasound examination of the kidney of an adult female ostrich (*Struthio camelus*) in sitting position. The scanner was placed behind the last rib and directed dorso-caudally against the flank.

and printed using a videographic printer (Sony® UP – 895 MD, Sony Corp., Tokyo, Japan). A full-length view of the kidney was not obtained due to the anatomical position of the caudal middle lobe and caudal lobe of the kidney and the large size of the kidney. The ultrasonograms of the different structures of the visualized lobes of kidneys were described.

The ultrasonograms obtained were scanned and viewed using a computer. Sample areas within the ultrasonograms were selected for histogram analysis and echo mean values were calculated using an image analysis software (Adobe Photoshop CS7â, Adobe System Incorporated, 2007). Comparison of echo mean values of the renal cortex and renal medulla among the three groups of ostriches was conducted. The width and thickness of the cranial half of the kidneys were measured using the ultrasonograms' internal scale (in cm). The dimensions of the visualized lobes of the kidneys of the three groups of ostriches were compared.

RESULTS AND DISCUSSION

Renal ultrasonography in ostriches was conducted using the lateral approach while the animal was in sitting or standing position. The lateral approach was used in the examination, where the scanner was placed on the lateral side of the ostrich, behind the last rib and the scanner was directed caudo-dorsally against the flank of the ostrich. Even for a large and massive avian species such as ostriches, though the contact area may be large, there were also much anatomical interferences that blocked the ultrasound waves. In avian species, examination of kidneys through placement of transducer on the lateral region is challenging and can give erroneous images due to the obstruction caused by the ribs, the pelvic girdle, bones and air sacs, especially the abdominal air sacs which are located posterior/caudo-dorsally covering the caudally located organs (Hofbauer and Krautwald-Junghanns, 1999). In this study, the ventral approach was not possible due to the interferences caused by air sacs, digestive tract and other abdominal organs.

The kidneys of the ostriches extended from the caudal margin of the lungs to the caudal end of the synsacrum; the dorsal half of the kidney was embedded deeply in the synsacral fossae (Bezuidenhout *et al.*, 1998). Due to these anatomical interferences, the only acoustic window observed in this study was the space between the caudal pair of ribs and cranial edge of the pelvic girdle/bones. In the dorsal approach, the caudal lumbar vertebral and pelvic bones interfere with the examination. Caudo-laterally, the pelvic bones together with the synsacrum interfere with the ultrasonographic examination, especially in the caudal part of the middle lobe and the caudal lobe.

Upon ultrasound examination of the kidneys, only the cranial lobe and the cranial part of the middle lobe were observed. The caudal part of the middle lobe and the caudal lobe of the kidneys were not detected because they were deeply embedded in the fossae of the synsacrum, agreeing with the reports of Deeming (1999) and Nabipour *et al.* (2009). Thus, the overall length from cranial pole to caudal pole of each kidney was not obtained. Only the thickness and width of the right and left kidneys were measured and evaluated. The width of the kidneys in the present study was similar to the width reported by Deeming (1999) in ostriches - 70 mm. Deeming (1999) also reported, upon gross examination, that the kidneys are red-brown in color with a granular appearance and 300 mm long.

In ostrich, each kidney is divided into cranial, middle and caudal divisions by large veins. The oval cranial divisions lie between the last vertebral rib and the pelvis, the narrow middle divisions lie along the midline of the synsacrum between the two acetabula while the caudal divisions are the largest and extend from the acetabula to the middle of the pelvis (Deeming, 1999). The kidneys of avians are elongated and divided into three lobes (Samour and Naldo, 2007). In rock dove, collared dove and owl, the kidney was observed to consist of a large caudal, a small middle and a cranial division; the kidney extended from the caudal margin of the lungs to the caudal end of the synsacrum (Nabipour *et al*., 2009). This agrees with the findings in the present study.

Ultrasound examination of the visible cranial lobe and cranial part of the middle lobe of the kidneys of ostriches revealed a lobulated appearance and the presence of a thick hyperechoic capsule, hypoechoic cortex and anechoic medulla (Figure 2). Histologically, the kidneys of the avian species, like in mammals, consist

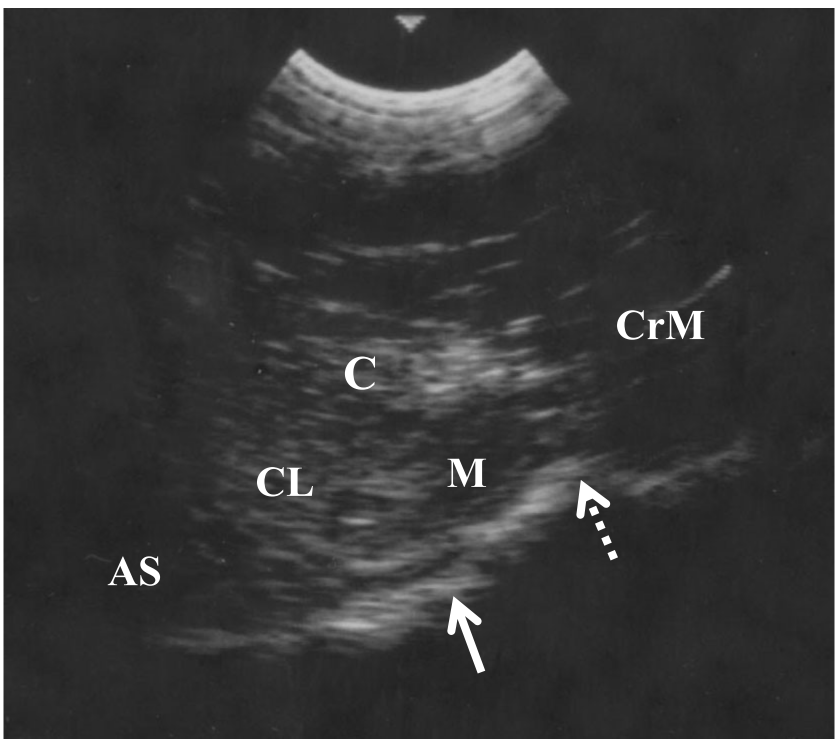

Figure 2. B-mode longitudinal scan of the left kidney of female adult ostrich *(Struthio camelus)* showing a cranial (CL) and cranial part of the middle lobe (CrM), thick hyperechoic capsule (solid arrow), cortex (C) and medullary (M) region. AS is air sac. Note the invagination (dashed arrow) dividing the CL from the CrM.

of two zones, the cortex and medulla (Casotti *et al.,* 2000). But the kidneys of ostriches lacked the defined cortex, medulla or renal pelvis found in mammals. The junction between the cortex and medulla was indistinct (Figure 3), unlike in dogs and cats where there is a distinct cortico-medullary junction and distinct pelvis (Nyland and Mattoon, 1995; Kealy and McAllister, 2000; Mannion, 2006). The kidneys of the ostrich were divided into units called lobules. The lobules have a cortex and medullary cone (Carpenter *et al.*, 2003). The cortex and the medulla were arranged in cones of different lengths, which were distributed randomly within the kidney (Casotti *et al.,* 2000).

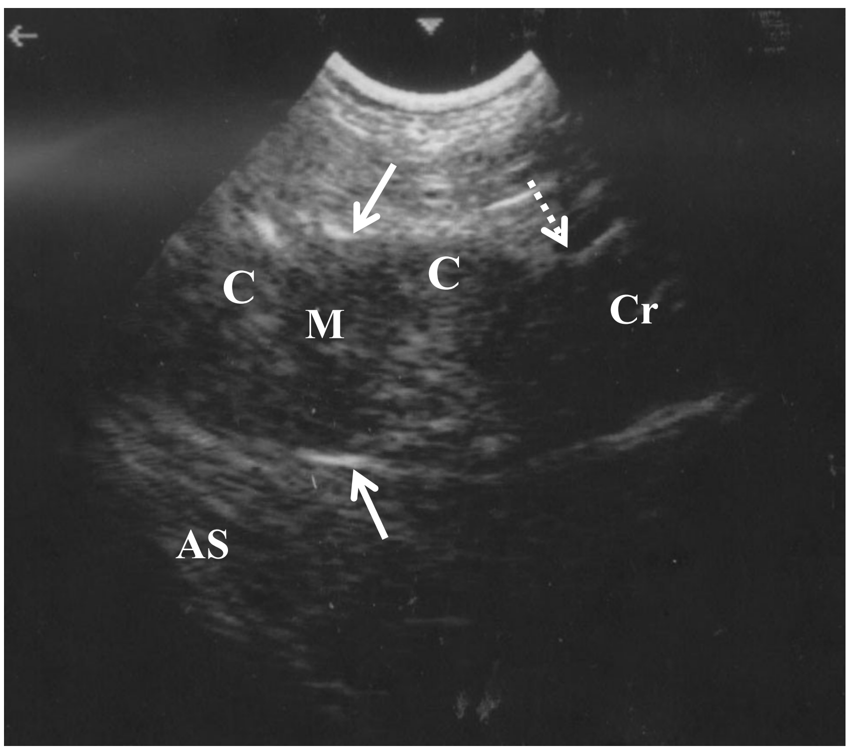

Figure 3. B-mode longitudinal scan of the left kidney of juvenile ostrich *(Struthio camelus)* showing a cranial lobe (CL) featuring a cortex (C), medulla (M) and hyperechoic capsule (solid arrows) in the middle lobe. Note the invagination (dashed arrow) dividing the cranial lobe from middle lobe.

Among the right kidneys of ten ostriches, five were partially visible and two were not visible (Table 1). For the left kidneys, two were partially visible and two were not visible. By group, the kidneys of the adult females and juveniles were more visible than those of the adult males. This could be due to the greater size of the structures in males which interfere with the visibility of the kidneys, *i.e.* the ribs, pelvic girdle and air sacs. In female and juvenile ostriches, the left kidney had greater visibility than the right kidney.

The width and thickness of the left and right cranial lobe of kidneys of the different groups of ostriches are shown in Table 1. In juveniles, the left cranial lobe of the kidney appeared to be wider than the right. For thickness, for those with observed data, there was no difference observed between the left and right kidneys and the different groups of ostriches. Acorda *et al.* (2009) observed no differences in the size of the kidneys between adults and juveniles in sheep at different ages.

Table 1. Mean±S.D. of the width (cm) and thickness (cm) of kidneys obtained from renal ultrasonograms of ostriches (*Struthio camelus).*

Group	Right kidney		Left kidney	
	Width	Thickness	Width	Thickness
Adult female				
1	7.0	2.9	6.9	1.9
2	PV	PV	5.5	2.3
3	6.2	2.8	5.4	2.1
4	NV	NV	6.2	2.3
Mean±S.D.	6.6±0.6	2.9±0.1	6.0±0.7	2.2±0.2
Adult male				
1	PV	PV	PV	PV
2	PV	PV	PV	PV
3	PV	PV	NV	NV
Mean±S.D.	-	-	-	-
Juvenile				
1	NV	NV	NV	NV
2	5.4	3.1	7.0	3.0
3	PV	PV	5.6	2.9
Mean±S.D.	5.4±0.0	3.1±0.0	6.3±1.0	3.0±0.1

PV: partially visible; NV: not visible.

The echo mean values of renal cortex and medulla are shown in Table 2. In all groups, the cortex had greater echo mean values than the medulla. The higher echo mean values of the cortex could be due to the higher density of the cortex compared to the fluid-filled medulla. The renal cortex had higher echo mean values compared to the renal medulla in dogs (Acorda and Ella, 2011) and Bengal tigers (Acorda and Mergilla, 2010). No significant differences in the cortex and medulla between the left and right kidneys of the ostriches were observed.

Research is an investment in the future of the ostrich industry. To this end, existing knowledge should be applied and more funds should be made available for

Table 2. Mean±S.D. of the echo mean values of renal cortex and medulla obtained from renal ultrasonograms of ostriches (*Struthio camelus).*

Group	Right Kidney		Left Kidney	
	Cortex	Medulla	Cortex	Medulla
Adult female				
1	77.9	40.7	80.3	52.2
2	66.7	45.3	78.8	44.5
3	68.3	41.7	60.8	45.5
4	NV	NV	71.7	44.5
Mean±S.D.	71.0±6.1	42.6±2.4	72.9±8.9	46.7±3.7
Adult male				
1	49.5	35.5	63.7	36.9
2	71.1	44.6	76.1	39.2
3	63.9	39.3	NV	NV
Mean±S.D.	61.5±11.0	39.8±4.6	69.9±8.8	38.1±1.6
Juvenile				
1	NV	NV	NV	NV
2	55.6	37.9	57.3	37.3
3	75.3	50.6	74.4	43.6
Mean±S.D.	65.5±13.9	44.3±9.0	65.9±12.1	40.5±4.5

PV: partially visible; NV: not visible.

research in this field, particularly at times when the industry finds itself under economic pressure (Huchzermeyer, 1999). According to Samour and Naldo (2007), more studies are needed to create a standard set of reference avian ultrasonic images and to relate them to clinical and laboratory findings. The time of examination was limited due to avoidance of stress for the samples. Although not needed (Kahn, 2005), the use of chemical restraint might be of help in examining the animals at longer time, thus stress will be eliminated. Prior to examination, fasting for 12-48 hours has been recommended to provide better images (Samour and Naldo, 2007). However, since the ostriches in the present study were free ranged and enclosed in an open wide area, fasting was not performed. The positioning of the ostrich was also significant in order to determine and get a good ultrasonogram of the kidneys of the ostrich, juvenile or adult, male or female. The examination for the male adult ostriches should have been in sitting position, too, like the female adult ostriches. The general limiting factors were the size of the ostriches, the pelvic bones/girdle/synsacrum, massive leg-muscles, type of transducer used, the ultrasonography machine settings, positioning of the samples, and the extensive air sac system - caudal thoracic and abdominal air sacs.

The results of the study suggest that a portion of the kidneys, particularly, the cranial lobe and cranial part of the middle lobe can be examined using ultrasonography to determine its features as well as calculate the echo mean values. These could be useful for characterizing diseases and disorders of the kidneys in ostriches.

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