Ultrasoundographic appearance of the coelomic cavity in healthy green iguanas

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**Objective**—To describe the ultrasoundographic appearance of the coelomic cavity in healthy green iguanas.

**Design**—Cross-sectional study.

**Animals**—26 healthy green iguanas (20 males and 6 females).

**Procedures**—For coelomic ultrasonography, animals were physically restrained in dorsal recumbency by an assistant; chemical restraint was not used. Qualitative and quantitative observations were recorded.

**Results**—Structures that could be visualized in all animals included the heart and cardiac chambers; liver; caudal vena cava; hepatic veins; portal vein; gallbladder; pyloric portion of the stomach; and, when distended, urinary bladder. Visualization of the kidneys was poor. The spleen could be identified in 17 animals, and the gonads could be identified in 22, but were most easily identified in males evaluated during November (ie, during the breeding season); no females were evaluated during the breeding season. Physiologic enlargement of the testes yielded an acoustic window for the spleen by displacing overlying intestine. Anechoic, free coelomic fluid was identified in 3 animals. Measurements of overall cardiac size, ventricular wall thickness, gallbladder size, thickness of the pyloric portion of the stomach, and splenic size were obtained. Only ventricular wall thickness was significantly correlated with body weight.

**Conclusions and Clinical Relevance**—Results suggested that ultrasonography allowed examination of most coelomic structures in green iguanas. The procedure was easily performed and was well tolerated in conscious animals. (J Am Vet Med Assoc 2008;233:590–596)

Although several overviews of ultrasonography in reptiles have been published,1–3 thorough descriptions of normal ultrasonographic anatomy are lacking for many reptile species, including the green iguana (*Iguana iguana*). Green iguanas are among the most popular captive reptiles in the United States. They are an arboreal, primarily herbivorous species native to Central and South America and Caribbean and Pacific islands.4,5 Breeding occurs in the fall and winter months, during which time gonad size substantially increases. Green iguanas belong to the Squamata order of reptiles, which consists of the lizards and snakes. Their suborder, Sauria, comprises the lizards, and their family, Iguanidae, includes the green iguana and similar species, such as other iguanas and the anoles.6 Green iguanas are common pets and zoologic specimens and serve as anatomic models for iguanids and other sauurians. The purpose of the study reported here was to describe the ultrasonographic appearance of the coelomic cavity in healthy green iguanas.

**Materials and Methods**

Twenty-six healthy green iguanas (20 males and 6 females) from 2 breeding facilities were used in the pres-
After ultrasonographic examinations were completed, iguanas were anesthetized for an endoscopy training course or additional diagnostic imaging and were subsequently euthanatized by means of IV administration of a barbiturate overdose. Necropsies were performed to clarify or illustrate coelomic anatomy (Figure 2), to confirm imaging findings, and to verify sex. The study protocol was reviewed and approved by the University of Georgia Animal Care and Use Committee.

**Statistical analysis**—Measurements of anatomic structures were tested for normality by use of graphical methods (histograms and Q-Q plots) and the Shapiro-Wilk test. Pearson correlation coefficients were calculated to test whether body weight was correlated with other measurements. Descriptive statistics (mean, SD, median, and range) were calculated. All analyses were performed with standard software. Values of $P < 0.05$ were considered significant.

**Results**

Use of a large number of transducer positions and orientations (Figure 3) allowed visualization of the heart and cardiac chambers; liver; caudal vena cava; hepatic veins; portal vein; gallbladder; pyloric portion of the stomach; and, when distended, urinary bladder.

**Heart**—The heart was imaged within the pectoral girdle, just dorsal to the manubrium and sternum, which cast an acoustic shadow over it. Both atria and the single ventricle were well visualized. Blood within the chambers was mildly to moderately echogenic (Figure 4). The ventricle was a thick-walled structure, with mean $\pm$ SD thick-
ness of the ventral wall of the ventricle (ie, distance between the ventral midline epicardial surface and the endocardium of the cavitum arteriosum, measured in a sagittal plane at the approximate midpoint of the length [apico-basal dimension] of the ventricle) being 0.42 ± 0.07 cm (range, 0.31 to 0.62 cm). There was a significant (R = 0.52, P < 0.01) linear correlation between body weight and ventricular wall thickness (Figure 5).

Measurement of overall cardiac size was difficult owing to shadowing by the sternum, particularly in the sagittal plane. In the transverse plane, mean ± SD dorsoventral cardiac dimension measured on the image with the largest cross-sectional area was 1.57 ± 0.21 cm (range, 1.23 to 1.97 cm) and mean lateral cardiac dimension was 2.04 ± 0.40 cm (range, 1.48 to 2.99 cm). We did not detect significant linear correlations between body weight and either dorsoventral cardiac dimension or lateral cardiac dimension.

Liver—The caudal vena cava could be traced from the heart caudally into the parenchyma of the right side of the liver. The ventral surface of the liver was in contact with the ventral coelomic wall, facilitating ultrasonographic examination. Cranially, the liver extended to the level of the cardiac apex. Caudally, the liver extended to a point approximately at the junction of the middle and caudal thirds of the coelom. The liver had the appearance of a rounded wedge, with the caudal aspect having the largest cross-sectional area, and was incompletely bilobed. The infrahepatic caudal vena cava was easily identified (Figure 6). Pulsed-wave Doppler ultrasonography revealed a pulsatile waveform in the caudal vena cava that was synchronous with the heart rate. The appearance of the pulsatile waveform obtained during pulsed-wave Doppler ultrasonography of the infrahepatic portion of the caudal vena cava varied substantially from 1 animal to the next but was always biphasic (Figure 7). In the caudal aspect of the liver, a large hepatic vein with echogenic walls could be seen entering the caudal vena cava from the left (Figure 8). Caudal to this, the caudal vena cava turned toward the right lateral aspect of the coelomic wall but became indistinct after exiting the liver. The portal vein could be identified as a vessel running in an approximately sagittal plane and entering the liver to the left of the gallbladder, near the midline. A short distance caudal to the liver, the large ventral abdominal vein could be identified where it joined the portal vein. The confluence of these 2 vessels could usually be seen in a sagittal plane (Figure 9), although excessive transducer pressure obscured this confluence. Hepatic parenchyma was of a uniform echotexture with medium echogenicity that was interrupted only by vascular structures. Hepatic lobation was indistinct. The echogenicity of the liver was similar to that of the spleen, testes, and fat bodies.

Gallbladder—The gallbladder was easily identified adjacent to and partially embedded in the caudoventral border of the liver, slightly to the right of midline. Gallbladder content was anechoic, except that 2 of the 26 iguanas had a small amount of dependent material of mineral echogenicity and 1 had a moderately echogenic central aggregate of material surrounded by anechoic content. The gallbladder typically was an elongated oval in the sagittal plane, although other conformations were sometimes seen (Figure 10). Mean ± SD long-axis dimension of the gallbladder in the sagittal plane was 1.67 ± 0.40 cm (range, 1.00 to 2.72 cm), and mean short-axis dimension in the sagittal plane was 0.67 ± 0.16 cm (range, 0.34 to 1.00 cm). We did not detect significant linear correlations between body weight and gallbladder dimensions. Other biliary structures could not be identified.

Gonads—The gonads could be visualized in all 19 male iguanas examined in November (ie, during the breeding season; Figure 11), although identification of the right testis was sometimes slightly hindered by...
an overlying gas-filled cecum. The testes could not be identified in the 1 male examined in July, and ovarian tissue could be visualized in only 3 of the 6 females examined in July.

In those animals in which the gonads were visualized, the gonads were in contact with the dorsal surface of the coelomic cavity in the lumbar region, lateral to the caudal portion of the aorta, with the right testis slightly cranial to the left. The testes had a homogeneous echotexture, with echogenicity of the testes similar to that of the adjacent spleen. In animals in which the gonads were not visualized, the area was obscured by overlying gas- and ingesta-filled gastrointestinal tract structures. A ventrolateral to lateral approach provided the best window to visualize the gonads in the females in which ovaries were identified. In these 3 iguanas, the ovaries appeared as chains or conglomerations of spherical, anechoic structures near dorsal midline (Figure 12).

Figure 8—Oblique ultrasonographic image of the liver in a green iguana illustrating the junction between a hepatic vein (down arrow) and the caudal vena cava (up arrow). Notice the echogenic walls of the hepatic vein. Acoustic shadows from ribs are also present. The gas-filled cecum (C) is seen caudal to the liver. Right cranial is to the left, and ventral is to the top.

Figure 9—Sagittal ultrasonographic image of the portal vein in a green iguana illustrating the junction between the portal vein (up arrows) and the ventral abdominal vein (down arrow) just before the portal vein enters the liver. The position of the cecum is indicated (C). Cranial is to the left, and ventral is to the top.

Figure 10—Sagittal ultrasonographic image of the gallbladder (G) in a green iguana. The gallbladder is adjacent to the caudoventral surface of the liver (L), slightly to the right of the midline. The aborad aspect of the pyloric portion of the stomach (S) can be seen caudal to the gallbladder, and the cecum (C) is seen dorsally. Cranial is to the left, and ventral is to the top.
Spleen—The spleen was identified in 17 of the 26 iguanas as a rounded, tapering cylindric structure adjacent to the left dorsal aspect of the coelomic wall in the mid portion of the coelomic cavity (Figure 13). The spleen could be identified in 14 of the 19 males examined during July. In these animals, physiologic enlargement of the testes, specifically the left testis, provided an acoustic window, and the caudal pole of the spleen was identified adjacent to the cranial pole of the left testis. The spleen could be clearly identified in only 3 of the 7 animals examined during July. For all animals in which the spleen was identified, the ideal transducer position varied from the ventral aspect of the trunk to the left lateral surface of the trunk. The spleen was circular to slightly ovoid in transverse section. Echogenicity was similar to that of adjacent testes and fat bodies, and echotexture was homogeneous. Mean ± SD dorsoventral dimension of the spleen measured on images obtained in the sagittal plane was 0.45 ± 0.07 cm (range, 0.34 to 0.60 cm). We did not detect a significant linear correlation between body weight and dorsoventral dimension of the spleen.

Gastrointestinal tract structures—The cecum could be recognized as a thin-walled, gas- and ingesta-containing structure occupying a large portion of the coelom caudal to the liver. The gastric fundus was difficult to identify but was dorsal to the head of the cecum when seen. Small intestine was not clearly identifiable.

The segment of the gastrointestinal tract that could be most easily identified was the pyloric portion of the stomach (Figure 14), which was seen in all 26 animals and was recognized on the basis of its thick hypoechoic muscular layer. The pyloric portion of the stomach extended obliquely in a left-caudal to right-cranial direction, usually adjacent to the ventral coelomic wall, and was devoid of gas or ingesta in most animals. Motility was rarely observed. The oral aspect of the pyloric portion of the stomach could often be seen draped over the left testis in males examined during November. The aboral aspect (ie, the portion adjacent to the pylorus) could be seen caudal to the gallbladder. The pylorus was sonographically indistinct. Mean ± SD thickness of the wall of the pyloric portion of the stomach was 0.24 ± 0.03 cm (range, 0.18 to 0.32 cm). We did not detect a significant linear correlation between body weight and thickness of the wall of the pyloric portion of the stomach.

The descending colon contained formed feces, a copious amount of anechoic fluid, or both and was ini-
tially mistaken for the urinary bladder or a collection of free coelomic fluid in some animals. The colon's approximately tubular shape and thicker wall were used to differentiate it from the urinary bladder. Active nematodes, presumably *Oxyuris* spp, were identified in the descending colon of 1 iguana (Figure 13).

**Urinary bladder**—The urinary bladder was identified as a thin-walled, flaccid structure that conformed to surrounding structures in the caudal aspect of the coelom, making it difficult to differentiate from free coelomic fluid. Location of anechoic fluid that was seen was used to indicate whether the fluid was urine or free within the coelomic cavity. Also, mobile, highly echogenic urates could often be identified within the urinary bladder, distinguishing it from the descending colon and free fluid (Figure 16). The caudal extent of the urinary bladder could be identified only as a thin, tapering structure extending into the pelvic cavity. Urinary bladder distension was variable, and urinary bladder dimensions were not measured because of the complex shape of the urinary bladder as it conformed to the shape of surrounding organs. In addition, shape of the urinary bladder was easily changed with minimal transducer pressure.

**Kidneys**—The kidneys were clearly seen in only 4 of the 26 animals, and even in these animals, only the cranial poles of the kidneys were seen. The kidneys were seen by placing the transducer in a transverse prepubic position and angling the beam toward the pelvic canal. On images obtained in this manner, the kidneys appeared as paired, hypoechoic, round to ovoid structures on either side of the colon (Figure 17).

**Coelomic cavity**—A small to moderate amount of free anechoic fluid was definitively identified in the coelomic cavity in 3 of the 26 animals. Owing to the difficulty of definitively determining whether anechoic fluid was urine in the urinary bladder, fluid in the descending colon, or free fluid in the coelomic cavity, it was likely that other animals with free fluid in the coelomic cavity were not identified.

Discrete, paired fat bodies could be found in the caudolateral portions of the coelom in several animals. Because of their shape and uniform echotexture, fat bodies were initially mistaken for other organs, such as the spleen, in some animals. But, careful examination revealed that these structures blended with adipose tissue of a more typical appearance as they were followed laterally and lacked visible internal vasculature. The pancreas and adrenal glands could not be identified in any animals.

Visual inspection of the histograms and Q-Q plots revealed no major departures from normality. Results of the Shapiro-Wilk test for normality indicated that the assumption of normality could not be rejected for any of the measured dimensions, with the exception of lateral cardiac dimension data (*P = 0.044*). When the highest datum point (2.99) was removed from the lateral cardiac dimension data, results of the Shapiro-Wilk test indicated that the assumption of normality could not be rejected (*P = 0.165*). On the basis of the findings of the plots and tests for normality and the fact...
that simple linear correlation analysis is robust to small departures from normality. Pearson correlation coefficients were used to test for linear correlations of measured anatomic structures with weight.

**Discussion**

Results of the present study suggested that the heart and cardiac chambers; liver; caudal vena cava; hepatic veins; portal vein; gallbladder; pyloric portion of the stomach; and, when distended, urinary bladder could be visualized during ultrasonography of the coelomic cavity in healthy green iguanas. The spleen and gonads could be evaluated in most animals but were most easily identified in males evaluated during November. Visualization of the kidneys was poor. The major obstacle during coelomic ultrasonography was the presence of substantial amounts of gas and ingesta, primarily within the cecum. Despite this, most organs could be examined in most individuals.

Diseases of the green iguana in which coelomic ultrasonography could potentially be useful clinically include abscesses, neoplasia, gout, hepatic disease, gastroenteritis, gastrointestinal tract foreign bodies, intussusception, renal disease, urinary calculi, and reproductive disorders. Our findings also suggested that ultrasonography could be used to evaluate reproductive status and determine sex.

Visualization of the kidneys was poor in the present study, and an alternative approach to renal ultrasonography in this species that involves placing the transducer just caudal to the pelvic limbs and angling the beam cranially has been described. Also, use of a transducer with a moderately large footprint, such as the one used in the present study, may make it more difficult to angle the ultrasound beam into the pelvic cavity.

In published descriptions of cardiac ultrasonography in snakes, scanning from the ventral aspect of the body has been recommended. To our knowledge, no protocols for cardiac ultrasonography in lizards have been published. However, several sources indicate that an axillary transducer location can be used in lizards. Because a thorough description of echocardiographic findings was not a goal of the present study and because the heart and cardiac chambers were well seen with a ventral transducer location, the axillary location was not evaluated. Further research is needed to determine the value of alternative transducer locations in this species.

Importantly, iguanas used in the present study were smaller than some iguanas that may be seen in clinical practice. We do not believe that this was a substantial limitation, however, because there were no apparent changes in ultrasonographic anatomy despite the wide range of size for animals that were used. Also, because iguanas continue to grow throughout most of their lives, it is difficult to define a typical size for adult iguanas.

Animals in the present study were physically restrained during ultrasonography, and in the few animals that struggled initially, placing a bandage over the eyes decreased motion sufficiently to allow the examination to be completed. In contrast, physical restraint of large iguanas, especially males, is often difficult, and these animals may require chemical restraint to facilitate ultrasonography and prevent injury to the ultrasonographer and assistants. In addition, the scales of large iguanas may cause damage to transducers with a soft plastic scanning surface if the probe is slid against the grain of the scales. The thicker skin of larger animals may also impair penetration by ultrasound waves, degrading the image.

Of the measurements obtained in the present study, only ventricular wall thickness had a significant linear correlation with body weight. Possible explanations for the lack of correlation between other measurements (overall heart dimensions, gallbladder dimension, splenic dimension, and thickness of the wall of the pyloric portion of the stomach wall) and body weight are numerous. The spleen and gallbladder are known to undergo physiologic changes in size, which would weaken any correlation with body weight. The margins of the epicardial surface of the heart are not always easily discerned in a single image, which may introduce error into measurements of overall size. Although most animals lacked content in the pyloric portion of the stomach, those with some distension may have introduced variability into measurements of wall thickness, which could have led to reduced correlation. Other general factors include the low sample size and the possibility of nonlinear relationships between these measurements and body weight. Further studies with a larger number of animals spanning a larger body weight range would be needed to further explore these possibilities.

In conclusion, results of the present study suggested that coelomic ultrasonography allowed examination of most coelomic structures in green iguanas. The procedure was easily performed with common instrumentation and was well tolerated even though animals were conscious.

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**References**


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b. SAS, version 9.1, SAS Institute Inc, Cary, NC.