Abstract
The normal non-gravid uterus and ovaries of dogs and cats are either not seen or are poorly visualized with radiography. These organs are more clearly seen when enlarged because of pregnancy or disease. Ultrasonography allows pregnancy diagnosis at an earlier gestational age and allows better characterization of diseased organs. This imaging modality can serve as a diagnostic tool for conditions such as pyometra, endometritis, dystocia, failure of involution, ovarian cysts, and uterine or ovarian neoplasms.

Keywords: Pregnancy diagnosis, ultrasonography, radiology, pyometra, failure of involution

Normal reproductive tract
The normal non-gravid uterus is generally not distinguishable from the small intestine on radiographs of dogs. The ovaries are also not normally seen radiographically. In cats, the bladder is located more cranially than in dogs allowing the uterus to be occasionally visible. In a study of 50 intact cats examined with digital radiography, the uterus could be identified as a longitudinal fluid-opaque structure between the bladder/urethra located ventrally and the colon located dorsally in 14 cats. The uterus was best seen when compression was applied to the caudal abdomen with a wooden spoon. Iodinated contrast can be placed in the vagina using a Foley catheter to check for fistulae or tears but in most cases, ultrasonography has more value for imaging the female reproductive tract.

A high frequency transducer (7-12 MHz) should be used for all cats and most medium sized dogs although a 5 MHz transducer can be used for very obese or large dogs. It is best to avoid scanning the uterus after an enema, which would increase colonic gas. Sometimes a partially distended urinary bladder can serve as sonic “window.” The patient can be scanned in either lateral or dorsal recumbency. In dorsal recumbency, the uterus is more likely to be symmetrically placed and is easier to follow but it can sometimes be easier to identify the uterus from the lateral aspect where it is more superficial. If the ovary can be located, scanning can be done between the ovary and bladder to detect the uterus although the uterus is smaller close to the ovary. The ovaries are best examined with the patient in left and right lateral recumbency since they are dorsally located near the kidneys. There is greater difficulty if the probe is placed ventrally with the patient in dorsal recumbency because there will be greater distance between the transducer and ovary and there will be more intervening loops of bowel containing gas. If the probe is placed longitudinally on the body wall, the ovary can be found superficially deep to the skin and peritoneum, usually within 2 cm ventral, caudal, caudolateral, or caudomedial to the kidney. In a few greyhounds we imaged, the ovary was found medial to the mid-portion of the kidney at ovariohysterectomy.

In the non-gravid female, the uterus is best seen when the patient is in estrus. In the transverse plane, the uterus appears as a homogeneous hypoechoic circular structure or ellipse, about 0.5-1.0 cm depending on body weight. Usually the myometrium and endometrium cannot be distinguished. In the longitudinal plane, the uterus appears as a solid, slightly undulant, tubular structure. The body and horns are homogeneously echoic with no apparent lumen except during estrus when some blood may normally be present. During estrus and early pregnancy, the horns become mildly enlarged and more hypoechoic; some fluid may be in the lumen. An endometrial stripe is occasionally seen.

Care must be taken to avoid mistaking the aorta, caudal vena cava or small intestine for the uterus. The aorta and caudal vena cava can be distinguished from the uterus by using Doppler ultrasonography, if available. Otherwise, differentiation can be made because vessels are usually anechoic with a proper gain setting so that they appear as tubular structures with echogenic parallel walls in the sagittal plane. Additionally, pulsatility may be noted in the aorta and both vessels branch caudally whereas the uterus bifurcates cranially. Unlike the small intestine, the uterine wall does not exhibit wall...
layers. Peristalsis and hyperechoic gas or ingesta can usually be seen in the intestinal lumen. Differentiation is more difficult if infiltrative disease in the small intestine causes a loss of wall layering. In that case, following the abnormal area cranially and caudally should reveal a connection to normal bowel.

The normal cervix is usually dorsal and slightly cranial to the trigone of the urinary bladder. In transverse images, the normal cervix appears as a hyperechoic, concentric structure, most prominent in dogs during proestrus, estrus, and early pregnancy. During estrus, the cervix is enlarged and hypoechoic, with a central hyperechoic ring. In the immature dog and during late pregnancy, the cervix is flatter and more difficult to identify.

The normal vagina is often found within pelvic canal where it is difficult to see transabdominally because of overlying bony structures. When visualized, hyperechoic folds may be seen centrally and the uterus may be triangular in cross-section. In estrus, the vagina is more hypoechoic.

The normal ovary is approximately 1.5 cm x 0.7 cm x 0.5 cm in 25 lb dog. The feline ovary is usually less than 1 cm in length. Follicles may be visible in the outer cortex while the medulla is located centrally. In estrus, the ovaries become larger, rounder, and contain mature follicles. Size increases with follicular development. Ovulation is signaled by a decrease in follicular size and number, which can fall to zero. Although it is tempting to think that sonography could be used to determine the time of ovulation, this is usually not possible because it is difficult to differentiate between a corpus luteum and follicle.

Follicles appear as anechoic or hypoechoic cyst-like structures and are first seen in proestrus, increasing in size until ovulation when they reach a maximum size of 1 cm in larger dogs. Some do not rupture and may be seen up to 7-9 days after ovulation in the gravid animal or may remain even longer in the non-gravid animal. After ovulation, the follicle fills with blood (corpus hemorrhagicum). Then, the blood is resorbed (corpus luteum). The corpus luteum persists through pregnancy or diestrus (if pregnancy does not occur). The corpus luteum degenerates into area of scar tissue (corpus albicans) when the animal delivers. Large corpora lutea appear as circular hypoechoic regions that may contain fluid and that resemble follicles. They may be solid, deforming the ovarian surface, and may have a thick wall. Hyperechoic areas in the ovary can represent fibrovascular connective tissue. Gradually fluid-filled corpus lutea decrease in size and become more echogenic until in anestrus or diestrus, the ovary is difficult to find.

Pregnancy

On radiographs, mineralization of the fetus is visible at about 45 days post LH surge in the dog. In the cat, uterine enlargement is present at 25-35 days of gestation. Mineralization of the fetal skeleton is present at 26-45 days of gestation.

Using sonography, pregnancy can be detected in dogs as early as 17-20 days after the luteinizing hormone peak (15-20 days after 1st breeding). Initially, the chorionic cavity will be seen as a 1-2 mm anechoic spherical vesicle. The embryonic mass appears about 5 days later at the periphery of the chorionic cavity. The fetal heartbeat becomes apparent. Pregnancy diagnosis is recommended at 27 days after the luteinizing hormone peak when the gestational sac is about 1.0 cm and there is a detectable heartbeat.

In the cat, the gestational sac can be detected on sonography at 11-14 days after breeding. The fetal pole shows as “echogenic linear density” at 15-17 days. Pregnancy diagnosis is recommended at 16-20 days. Note that for both dogs and cats, the accuracy of diagnosis is dependent on the resolution of the machine, imaging characteristics of the patient, and the experience of the sonographer.

Fetal age can be estimated based on the time of detection of structures. For example, the bladder and stomach are visible by 35-39 days after the luteinizing hormone surge in dogs and by 29-32 days after breeding in cats. Alternatively, calculations of fetal age or days to parturition can be made based on gestational sac diameter, crown-rump length, head diameter and body diameter. Prediction of fetal number is inaccurate as a fetus could be missed or counted more than once, intestinal gas could hide a
fetus, the gestational sac may be too small to see, and fetal death and resorption could occur at a later date.

The normal fetal heart rate is approximately 2x the heart rate of the mother. For dogs, the heart rate is 170-230 bpm while the rate is 200-220 bpm in cats. Bradycardia indicates hypoxia and fetal distress. For both species, heart rate < 170 signals fetal distress and heart rate < 150 signals an emergency situation.

In the postpartum female, the uterus is large, the walls are thick, moderately irregular, and moderately echogenic. The endometrium is the thickest layer initially. It is hypoechoic at placentaion sites and hyperechoic in inter-placentation zones. Placentaion sites are about 2.2-2.8 cm diameter while interplacentation zones are 1.0-1.5 cm in the early postpartum period. The myometrium initially has three layers: an inner hypoechoic circular muscle layer, a central hyperechoic fibrovascular layer, and an outer hyperechoic longitudinal muscle layer. The contents of the uterus are of mixed echogenicity including hypoechoic luminal fluid, more echogenic blood clots, and moderately echogenic fetal and maternal membrane remnants. Considerable involution occurs during the next three-24 days. The uterine wall gradually becomes thinner and less irregular. The endometrium is a moderately echogenic ring (thicker and more irregular at placentaion sites. The myometrium forms a hypoechoic ring. The contents become more homogeneous and hypoechoic so that the uterus has a target-like appearance in transverse images. In a study of beagle dogs, involution was not complete until about 15 weeks. In a study on cats, noticeable layers were gone by 28 days with the uterus appearing as a hypoechoic tubular structure sonographically.

**Abdominal masses**

Differentials for a mid-abdominal mass seen radiographically include the spleen, a pedunculated mass from the liver, an enlarged lymph node, an intestinal mass, or an ovary or retained testicle. Renal masses will be in a dorsal location initially but can grow ventrally to fill the abdomen. When the uterus enlarges, it usually forms tortuous, tubular structures although focal enlargement can occur mimicking a neoplastic mass. The urinary bladder is caudal but may reach the central area if overly full or displaced. Ovarian masses may be found dorsally but frequently they are located ventrally because of stretching of the ovarian ligaments. On sonography, an ovarian mass may appear as a well-defined homogenous mass caudal and separate from the kidney. Anechoic areas can indicate cystic or necrotic areas. Hyperechoic areas with deep acoustic shadowing can indicate areas of mineralization. Possible masses include sex-cord stromal tumors, adenocarcinomas, and teratomas.

A right ovarian mass may displace the descending duodenum and ascending colon medially while a left ovarian mass may push the descending colon and adjacent small intestine similarly. A large mass may pull the ipsilateral kidney ventrally. Some ovarian masses can be dorsal and bilateral.

Dorsocaudal masses can be important in that they may indicate enlargement of the medial iliac lymph nodes. These nodes drain the hindlimbs and pelvis. Inflammatory or neoplastic change can be seen associated with involvement of the reproductive organs. Masses in the ventrocaudal region could be associated with the uterus or male organs. Enlargement of the uterus in this area is most often caused by localized pyometra, other fluid, or pregnancy. Neoplastic uterine masses are rare although leiomyomas, leiomyosarcomas, and adenocarcinomas have been reported.

**Pyometra**

On radiography, pyometra most commonly presents as tortuous tubular opacities in caudoventral abdomen. The uterus must be larger than the small intestine to be identified. On the lateral projection, the small intestines are pushed dorsally and cranially and there may be more separation between colon and bladder than is normally seen. A wooden spoon or commercial paddle is useful to separate and compress adjacent organs and improve visualization of the uterus in less obvious cases. On the ventrodorsal view, it is more difficult to appreciate the tortuous fluid-opaque horns. As mentioned, pyometra can occasionally cause a focal enlargement rather than enlargement of both horns. Physical examination, blood tests, and ultrasound can be used to differentiate causes of uterine enlargement.
Differentials include pregnancy and other causes of fluid in the uterus such as mucometra and hydrometra. On ultrasonography, the contents of the uterus will be anechoic or echogenic with a swirling pattern although the type of fluid cannot be determined sonographically. Occasionally, pyometra will occur in the stump remaining after ovariohysterectomy. The stump will be seen as a fluid-filled structure between the bladder and colon. The uterus should not be aspirated to avoid spilling purulent material into the abdomen.

If rupture of the uterus has occurred, the abdomen will exhibit a partial or complete loss of serosal detail on radiography. Other differentials include rupture of a hollow organ, ascites associated with cardiac or liver disease, hemorrhage, peritonitis, and carcinomatosis. On ultrasonography, the uterus will be distended with cellular appearing fluid. Similarly appearing cellular fluid will be seen in the peritoneal cavity.

**Endometritis/cystic endometrial hyperplasia**

Endometritis or hyperplasia can result in an irregularly thickened uterine wall. The wall may be thickened and may contain small cysts. A small amount of hypoechoic or anechoic fluid may be present in the lumen. Follicles or cysts may be noted in the ovaries.

**Dystocia**

On radiography, the size of the fetus should be evaluated in comparison to the pelvic canal. Radiography might also reveal healed fractures that could compromise the size of the pelvic canal. Radiographic signs of fetal death include loss of flexion, overlapping skull bones, and gas in the uterus, fetal thoracic or abdominal cavities, or fetal vessels. Loss of flexion by itself should be interpreted with caution. A fetus may momentarily be stretching.

Ultrasoundography can be used to check for evidence of fetal distress signaled by a heart rate that is too fast or too slow. A heart rate <150 bpm equates to an emergency situation. If fetal death has occurred, there will be no detectable heartbeat or movement. Other sonographic evidence of fetal death includes excessive fluid in uterus, gas in the uterus or fetal tissues, and a loss of expected detail in the fetal anatomy.

In rare situations, a mummified fetus may be seen in the abdomen. If the fetus has been dead for some time, it may become a mineralized mass where the bones are compressed and the fetus is barely recognizable.

**Failure of involution**

The normal postpartum uterus is enlarged compared to the non-gravid appearance. The walls are thick, moderately irregular, and moderately echogenic. The myometrium and endometrium are distinguishable. Most involution should occur over about three-24 days in dogs but the involution is not complete until about 15 weeks. In cats, the uterus could still be identified at 28 days with ultrasound but wall layering was not seen. It is a judgment call in the early stages to decide whether involution is proceeding normally or not. It may be helpful to perform serial examinations to determine if involution is occurring.

**Cystic ovaries**

The ovary will not be appreciated on radiographs unless it is very large as it could be when a large cyst is present. Cystic ovaries may be associated with pyometra, cystic endometrial hyperplasia, or hydrometra. Radiographically, a fluid opacity is seen near or at the caudal aspect of the kidney. On sonography, cysts have anechoic contents, a distinct thin distal wall, deep acoustic enhancement, variable size, and can be unilateral or bilateral. Smaller cysts can be confused with follicles or corpora lutea. Additionally, inactive cysts cannot be distinguished from those that produce hormones on the basis of ultrasonography.
Selected references
