Reproductive and Urogenital Ultrasound of the Mare

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1. Introduction
With the increased availability and quality of ultrasound machines for the field practitioner, evaluation, diagnosis, and treatment of pathologic conditions of the mare reproductive and urinary tract has dramatically improved. Regarding the use of ultrasound in the reproductive management of the mare, the most significant positive impact was in the 1980s, when transrectal ultrasonography facilitated early and efficient management of mares with twins.\(^1\)–\(^3\) This application has dramatically reduced the number of twins and twin-related reproductive loss in the equine breeding industry. This document will review some of the basic ultrasonographic characteristics of the mare reproductive and urinary tract as well as the caudal abdomen that are accessible by the transrectal and transabdominal approach. Although a detailed description of ultrasonography of the mare’s reproductive and caudal urinary tract is provided elsewhere,\(^4\)–\(^9\) this document will help by highlighting techniques, landmarks, and measurements that will increase the repertoire of the practitioner in a field setting.

2. Methods for Evaluation of the Mare Reproductive Tract and Urogenital Tract
This discussion will be limited to structures that can be identified and evaluated using a standard mid-to-high frequency rectal linear array transducer (5-7.5 MHz) with a maximum depth of 15 cm. For a more detailed instruction on how to manipulate and optimize settings for ultrasound evaluation, the reader is referred to a more comprehensive review.\(^6\),\(^10\) For some machines, the ultrasound settings are preset, with a minimal ability to alter the settings. In most cases, the settings for reproductive transrectal ultrasound that are preset are usually appropriate for most cases to complete the examination described below. This document will review the highlights of mare reproductive ultrasound in the nonpregnant and pregnant mare, with a brief review on how to evaluate the urinary tract by using transrectal ultrasonography. Equine veterinarians are usually comfortable with performing a transcutaneous ultrasound evaluation on a horse for the purposes of a colic evaluation as well as transrectal palpation and ultrasound of the reproductive tract evaluation. In the case of a more in-depth transrectal evaluation or evaluation in a compromised or fractious animal, it is essential to prepare the patient for what may be a 20-minute procedure. Before the evaluation, the mare should be restrained safely in stocks or in a stall door by a handler competent and responsive to your requests and the horse’s behavior. Sedation may be required in the case of fractious or frightened horses or those unfamiliar with a transrectal evaluation. In the case of transrectal evaluation, chemical restraint is reliably achieved with 0.01 mg/kg detomidine HCl\(^a\) with 0.01 mg/kg butorphanol tartrate\(^b\) added in more fractious or anxious animals. Once the horse is compliant...
and restrained, by using adequate lubrication, evacuate the rectum fully to the cranial extent one can reach with their fingertips. In horses that may have friable rectal mucosa (diarrhea, colic, and dehydrations), 60 ml of sterile lubricant can be infused in the rectum before palpation to facilitate evaluation. In cases in which an infectious disease is suspected (e.g., *Salmonella*), the transducer can be placed in a palpation sleeve with lubricant to protect the transducer from becoming a fomite.

3. **Ultrasound of the Nonpregnant Mare**

Transrectal palpation and ultrasound of the reproductive tract include evaluation of the reproductive tract and also allow for evaluation of the caudal urogenital tract and peritoneal cavity. In cases of colic, suspected uterine or gastrointestinal (GI) viscera tear or hemorrhage, the transrectal exam can aid in this diagnosis and even identify the site of compromise. It is helpful during the transrectal evaluation to remember that any structure of interest can and should be viewed with the ultrasound in multiple orientations to better define it. For example, if there is a questionable structure identified in the cervix, the probe can be rotated from the cranial-caudal orientation to a transverse position and the exact location of the structure relative to the lumen can be identified. Evaluation of the following should be performed during each rectal exam for reproduction but also in cases of colic, chronic pain, and behavior issues that are often referred for evaluation. With ultrasound machines, there can be a delay in processing the image as one moves over an area of interest with the transducer. If moving too quickly with the machine set to a slower frame rate (less than 80 Hz), the operator will need to be cognizant to adjust or slow the movement of the transducer over areas of interest because if movement is too quick, small but significant abnormalities may not be identified. This is particularly important when evaluating for twins, and questionable vesicles should also be evaluated in multiple plans.

1. Pelvic inlet: Initial palpation should include evaluation for abnormal masses, palpation of the caudal aorta for dilations, confirmation of the normal location of GI tract, and sweeping of the pelvis and dorsal aspect of the pelvic inlet to try to identify any abnormal structures. It is also essential to ensure there is normal range of movement of the reproductive tract, bladder, and viscera. In cases of adhesions, they will often be identified by the inability to manipulate the structure in a normal fashion. Manipulation of viscera and sweeping the pelvis, under the ovaries and uterine horns and bladder, may be the only way to identify an issue. The ultrasound probe can be placed on any abnormal masses and doppler used to evaluate if blood flow is present (e.g., neoplasia). Abnormal masses (hematomas, neoplasia, and calcification) often disrupt the normal architecture and can be soft to firm and contain variable contents. Only neoplasia or the rare hematoma that encircles a vessel will have blood flow that can be diagnosed with doppler. Masses may be solid or fluid filled. The presence of free fluid is often determined by the echogenicity (usually hypoechogenic, but may contain swirling or flocculent material). Fluid that is dense (purulent or mucoide) may appear to have architecture, but often when jostled or tapped, the fluid can be seen moving in a swirling fashion relative to organized tissue. Very hyperechogenic flecks may represent air or mineralization. Adhesions often appear hyperechogenic or isoechoic to the surrounding tissue and may be thick (1-3 cm) or thin 1- to 5-mm strands outlined by hypoechogenic fluid.

2. Peritoneal fluid: One should always evaluate the ultrasonographic character and amount of the peritoneal fluid. Normally the largest measurable amount is small (<3 cm) anechoic pockets seen ventrolateral to the bladder and in some cases in small pockets around the ovaries and between viscera. Excessive free abdominal fluid (more than 10 cm at either side of the bladder, adjacent to the cervix and caudal uterus body) or change in echogenicity (normal is anechoic in appearance) should warrant further investigation (transabdominal ultrasound, bloodwork, or other diagnostics). One can often appreciate gas echos as pinpoint hyperechogenic dots that may coalesce in larger amounts dorsally, obscuring deep structures. This is useful in the case of ruptured GI viscera or uterus or recent surgery and should be searched for in the dorsal regions surrounding the ovaries and nephroplasmic space. Increased echogenicity may indicate peritonitis, hemoabdomen, or uroabdomen. Interestingly, in many systemically healthy animals that have had previous colic surgery, peritonitis, or cesarean section, one can see hyperechogenic tags (usually <0.5 cm at thickest region) attached to serosal surfaces outlined by anechoic fluid. They can often be identified in pockets of fluid as being attached to the serosal surface of the digestive tract.

3. Ovaries: Ultrasound and palpation of the overall size, texture, and intraovarian structures (follicles and corpora lutea); paraovarian cysts; and presence of a palpable ovulation fossa should be noted. Moveability of the ovary and response of the mare during palpation may also be important in cases of abnormal behavior.

4. Uterus: The uterus should be palpated for position relative to the pelvis (dependent and ventral positioning may inhibit normal
Luminal pyometra. Note the dorsal location and artifact created by gas. Fig. 1. Image of gas within the uterine lumen of a mare with pyometra. Note the dorsal location and artifact created by gas.

uterine evaluation, size, and tone. Ultrasound evaluation of the uterus proceeds from the tip of one horn, across the uterine body, and to the tip of the other horn, assessing the following:

- **Endometrial edema:** It is absent in diestrus or anestrus and increases under the influence of estrogen or inflammation. Presence of edema should be correlated to ovarian structures to make sure it is appropriate given the stage of the estrous cycle. Usually edema is gradated from 0 to 4, with 0 being uniform echogenicity of the endometrial folds and 4 being significant or excessive edema with heterogeneous “pin-wheel” appearance.

- **Luminal fluid:** The location, amount (usually measured in the dorsoventral plane in centimeters), and character (ranges from anechoic to hyperechoic) are evaluated. Normal uterine fluid is anechoic with only small amounts ≤1 cm in estrus. Fluid in diestrus is generally considered abnormal and should warrant investigation. Any echogenic fluid, unless recently foaled or mated should also be evaluated as it may represent purulent material, urometra, or other pathologic conditions. Again, intraluminal fluid should be compared to the ovarian structures to determine if it is appropriate. Slow, thorough evaluation of the entire uterus is critical to identify foreign bodies, retained endometrial cups, cysts, or areas with significant changes in echogenicity of the endometrium. Hyperechoic structures in the uterus can be associated with gas echoes (Fig. 1), scar tissue, mineralized material (endometrial cups can appear as multifocal pinpoint to 2 cm slightly hyperechoic to mineralized structures at the base of the uterine folds), foreign bodies, and urine sediment. In cases in which the uterine lumen requires further evaluation (suspected adhesions, cysts, and foreign bodies), the uterus can be infused with 1 to 3 L of sterile lactated Ringer’s solution with a cuffed bivona catheter, and transrectal ultrasound can be used to help outline the structures of question. Translumenal adhesions and foreign bodies will often appear as hyperechoic bands or structures outlined by the lavage fluid and in the uterine lumen. This technique may help differentiate if a structure identified on ultrasound is in the uterine lumen or the deeper uterine wall. This technique may also allow for evaluation of patency of the uterine horns.

1. **Cervix:** Transrectal ultrasonography can help identify anatomic defects that may not be appreciated by palpation. The inner linear longitudinal fibers of the cervix are easily seen surrounding the cervical lumen in the normal cervix during diestrus. To evaluate the cervix, the transducer is placed in the cranial-caudal orientation and directly above the cervix. The transverse image is obtained by rotation 90° within the pelvic canal. Disruption of the linear fibers, pockets of fluid, cysts, or regions of very different echotexture with blood flow present, may suggest pathology (muscular defects [Fig. 2], diverticula, neoplasia, cysts, or foreign bodies). The gold standard evaluation of cervical competency is digital evaluation during diestrus, but ultrasound evaluation may aid in identifying, characterizing, and defining anatomic relations of the structure of interest.

2. **Vagina:** The vagina is important to evaluate during the transrectal ultrasound evaluation prior to any vulvar or vaginal manipulation that would introduce air. In the normal mare, the vagina is collapsed with no air present. It is seen just dorsal to the bladder in the 3- to 5-cm space that is thin and collapsed in the normal mare (Fig 2). The caudal aspect of the cervix should be evaluated, as pathology can be seen commonly in this area. This area should be evaluated for the presence of fluid (urovagina, vaginitis, cervicitis, or fluid from the uterus), air (abnormal in large amounts and suggests failure of the vulvar and vestibulovaginal fold barriers), or structures such as hematomas, foreign bodies, or abnormal masses. Accumulations of large amounts of fluid in the vagina may also suggest a persistent hymen or abnormal fluid evacuation. Evaluation of the vaginal wall with ultrasound is also helpful in the case of rectovaginal fistulas (air is often seen traversing the dorsal vaginal wall to the rectum). One can better characterize the extent and location of abscesses, neoplasia, and hematomas. In cases of vaginal tears
due to breeding or foaling, the ultrasound again can be useful for identifying the extent and location of the tear, the presence of hematoma, and peritoneal fluid quality.

3. Vestibule/Vulva: Ultrasound can be useful in this region to help evaluate tears, abscesses, and hematomas. Air (hyperechoic) is often useful to help outline the path of a traumatic injury that can be better addressed once one knows the extent of the lesion.

In evaluation of the reproductive tract of the non-pregnant mare, the history, consistency of findings with stage of the estrous cycle, and behavior must all be considered to evaluate the animal. Additional diagnostics (e.g., uterine biopsy and hysteroscopy) or treatments are based on the consideration of all these data points.

4. Ultrasonography in the Pregnant Mare

The use of ultrasonography in the pregnant mare is important to determine the health of the pregnancy, identify twins for early management (13-16 days post-ovulation), and perform fetal sex determination. In early gestation, ultrasound imaging of the conceptus helps determine normal growth and normal development through familiarity of the “normal” ultrasound appearance of the conceptus and uterus. Using known developmental markers (28-day division of the conceptus with equal compartments of allantoic fluid and yolk sac), it is essential to rule out a nonviable pregnancy (lack of heartbeat or abnormal delayed growth) prior to endometrial cup formation at 35 days postovulation so that termination if necessary can be performed and the mare can have a chance to be bred back the same season. Fetal sexing can also be performed from 55 days postovulation onward in pregnancy, with the most efficient windows of sex determination at 55 to 75 days and 90 to 150 days. From 55 to 75 days (optimally 60 days), the location of the genital tubercle is used to determine sex, and later in gestation, the intra-abdominal gonad echotexture and external genitalia or mammary glands are used. Fetal sexing can be performed throughout gestation, but the recommended time windows are when the image is most reliably and rapidly obtained. For those trying to improve accuracy for sex determination, a stall-side phone app provides excellent images for immediate comparison. As the fetus and uterus enlarge with advanced gestation, imaging deeper structures becomes more efficient with a transducer of greater penetration (3-5 MHz) that can reach approximately 30-cm depth. Most linear transducers range from 5 MHz to 15 MHz and cannot penetrate these depths and a different transducer is needed. Despite this, fetal sexing can be performed with the linear rectal transducer by using a transrectal or transabdominal approach in some cases throughout gestation if the fetus is in the correct position. Below are some normal values and key time points that may be helpful when using transrectal ultrasonography to monitor a mare’s pregnancy and assess if there is pathology or abnormal development.

Embryonic Vesicle Size

The embryonic vesicle size (measurement of largest diameter of the vesicle) has been used to help predict if a pregnancy will not be maintained. Undersized vesicles indicated eventual loss in approximately 62% (21/34) of mares, emphasizing that size is an important parameter in assessing early equine...
pregnancy. Figure 3 can be used as a reference for normal equine vesicle size by day of gestation and reflects the work done by Dr. Ginther.4,6,32,33 The position of the embryonic vesicle after 16 days of gestation should be at the base of a uterine horn. Vesicles that spent the majority of time in the uterine body during the mobility phase were associated with increased rates of loss.2 In addition to vesicle size, appropriate early developmental landmarks as the pregnancy develops and the fetal heartbeat become visible are reviewed in Figure 4.33

In midgestation, the fetus and placenta can be evaluated by transrectal and transabdominal ultrasound using the linear transducer. For fetal evaluation in late gestation, the only limitation of this ultrasound technique is the depth of penetration. A lower frequency curvilinear transducer (3-5 MHz) can be used for imaging deeper structures, as is usually required for a detailed fetal evaluation. Again, the following discussion is limited to only the 15-cm depth linear transducer and what can be imaged and achieved with it. In the transrectal evaluation during mid- and late gestation, it is still critical to evaluate the vagina and cervical region to determine the presence of fluid, air, or any other type of contamination that may be abnormal. Evaluation of the cranial cervical region and any fluid accumulation between this and the chorionallantois should be noted. The allantoic and amniotic fluid, the amnion, and often the fetus and fetal orientation can all be evaluated partially during the transrectal exam. Fetal fluids should be assessed for echogenicity and depth. The orientation of the fetus can be determined by locating the orbit or tail by transrectal evaluation or the orientation of the rib cage by transcutaneous ultrasound. Fetal heart rate, movement, and tone (are the limbs and neck flaccid or is there flexion and extension?) can be assessed, as well as character and thickness of the amniotic membrane.7,8,10,22,33–35

Measurements of the combined thickness of the uterus and placenta (CTUP) taken just craniolateral to the cervix have been reported in normal mares and mares with placentitis and can serve, in conjunction with other clinical signs, as a way of identifying pregnancy compromise.8,36 The transrectal measurement is taken from the dorsal wall of the large vaginal artery to the allantoic surface just cranial and lateral to the cervix (Fig. 5). Below are the condensed estimates often used in practice for the upper limits of normal mare CTUP taken in late gestation.6,36–39 It is important to evaluate as much of the pregnancy as can be imaged, as the CTUP measurement alone does not describe regional pockets of separation, excessive edema in focal regions, or other pathology. For transcutaneous ultrasound evaluation of the pregnancy, one needs to minimally prepare the mare by removing any dirt or mud from the hair, as this will interfere with the image. Ideally one would shave the area but this is often not desired by clients. In the field, it is efficient to spray the abdomen with isopropyl alcohol (a one-gallon garden spray bottle works well), from the level of the udder to the xyphoid and approximately 1/3 of the lateral ventral body wall on the side of evaluation. The transducer is placed just lateral to the udder and moved cranially or in the direction of the hair in a systematic manner so that all regions where the uterus can be seen are imaged. Reapplying alcohol may help in regions with poor image quality. One of the most practical applications of the transabdominal ultrasound is determining if the mare is pregnant. In some situations, farms have moved to a rapid late transabdominal ultrasound pregnancy check that completely replaces the transrectal evaluation. To perform this, spray the area just craniolateral to the udder, and using the linear transducer, look for the presence of the fetus and placenta. This can allow for very rapid determination of pregnancy in the case of a field of mares when it is not known which animal aborted or for the purposes of expediency if the farm desires. Although some information is lost by foregoing the rectal palpation (distention of pregnancy, tone, and cervix), other information is gained (echogenicity of fetal fluids, fetal movement, and placental thickening). It may be obvious to some but remember that in the late pregnant mare the tissues that will be passed from outside to the fetus include skin >

Fig. 3. Normal early gestation development and ultrasound findings.
body wall > abdominal fat > peritoneal fluid > uterine wall and chorioallantois (often appear as one structure) > allantoic fluid > amniotic membrane (approximately 2 mm thick) > amniotic fluid > and fetus (Fig. 6). With practice, the transabdominal assessment of the pregnancy using a linear transducer can be used and is helpful in the field setting. It is recommended that the following 3 parameters are evaluated on each transabdominal ultrasound, as together they give a more thorough assessment of the patient health and pregnancy status.

1. Peritoneal fluid: First evaluate the amount of peritoneal fluid (normal is approximately less than approximately 5 cm [author’s experience]) with viscera lying on the abdominal floor) in depth and its echogenicity (normal is anechoic or hypoechoic relative to a large vessel).7,8,10–15 In a case of a colic in the mare, it is prudent to ensure there is not excessive or abnormal peritoneal fluid (hyperechoic or flocculent fluid).14,15 Periparturient hemorrhage is always a concern in the late gestation mare, so ruling out hemoabdomen (swirling, moderately echogenic fluid with minimal to no particulate matter) is useful before progressing to a rectal evaluation. This does not guarantee there is not hemorrhage but likely alters the course of treatment.

2. Evaluation of the uterus and chorioallantois: This region in most healthy pregnancies appears as a relatively uniform echogenicity with a smooth wall on the uterine side and occasional thickenings that represent uterine folds. In some mares, there is a clear definition between the endometrium and chorionic surface. In others, it is not as clear and the significance of this is not known, but the author has seen both in compromised and normal pregnancies. The higher frequency and shallow depth of the linear transducer allow very effective evaluation of the endometrial-chorionic and allantoic membrane interface. Pathologic thickenings, cysts, allantoic vesicles, and large pockets of separation (placentitis, fetal demise, and placental necrosis) can be identified in this way. There is significant folding often associated with

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Fig. 4. Determining embryonic age by diameter (mm) is depicted. From O. J. Ginther, Ultrasonic Imaging and Animal Reproduction: Horses.32
the nonpregnant horn in normal pregnancy and also at the region of the uterine bifurcation that can often be mistaken for “placental separation.” To differentiate between free fluid or parenchyma in the uterine-chorionic interface, increasing the gain and resolution helps visualize vessels and the echotexture of organized parenchyma consistent with uterine tissue compared to free fluid. Doppler can be used to assess questionable anechoic structures, and movement of the transducer into a different plane will help differentiate a tubular vessel from an irregular fluid pocket. One should optimize the ultrasound settings and understand how to change the doppler settings to identify blood flow in smaller vessels, which appear as anechoic circular structures in the placenta.\(^\text{16,36}\) If there is a question of the settings for doppler detection of blood flow, one can test the same settings on a region of vessels in abdominal muscle parenchyma. If it does not demonstrate blood flow in the abdominal musculature, the settings are inappropriate to assess blood flow in the uterus.

3. Thickness of the CTUP: This has been described for both transrectal (Table 1) and transabdominal evaluation.\(^\text{7,8,10,36–39}\) The transabdominal CTUP measurement is taken from the peritoneal surface of the uterus to the place where the allantoic membrane meets the allantoic fluid (Fig. 6). The maximal uteroplacental thickness was found to be 1.38 ± 0.23 cm in 33 mares evaluated with normal pregnancies in late gestation to term.\(^\text{8}\) Perhaps more important than the measurement is evaluation of excessive edema in any portion of the placenta (endometrium, chorion, allantoic membrane, or amnion), regions of placental separation, or greater variation in echogenicity and thickness. Edema often appears as heterogeneous echogenicity and areas of hypoechoic tissue (similar to the endometrium in estrus) with often the parenchyma stretched so that fibers, in extreme cases, make linear streaks (Figs. 5 and 7).

4. Evaluation of allantoic and amniotic fluid: In a group of 33 normal pregnancies evaluated in late gestation, the maximal vertical depth of amniotic fluid (7.9 ± 3.5 cm) was less than allantoic (13.4 ± 4.4 cm) and fewer echogenic particles were detected in amniotic fluid.\(^\text{38}\) The allantoic cavity is where hippomonas are formed; these allantoic accumulations can
appear as flocculent material to a well-organized concentrically ringed hyperechoic structure 2 to 20 cm in length. Significantly increased echogenicity and very flocculent material in either allantoic or amniotic cavities may indicate compromise, meconium release from the fetus, or inflammation and infection.39–45 It is not uncommon on some evaluations for there to be flocculent debris in the allantoic cavity, surrounded by relatively anechoic fluid if the mare has just been moving (walked in from field for evaluation).

5. Fetal evaluation: The ability to predict the outcome of the pregnancy based on biophysical markers diagnosed on ultrasound (fetal movement, character of fetal fluid, CTUP, fetal aortic diameter, and fetal heart rate) has not led to a universally accepted, highly reliable method to predict pregnancy outcome. A study in 2019 demonstrated that the biophysical profile that evaluated transabdominal CTUP, fetal heart rate, and fetal aortic diameter was reasonably sensitive (85.19%), specific (87.25%), and accurate (86.82%) in diagnosing compromised fetuses in 27/129 pregnancies.45 This topic has been explored in depth, with recent research suggesting fetal carotid ultrasonography may be helpful.46 While investigating the best way to identify pathology in utero, the following are a few useful pieces of information that can be obtained with just the linear array rectal transducer.

a. Orientation: Using the ribs and the narrowing of the ribs spaces or the location of the heart relative to the lungs and liver, the direction of the fetus can be ascertained. After 8 months of gestation, the fetus should be in anterior presentation and will likely not change orientation as the pregnancy progresses.4 Because of this, identification of a caudal fetal presentation at 310 days of gestation is helpful to appropriately prepare for foaling.

b. Fetal movement: By holding the probe still for several minutes, often gross fetal movement can be confirmed. The fetus goes through normal periods of rest, but if no fetal movement is appreciated, identification of a fetal heartbeat should be attempted.

c. Fetal heart rate: The ribcage is identified and followed cranially on the fetus (this usually corresponds to caudally on the mare). The maximum depth setting is useful in this scenario, as it allows one to see the widening and narrowing of the rib spaces (narrower cranially on the fetus). Once the heart is imaged, the practitioner can use either the M-Mode setting, doppler, or 2-D B-mode and count beats per

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minute. Although there is significant variation in the fetal heart rate, in general, it is more concerning when the heart beat is very low (<60 bpm) as compared to an elevation in heart rate. Average late gestation fetuses with normal pregnancies demonstrated regular cardiac rhythm with a mean heart rate of 75 ± 7 beats/minute.³⁸ Observing the fetus and re-evaluating heart rate is ideal, but in some cases, just identifying a heartbeat is the goal. In cases in which the heart cannot be identified, a large umbilical or fetal vessel can be identified and evaluated with doppler or magnification to detect ultrasonographic evidence of blood flow, and a heart rate can be determined.

d. Fetus: A thorough fetal exam in utero requires experience and time. For the purposes of most practitioners, a few key benchmarks are useful to take a preliminary assessment of the fetus.

i. Bladder: The bladder is normally collapsed or only slightly distended. A large round, anechoic fluid filled structure in the caudal fetal abdomen, not adjacent to the liver is most likely the bladder. This is abnormal if it appears distended, larger than the stomach, or obscured by the abdominal viscera. An enlarged bladder is often a sequelae to an umbilical cord torsion as the pressure elicited by twisting closes the urachal outlet into the allantoic fluid cavity.⁴¹–⁴⁵

ii. Umbilical cord: It is often recognized as a linear or coiled structure near the fetal abdomen or near the legs or the uterine bifurcation, containing 3 circular anechoic structures in cross-section (2 umbilical arteries, 1 umbilical vein).⁴¹–⁴⁵ For the amniotic portion of the cord (nearest the fetus), the urachus can often be identified as an irregularly shaped structure not much larger than the diameter of the vessels. Extensive sacculations or dilations with no flow on doppler may signal pathology, and again, excessive sacculations and distention with an enlarged bladder may suggest umbilical torsion.⁴¹–⁴⁵

iii. Fetal stomach: The fetal stomach is located right behind the liver as a rounded, usually anechoic fluid filled structure. The presence of fluid in the stomach is a normal finding and suggests the foal is swallowing amniotic fluid.

5. Urinary Tract Evaluation in the Horse by Transrectal Ultrasonography

Indications for transrectal ultrasound evaluation of the urinary tract include hematuria, stranguria, or any other indication of pelvic pain or pathology of the urinary system. The urinary tract can be evaluated well with the linear array rectal transducer, and in some cases, the parenchyma of the kidney is better visualized with a transrectal approach (Fig. 7). The urethra, bladder, ureters, and both kidneys can usually all be imaged with patience and practice. The cranial aspect of both kidneys can be difficult to image completely, and due to positioning, the right cranial ureter and kidney are more difficult to image. A smooth muscle relaxant such as N-butylscopolammonium bromide⁴ can be used to facilitate rectal relaxation if the there is too much tension on the rectal tissue during evaluation.

Pelvic Urethra

In the mare, this is usually identified approximately 3 to 12 inches cranial to the anus and extends from the bladder cranially to the ventral aspect of the vestibulovaginal fold caudally. The urethra in the mare is usually collapsed and has a slightly echogenic line demarcating the lumen that runs from the caudal opening to the bladder (caudal to the cervix or just at
the same level), to beneath the vestibulovaginal fold (often demarcated by air in the vestibule).\textsuperscript{9}

**Bladder**

The normal palpation of the equine bladder should not be distended so that it fills the pelvic inlet. Normally, the dorsal bladder wall does not extend above the brim of the pelvis, and if it is painful upon palpation or manipulation, this is abnormal. Often large bladder stones can be palpated in an emptied bladder. Ultrasound in the normal animal reveals a smooth bladder wall with uniform echogenicity and slightly wrinkled when collapsed.\textsuperscript{9,11} The ultrasonographic appearance of urine can be relatively anechoic to heterogenous swirling fluid with variable sediment in the ventral aspect. Bladder stones appear as smooth to irregular surfaced, hyperechoic structures that reflect the ultrasound such that tissue deep to the structure cannot be imaged.\textsuperscript{11} Movement of the bladder can help identify if the pathology is attached to the bladder wall or ureters and help to characterize and estimate size of the structure. Bladder rupture can have a variable appearance with collapsed bladder and increased free fluid in the abdomen.\textsuperscript{9,11,15} The continuity of the bladder wall is evaluated, and if there is no free fluid and the bladder is distended, rupture is unlikely.

**Ureters**

Ureteral trauma is rare and likely underdiagnosed, as it is not an area that is commonly evaluated. The easiest way to identify and evaluate the ureters is to identify the bladder and then place the transducer in transverse orientation, moved caudally to the region of the bladder neck and beginning of the pelvic urethra (Fig. 8). On the dorsal aspect of the bladder, the ureters will be small (\(<5\) mm in diameter, wall thickness of \(<2\) mm in the normal adult).\textsuperscript{9,47–49} The ureteral opening will appear as an irregular surface on the luminal surface of the bladder wall at approximately the 10 and 2 o’clock position. If one waits, as urine is emptied into the bladder, the ureters will distend and swirling fluid can be seen entering the bladder. The ureters can be followed cranially, sometimes all the way to the entrance to the renal pelvis. Once identified caudally, the transducer is manipulated to keep the ureter in cross section and is followed cranially. Intermittent filling with urine will help confirm their presence if one is unsure. Excessive dilation and hyperechoic contents that obscure the lumen warrant investigation of the kidney, and ureteral urine flow should be assessed (Fig. 8).

**Kidneys**

The kidney parenchyma can be evaluated well with the transrectal approach (Fig. 9). The limitation is that often the cranial aspect cannot be reached and imaged, and occasionally the right kidney is so far cranially that it is not easy to even image the caudal aspect. Renoliths, calcification within the kidney, and excessive dilation or trauma to the kidney have all been imaged with this transrectal approach.\textsuperscript{14,46}

The more one uses the ultrasound to evaluate their patients, the more familiar one becomes with what is normal. This is essential in later being able to differentiate normal from abnormal and help with early diagnosis of conditions that may have been missed without ultrasonic evaluation. The reader is encouraged to practice new ways of using their ultrasound equipment, as it will enhance the quality of care of the patients.
The Author has adhered to the Principles of Veterinary Medical Ethics of the AVMA.

Acknowledgments

Declaration of Ethics
The Author has adhered to the Principles of Veterinary Medical Ethics of the AVMA.

Conflict of Interest
The Author has no conflicts of interest.

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