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Ultrasound as a diagnostic aid for anatomical defects of female reproductive tract: An overview

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Abstract
Ultrasonography is the most informative and accurate method to diagnose the reproductive diseases of animals. By means of ultrasonography it is possible not only to visualize the reproductive organs, but also to obtain valuable information about the size of internal formations, their morphotypesin a non-invasive manner. With the help of ultrasonography one can elimination the unproductive animals at an early age which allows improving the economic benefit of specialized animals and, consequently, increasing the production of animal husbandry.

Keywords: ultrasound, anatomical defect, female reproductive tract, animal husbandry

Introduction
In animal practice, ultrasonography has become an important component of small and large animal theriogenology since its introduction to practice in 1978. The application of ultrasound as a tool in animal reproduction has lingering from its initial role in safe and early pregnancy diagnosis to its current use in the approach to clinical reproduction (obstetrics, infertility, urogenital disorders) [1]. The availability of reasonably priced, better-quality diagnostic ultrasound equipment has become a standard of practice in many communities, private practices, via readily accessible referral centers. The recent development of scanhead technology hasallowed improved visualization of reproductive anatomy. Before performing the specific evaluation of the female reproductive tract, the abdomen should be evaluated methodically with the animal in dorsal recumbency. The discovery of abnormalities in other systems can be relevant to reproductive disorders [2]. It is possible to view the entire reproductive system in a non-invasive manner with the help of ultrasound technology [3]. For doing these, the user needs to be master the physical principles of ultrasonography in anorder to perform a meaningful examination with the help of instrument. The quality of the images depends above all on the user's understanding of the interactions between the ultrasound wave and the organ tissue, as well as proper use and control of the instruments [4].

Basic principles and probe indications
General description of the ultrasonic images
Generally, the images on the ultrasound screen represent a fine section of an organ, grossly resembling a weakly-magnified histological cut [5]. The probe while keep on the organ position similar to the passage of a knife, slicing through an organ tissue from top to bottom. Ultrasonography thus presents a flattened two-dimensional image of a finely-cut section of tissue; while in radiography it is a two-dimensional superimposed view of the entire thickness of an animal or of a limb under observation. The ultrasound images are fast improved and images are superimposed one over the other as the probe moves across a tissue surface. The rapid sequence of tissue section views gives an impression that the structures are moving like an animated cartoon. When interpreting sectional views of an organ on the screen, it is essential to have a good appreciation of the three-dimensional shape of the organ in space.

Characteristics of probe and its resolutions
The probe is the most fragile component of the ultrasound apparatus. In the Veterinary practice, we usually use the probes having a frequency of 3.5, 5.0 or 7.5 MHz. [6]. The ability of the instrument to distinguish between two structures located very close together along the

axis of the ultrasound beam is called its axial resolution. The axial resolution is best when the groups of waves emitted have a short wavelength. Since the number of cycles in each group of waves is set according to instrument design, the only way to shorten their length is to use a probe with a higher frequency [7]. For example, the group of waves produced by a 7.5 MHz probe will be shorter than one produced by a 3.5 MHz probe and will provide better axial resolution.

Linear and sectorial are the two types of probes (Figure 1). In animal gynaecology, linear probes are preferred for transrectal ultrasound examinations of the ovaries and uterus [8]. This probe has a set row of crystals that are selected electronically to form a rectangular image. The linear probe provides good resolution for tissues located close to the probe. Sectorial probes have one or several crystals whose position produces a beam in the shape of a pie slice. The sectorial probe having advantage that it doesn't require a large surface of contact, and it scans a greater overall surface. The disadvantage is that the visual field and the lateral resolution (i.e. the ability of a system to differentiate between two adjacent structures) are more restricted close to the probe. The sectorial probe is ideal for viewing the small ruminant fetus by transabdominal ultrasound imaging and for ultrasound-guided transvaginal aspiration of bovine follicles [8].

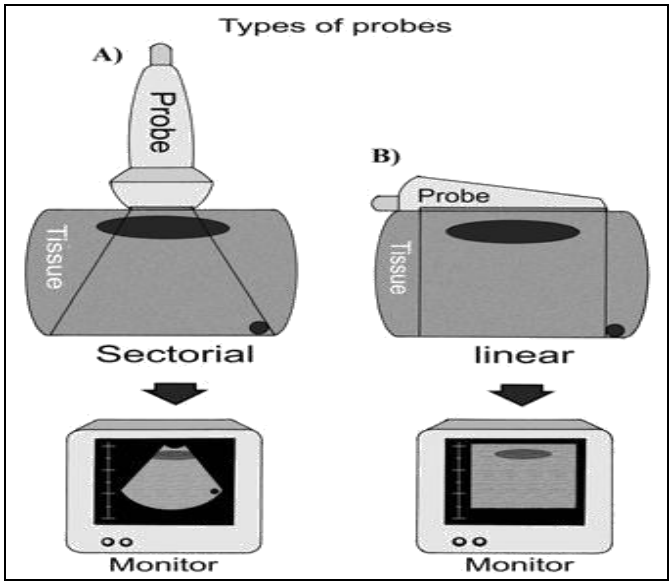


Fig 1: Types of probes (A = sectorial and B = linear)

The details contained in an ultrasound image (resolution) as well as the depth of the tissue observed depend on the frequency and the focalization of the scanning beam. With a lower frequency, tissue penetration will be deep, but the resolution will be lower. A higher frequency enables better resolution, but beam attenuation will be greater and it will not penetrate the tissue as deeply.

The description of ultrasound images is based on an evaluation of the shape, contour, size, and position of the structure being studied, as well as its echogenicity, which depends on the amplitude of the echoes received [8]. An echogenic structure reflects the majority of sound waves back to the probe and thus appears from white to different shades of grey on the screen. Anechogenic structure does not produce echoes; instead, it transmits the waves on to more deeply situated tissues. An example of an anechogenic structure is follicular fluid, which appears black on the screen. The terms hypoechogenic and hyperechogenic indicate respectively a decrease and an increase in relative echogenicity in comparison with the surrounding tissue, whereas the term isoechogenic is used to describe similar echogenicity with the surrounding tissue.

Ultrasonography for diagnosis of female reproductive disorders

Ovarian evaluations

Ovarian agenesis (no ovaries): This condition is most often seen in ruminants, pigs, and dogs. Ovarian agenesis can affect one or both ovaries and the associated tubular genitalia may be absent or underdeveloped. In large animal it is easy to diagnose by rectal palpation but in small animal ultrasonography will help to diagnose accurately. Generally, if the ovaries do not contain any distinct structures thenit shows small, oval-shaped, homogenous structures, which are hypoechoic relative to the surrounding tissue. In the condition of ovarian agenesis, such structures are not visible.

Ovarian hypoplasia and ovarian dysgenesis: Small, misshapen ovaries and usually the tubular tract is also an underdeveloped and weird. This condition is seen most often in horses, it is Turner's syndrome. Animals genetically are XO. Ultrasonography will help to diagnose the condition accurately.

Ovarian remnants (misplaced bits): Sometimes spayed animals still come into heat. For these animals, there are two possibilities. There may congenitally be small bits of ovary in some location other than the ovary or during a spay it is possible that some incompletely removed snippets might remain in the abdominal cavity and continue to cycle. Though in large animal it can be evaluated per rectum but it become impossible, transabdominal ultrasonography in small animal will help to diagnose the condition properly [9].

Ovarian cyst: Ovarian cysts (Figure 2- B) are the common cause of infertility in cows. According to present-dayconcepts, they arise because of delayed and/orinadequate secretion of luteinizing hormone during estrus. Anovulation with the transformation of pre ovulatory follicle into the ovary cyst leads to lengthening of the calving interval, disturbance of the reproduction rhythm and, consequently, economic losses [10].

Ovaries were examined by longitudinal and transverse scanning, while determining their maximum size (length, width, and thickness). Their volume was calculated using the formula for thee llipsoid volume (0.523 multiplied by length, width, and thickness). Special attention was paid to the ovary structure. When examining by ultrasound the infertile cows, thin-walled liquid anechoic formations larger than 20 mm were taken as ovarian cysts, given that at the first and second tests there was no corpus luteum [11]. Cystic ovaries were judged by the presence/absence of the parietal luteal tissue. The pattern images were transferred to and saved in the computer.

Follicular cysts on echograms were defined as single unilateral or bilateral thin-walled liquid formations of round, oval or irregular shape with a uniform anechoic content and area of signal enhancement on the back surface.

Cystic endometrial hyperplasia (CEH): Cystic endometrial hyperplasia (CEH) is a pathological condition of the compromised uterus of middle-aged to old, diestrous bitches and may occur as a result of an exaggerated and abnormal

response to chronic and repeated progesterone stimulation [12]. The already compromised uterus in CEH when invaded by mainly *E. coli* from the vagina begins to proliferate inside the numerous cysts and crypts leading to development of pyometra and when the local immunity reduced as a result of local tissue degeneration, it leads to a condition called cystic endometrial hyperplasia-pyometra complex [13].

The USG examination revealed irregular margins of the uterine wall, thickening and presence of multiple circular anechoic distended glandular cysts inside the uterine wall along with distended uterine horns (Figure 2-C) which was filled with echogenic cellular uterine contents [14].

Uterine structure evaluation:

Unicornuate uterus: A unicornuate uterus represents a uterine malformation where the uterus is formed from one only of the paired Mullerian ducts while the other Mullerian duct does not develop or only in a rudimentary fashion [15]. Sometimes it called as *hemi-uterus* which having single horn linked to the ipsilateral fallopian tube that faces its ovary. A unicornuate uterus may be associated with a rudimentary horn on the opposite site. This horn may be communicating with the uterus, and linked to the ipsilateral tube. Occasionally a pregnancy may implant into such a horn setting up a dangerous situation as such pregnancy can lead to a potentially fatal uterine rupture [8]. Surgical resection of the horn is indicated. For diagnosis helpful techniques to investigate the uterine structure are trans vaginal ultrasonography and sonohysterography, hysterosalpingography, MRI, and hysteroscopy. More recently 3-D ultrasonography has been advocated as an excellent non-invasive method to evaluate uterine malformations.

Cervical evaluation

Double cervix: Double external os of the cervix occurs when Mullerian ducts don't fuse. There may be a band of tissue caudal to, or in, the external os of the cervix. In other cases, there is a true double external os opening into a single caudal part of the cervical canal. Affected animals usually conceive normally. Sperm don't care which door they go in. But there can be obvious problems at the time of parturition. So early diagnosis before breeding is essential to safe the mother as well as offspring and with the help of ultrasonography it can be diagnose accurately at earliest.

Early diagnosis of abnormal pregnancy

Fetal Anomalies: During the ultrasound examination for pregnancy, and especially when determining the sex of the fetus, it is very important to ensure that the fetus is viable and its appearance is normal. Although the following defects are rare, it is important to be able to recognize them: siamese twins; schistosomus reflexus; amorphous globosus. These anomalies are acquired or congenital defects may be noted during the ultrasound examination of foetus. These conditions have a very poor prognosis for fetal survival. Before proposing the termination of the pregnancy on the female animals presenting these anomalies, it is essential for the veterinarian to do a careful ultrasonographic examination using more than one view and to repeat the scanning more than once to confirm his definitive diagnosis.

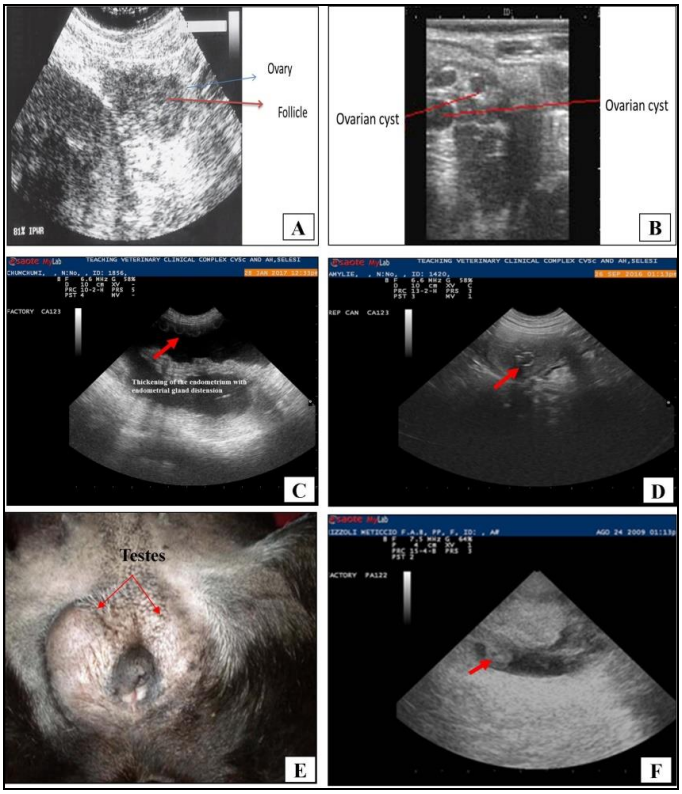
Early fetal resorption: Early fetal resorption is defined as prenatal death which is followed by subsequent degeneration and complete resorption of the fetus [16]. Death of the conceptus can occur at any stage of pregnancy in animals and it may be manifested by partial or total embryonic death or resorption, partial or total abortion of live or death fetus, still born or fetal mummification and retention of fetuses within the dam's womb beyond the normal time of parturition. The death of the fetus during the first half of pregnancy may result into resorption or unobserved abortion [17]. Uterine fluids were not evident in contrast to the snowy appearance of the lumen of uterus. Uterine wall was thickened. Foetal parts were rarely identified and mostly appeared as a poorly defined echogenic mass (Figure 2-D).

Abnormal sex: Abnormal sex development could derive from sex determination errors (i.e. discordance between chromosomal and gonadic sex) or from discordance from gonadal and phenotypic sex (i.e. errors in sex differentiation process). In the first case the affected animals are referred as sex reversal, whereas in the second one they are called pseudohermaphroditism. In small animals there are four principal categories of intersex individuals:

1) True hermaphroditism: The animals having both gonadal tissues, but the secondary sex characteristics and external genitalia of the opposite sex. Testes and ovaries are present in various combinations. A testis may be found on one side and an ovary on the other side, an ovotestis or bilateral ovotestes may be present [18].

2) Female pseudohermaphroditism: In these animals, there having XX chromosomes (without sign of SRY gene presence) and ovaries but external genitals appear masculine. The female animal having an enlarged clitoris and even a prostate. The cause is the excess of testosterone during pregnancy even if the real origin of this abnormal testosterone content is often unknown. Normally these subjects are sterile and ovariohysterectomy is recommended [19].

3) Male pseudohermaphroditism: In these animals, the testes are present but the external genitals appear female (Figure 2-E). In several cases the male having vestigial oviducts and uterus. The testes may be present in the abdomen, the scrotum or lateral to the vulva. A penis can bevestigial oviducts and uterus. The testes may be located within the abdomen, the scrotum or lateral to the vulva. A penis can be present or, more often, it is an enlarged clitoris. If penis and testes are present the diagnosis is more difficult and the abdominal surgery is necessary to find vestigial female organs. Physical examination of the external genitalia revealed the presence of a vulva, the absence of a scrotum and penis. Laterally to the vulva, on the right side, an enlarged subcutaneous structure with irregular surface was found. On the left side a small and regular subcutaneous structure was identified. The ultra-sound examination of these structures was compatible with right and left testis. The scrotum may not be found. Abdominal ultrasound did not show uterus or other Mullerian derivatives. The ultrasound examination of right testis showed a complex mass with a necrotic area. The colour Doppler showed an increase of peripheral and inner signal of blood flows. The left testis was not well defined and it appeared hyperechoic as fat tissue with-out evidence of blood flow (Figure 2- F) [20].



A normal ovary in a bitch
B ovarian cyst
C cystic endometrial hyperplasia
D fetal maceration
E male pseudo hermaphroditism
F hyperplastic testis

Fig 2: Different reproductive disorders

Laparotomy for ovariohysterectomy was performed seven years earlier, but neither a uterus nor the ovaries were found. Most likely, the presence of undescended testes was considered.

Conclusion

At the present stage, the transrectal visual sonography is the most informative and accurate method to diagnose the reproductive diseases of animals. By means of ultrasonography it is possible not only to visualize the gynecological organs, but also to obtain valuable information about the size of internal formations, their number, localization and morphotypes. Carrying out comprehensive scientific research, aimed at the elimination of unproductive animals, allows improving the economic benefit of specialized animals and, consequently, increasing the production of animal husbandry.

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