COMPARISON OF THE ACCURACY OF THE DIAGNOSTICS OF PHYSIOLOGICAL AND PATHOLOGICAL CONDITIONS IN BOVINE OVARIES BY MEANS OF RECTAL PALPATION AND ULTRASONOGRAPHY

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Abstract

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The accuracy of the diagnostics of physiological and pathological conditions in bovine ovaries was studies in 33 cows (66 ovaries) by means of ultrasonography. The results were simultaneously compared to palpation findings by two examiners and to findings in the ovaries of these cows slaughtered 20 hours after the examination. The accuracy of detection of follicles smaller than 5 mm was very low both for palpatory and ultrasound examination. The accuracy increased in the follicles of a diameter of 6 to 10 mm, from which 88.9% were detected by ultrasonography at predictive value of 94.1%, while the results with the palpatory findings equaled 44.4% and 41.7% of the follicles at predictive values of 45.7% and 57.7%, respectively. All follicles larger than 10 mm were detected by ultrasonography; maximum two fifths of these follicles were detected by palpation. The larger the size of the follicles the more accurate their detection was. Follicular cysts larger than 25 mm were detected reliably by all examiners. At the detection of corpora lutea (CL) smaller than 10 mm the results reached 57% by ultrasonography at a high predictive value. Palpatory findings equaled 64.3% and 35.7% at the predictive values of 40.9% and 55.6%, respectively. All 26 CL larger than 10 mm were detected while only 24 and 19 were detected by palpation at a lower predictive value than with ultrasonography. Ultrasound imaging appeared as more reliable for the detection of cavities inside CL, filled with clear liquid. The cavity was detected by palpation in cases with a blood clot present in the cavity. Ultrasonography appeared as a very reliable method for diagnostics of physiological and pathological ovarian conditions. In order to obtain a most accurate diagnosis, a complete examination of the whole genital tract by both methods is necessary.

Cattle, diagnostics of ovarian conditions, ultrasonography, rectal palpation

A correct recognition and differentiation of individual stages of the sexual cycle is of great importance for animal husbandry and production in cattle farming. The need for a timely and reliable diagnostics of ovarian conditions exists also because of a relatively frequent occurrence of fertility disorders in cattle. According to Kudláč et al. (1977), the functional disorders of the ovaries are especially frequent, reaching 25 to 35% of the cases of infertility. The percentage can increase in herds with high milk yield.

The rectal palpation of genital organs is regarded as an essential method for the diagnostics of individual stages of the sexual cycle. Although this method is relatively accurate and forms a base for the professional approach to each case, it is well known that an exact description of the condition might be frequently difficult and a false interpretation can occur to a certain extent. The frequency of errors at the rectal palpation of the ovaries is estimated at approximately one

third of the false diagnoses (Dawson 1975, Holý et al. 1978, Grunert 1975, Stolla and Himmer 1980). Certain subjective approach must be always considered (Kudláč et al. 1979), and this subjective approach determines the extent of the errors in the diagnosis. At present, ultrasonography is an important contribution for making the clinical diagnostics more accurate. Pierson and Ginther described the advantages of ultrasonography already in 1984. The ultrasonographic features of the ovarian stroma, the follicles, and the corpora lutea are described by Edmondson et al. (1986), Kähn and Leidl (1986), Pieterse (1989) and others. Ultrasonography of pathological ovarian conditions was described by Kähn and Leidl (1989), the diagnostics of luteal and follicular cysts in cattle by Farin et al. (1990) and others. Our experience in this field was also already published (Grygar and Kudláč 1989, Grygar 1990).

The assessment of reliability of the clinical diagnostic methods — rectal palpation and ultrasonography — of ovarian conditions in the bovine is presented in this work. The results were compared to findings in the same animals after slaughter.

Materials and Methods

The ovaries of 33 non-pregnant cows, crossbreds of Czech Red and Black and White cattle of various ages were examined independently by two examiners by rectal palpation and by one examiner by ultrasonography. The case history was not known to the examiners. Approximately one half of the cows was examined first by rectal palpation and then by ultrasound, and the rest in an opposite way.

A scanner Aloka SSD-210 DX II with a 5 MHz linear probe was used for transrectal examination (Kudláč and Grygar 1989, Grygar and Kudláč 1989, Grygar 1990). At the time of the study (April 1990) the examiner had experience from approximately 5 000 ultrasound and palpatory examinations of genital organs in cows and heifers.

Every examiner assigned the ovarian findings into classes according to the follicle sizes (2 to 5 mm, 6 to 10 mm, 11 to 15 mm, 16 to 20 mm, and 21 to 25 mm). If a circular image was not obtained by ultrasonographic examination of the follicle, an average made out of the two dimensions found in the frozen image of the follicle was used for its classification. The follicular formations larger than 25 mm were regarded as follicular or luteal cysts. Corpora lutea were classified into the groups according to their size — 6 to 10 mm, 11 to 20 mm, and more than 20 mm. The maximum palpable diameter or the maximum cross-section on the ultrasound image was taken into account. Classification was made with regard to the age and according to the morphology or echogenicity of the displayed corpus luteum. Attention was paid to the possible presence and features of a cavity in the corpus luteum both at palpatory and ultrasonic examination. If the cavity was not circular, the length and width of the cavity was measured (Kähn 1986) and an average was calculated from these values.

The cows were slaughtered approximately 20 hours after the palpatory and ultrasonographic examinations. Their ovaries were excised and the individual ovarian structures were measured at the cross-sections of the ovaries. The dimensions were evaluated in the same way as on the frozen ultrasonic image.

The obtained results were used for the calculation of the sensitivity ($100a/a+c$) and the positive predictive value ($100a/a+b$) according to Pieterse et al. (1990), where a = number of correct positive diagnoses, b = number of incorrect positive diagnoses, c = number of incorrect negative diagnoses.

Results

The numbers of follicles and corpora lutea are summarized by their sizes in Tab. 1. The numbers of follicular cysts, found on the excised ovaries, are also in Tab. 1 (33 cows, 66 ovaries). Furthermore the numbers of cyclical or pathological structures, correctly detected and classified by the examiners 1 and 2, using rectal palpation, and by the examiner using ultrasound, are presented. The cases in brackets in the separate classes, marked by +, indicate formations that were not present in the ovaries *post mortem*. These findings were incorrectly diagnosed by the examiners, or they were incorrectly classified (i. e. they represent incorrect positive diagnoses). The sensitivity and the predictive value for the size classes are calculated in groups by the examination methods in Tab. 2.

Post mortem, the largest number of follicles (n = 261) was found to be 2 to 5 mm in size, while large numbers of these follicles were of 2 to 3 mm. Accurate measurements and counting of so small follicles were somewhat difficult even *post mortem*. Ultrasonography detected correctly approximately one half of these small follicles.

Table 1

The comparison of the findings in cow ovaries by rectal palpation, ultrasonic imaging, and inspection after the excision after slaughter (n = 33 cows, 66 ovaries)

Examination method	Follicles (mm)					Follicular cysts (mm)	Corpora lutea (mm)			Luteal cysts
	2–5	6–10	11–15	16–20	21–25	>25	6–10	11–20	>20	
Rectal palpation (examiner 1)	86 (+6)	16 (+19)	13 (+15)	2 (+2)	1 (+1)	2	9 (+13)	7 (+6)	13 (+3)	(+2)
Rectal palpation (examiner 2)	5	15 (+11)	5 (+4)	3 (+1)	1	2	5 (+4)	5 (+5)	10 (+1)	(+1)
Ultrasonography	134 (+3)	32 (+2)	22 (+1)	7	1	2	8 (+1)	9	17	0
	261	36	22	8	1	2	14	9	17	0

Note: The numbers of false positive diagnoses (b) are in brackets

Table 2

The accuracy of the ultrasonic imaging compared to the rectal palpation based on inspection of the excised ovaries after slaughter (n = 66 ovaries)

Examination method		Follicles (mm)					Corpora lutea (mm)		
		2–5	6–10	11–15	16–20	21–25	6–10	11–20	>20
Rectal palpation (examiner 1)	C%	33 0	44 4	59.1	25.0	100	64.3	77.8	76.5
	PPH%	93 5	45 7	46.4	50.0	50.0	40.9	53.8	81.3
Rectal palpation (examiner 2)	C%	1.9	41.7	22.7	37.5	100	35.7	55.6	58.8
	PPH%	100	57 7	55.6	75.0	100	55.6	50.0	90.9
Ultrasonography	C%	51 3	88 9	100	87.5	100	57.1	100	100
	PPH%	97 8	94 1	95.7	100	100	88.9	100	100

Note: C – sensitivity
PPH – predictive value

Table 3

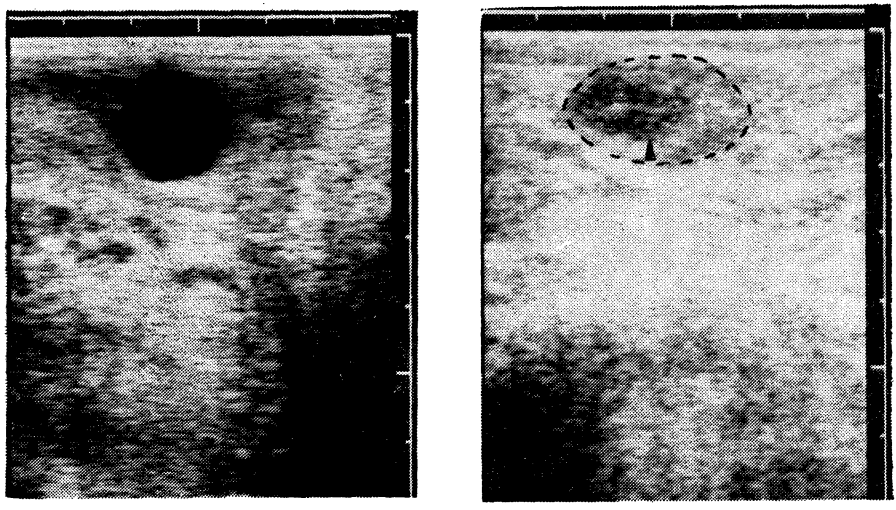
The comparison of the follicles 11 to 25 mm in size and corpora lutea larger than 10 mm, i. e. of the formations of diagnostic importance (n = 33 cows, 66 ovaries)

Examination method	Follicles (mm) 11–25	Corpora lutea (mm) >10
Rectal palpation (examiner 1)	20 (+14)	24 (+5)
Rectal palpation (examiner 2)	10 (+4)	19 (+2)
Ultrasonography	31	26
Inspection of excised ovaries	31	26

Note: The numbers of false positive diagnoses (b) are in brackets.

Examiner 1 that used rectal palpation detected approximately one third (see Tab. 1) of the 2 to 5 mm follicles from their total number. Examiner 2 detected only 5 out of 261 follicles of this size. The predictive value of the results of all examiners was relatively high in this follicle size class. The low sensitivity (1.9%) and high predictive value (100%) is mostly apparent in examiner 2.

It is much easier and more objective to evaluate detection of the follicles sized 6 to 10 mm present in the ovaries in smaller numbers (n = 36). The reliability



a b

Fig. 1. Cyclical formations in the left and right ovary of a cow in peak heat.
1a — Follicle diameter 16 mm (circular anechogenic image).
1b — Corpus luteum in regression (the edge is marked by the arrow) placed in the stroma (limits are marked by dashed line).

Fig. 2. Typical echogenic image of a compact mature corpus luteum with the dimensions 32 × × 26 mm. Next to the corpus luteum at the left side there is a circular anechogenic zone — a follicle.

of determination of the follicles of this size by ultrasonic imaging was very good (sensitivity of 88.9% and predictive value of 94.1%).

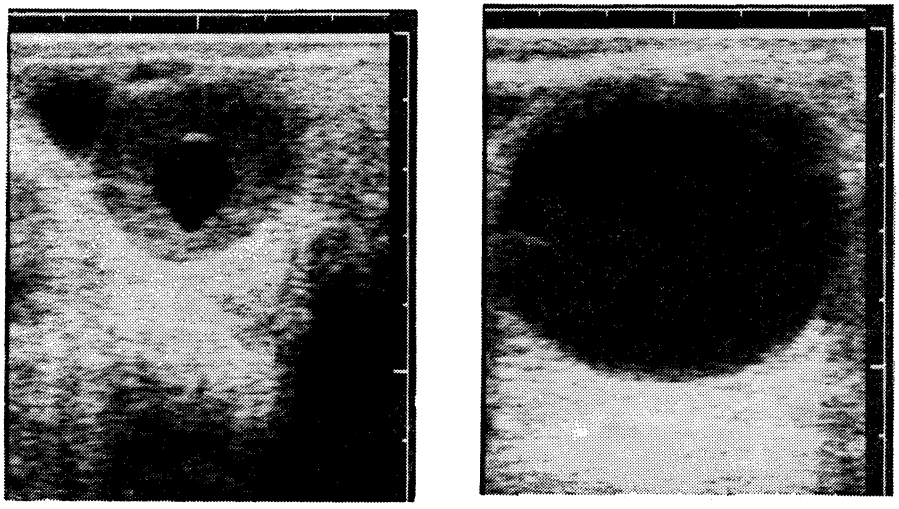
High reliability of the ultrasonic imaging was found in detection of the follicles 11 to 25 mm in size. All 31 follicles found *post mortem* were also displayed by the scanner. Only one disproportion in the classification was observed.

The accuracy of the examination by rectal palpation is lower both in examiners 1 and 2 as compared to the results of ultrasonic imaging also in the groups follicles 11 to 25 mm in size (see Tab. 1 and 2). When accuracy of the results of examiners 1 and 2 are compared, it is clear that examiner 1 reached lower predictive value at higher sensitivity.

A simplified (summarized) evaluation was used for further processing of the results on the reliability of rectal palpation and ultrasonography, because according to Kähn and Leidl (1986) the formations on the ovary that can be clinically detected are larger than 10 mm. Therefore incorrect classifications into another size class within 11 and 25 mm were ignored. It is apparent from Tab. 4 that the reliability of ultrasonic imaging is much higher than the reliability of rectal palpation.

More than one half (57%) of corpora lutea was detected correctly by ultrasonography at a relatively high predictive value (only one false positive detection of corpus luteum). The sensitivity of examiner 1 was higher (64 %) but the predictive value was low. There was an opposite trend in the results of examiner 2.

The class of corpora lutea 11 to 20 mm in size and more than 20 mm is more important for the diagnosis.



a b

Fig. 3. Ultrasonography can clarify the cases that are problematic to interpret by palpation. Ovaries of a cycling cow.

3a — Left ovary. Mature corpus luteum with cavity filled with anechogenic liquid. The cavity that is not luteinized has the dimensions 12 × 10 mm. Next to the corpus luteum at the upper left side there is an anechogenic follicle.

3b — Right ovary. Follicular cyst with the dimensions 50 × 42 mm.

The results of ultrasonic imaging in this class (Tab. 1 to 4) were completely convincing. All corpora lutea (CL) were correctly detected. Both examiners reached good results by rectal palpation (Tab. 3 and 4). Examiner 1 detected correctly 92% CL, examiner 2 reached 73% at a lower predictive value.

Out of 40 CL detected after slaughtering altogether 14 CL (35%) contained a central cavity 2 to 16 mm in diameter (see Tab. 5). Ten cavities (71.4%) were filled with a clear liquid, 4 cavities (28.6%) were filled with blood clots.

Ultrasonic imaging correctly detected all 10 cavities filled with clear (anechogenic) liquid. Neither of the 4 cavities, filled with blood clots was detected by

Table 4

The accuracy of ultrasonic imaging compared to rectal palpation based on the actual finding after slaughter in the ovarian formations of the size of a diagnostic importance — follicles of 11 to 25 mm and corpora lutea larger than 10 mm (n = 66 ovaries)

Examination method		Follicles (mm) 11–25	Corpora lutea (mm) >10
Rectal palpation (examiner 1)	C%	64.5	92 3
	PPH%	58.8	82 8
Rectal palpation (examiner 2)	C%	32.3	73 1
	PPH%	71.4	90 5
Ultrasonography	C%	100.0	100 0
	PPH%	100.0	100 0

Note: C – sensitivity
PPH – predictive value

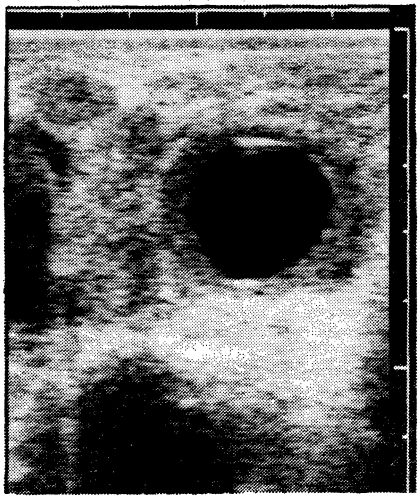


Fig. 4. Corpus luteum with a cavity on day nine after the ovulation. The large central cavity (22×20 mm) is filled with anechogenic liquid. The luteal wall is 4 to 7 mm thick (at various places). The corpus luteum appeared later as *corpus luteum graviditatis*.

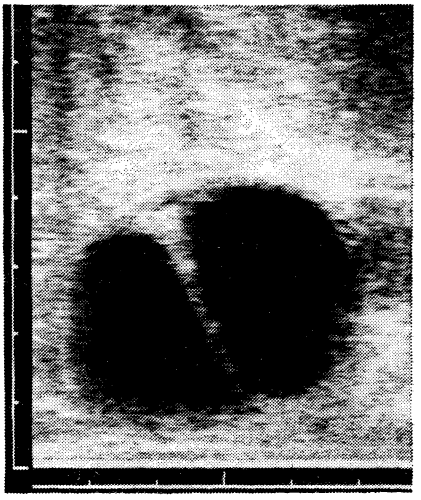


Fig. 5. The ultrasond image of two follicular cysts that may be diagnosed as a single cyst by rectal palpation.

Fig. 6. Luteal cyst of the dimensions 37 × × 33 mm. The dimensions of the cavity are 30 × 29 mm. The luteal cyst is 4 mm thick at the place marked by arrows. The fine echogenic structures inside the cyst occur frequently in luteal cysts.

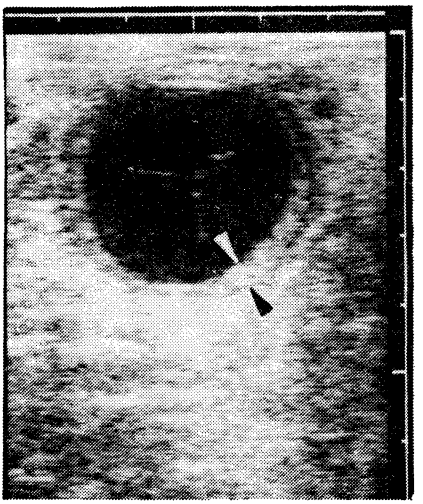


Fig. 7. Ultrasonic image of the cow ovary placed in a water bath. The corpus luteum on the picture was examined before the slaughtering (Tab. 5, case number 11). The luteal wall is apparent (arrows) and its thickness is 4 mm in the upper right part. The corpus luteum cavity is filled with the hyperechogenic (granulating) blood clot without luteal cells (demonstrated by histological examination). The plane of the image covers a small ovulation papilla, facing the probe.

ultrasonography. Three out of the four cavities had dimensions on the threshold for detection by the used instrument (2 to 3 mm), however, one cavity was 15 mm in diameter and was surrounded by luteal wall about 5 mm thick. All detected cavities were confirmed *post mortem*, and therefore no false diagnoses were made by ultrasonic imaging (predictive value of 100%).

Examiner 1 detected correctly 5 cavities (41.7%) in the 12 CL detected by him (Tab. 5), however, his predictive value was relatively low as well as the sensitivity (41.7%).

Examiner 2 detected correctly only 1 (8.3% CL with cavity in the 12 CL detected by him. This cavity 15 mm in size filled with blood clot was correctly referred to as a large one. The predictive value of the results of examiner 2 was 100%.

Discussion

It is very difficult to select the correct methodology for comparison of the reliability of two completely different diagnostic methods, i. e. rectal palpation (when the examiner can make a decision only according to what the feels) and ultrasonography (the information for the diagnosis is perceived by sight by means of a sophisticated technology). The physiological and pathological conditions in the cow ovaries were selected for comparison of the two methods,

Table 5

Detection of the cavities inside the corpora lutea by rectal palpation and ultrasonograp hy

Examination method	Individual cases of CL with a cavity or false positive diagnoses of CL with a cavity classified according to the size of CL																				
	6–10 mm			11–20 mm							> 20 mm										
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.
Rectal palpation (examiner 1)	0	⊖	0	0	+1	1	0	0	1	+1 (jemn. d.)	1 (⌀ 10–15)	+1 (jemn. d.)	0	1	+1 (jemn. d.)	+1	1	+1	+1	lut. c.	0
Rectal palpation (examiner 2)	0	⊖	0	0	0	0	0	0	0	0	1 (vel. d.)	0	0	0	0	0	0	0	0	lut. c.	0
Ultrasonography	0	0	0	1 (⌀ 5)	0	1 (náz. d.)	1 (⌀5)	1 (⌀ 4)	1 (⌀ 5)	0	0	0	1 (⌀ 3)	1 (⌀ 17)	0	0	1 (⌀ 2)	0	0	1 (⌀ 5)	1 (náz. d.)
After slaughtering	1 (⌀ 2) *	1 (⌀ 3) *	1 (⌀ 3) *	1 (⌀ 5)	0	1 (⌀ 2)	1 (⌀ 5)	1 (⌀ 3)	1 (⌀ 7)	0	1 (⌀ 15) *	0	1 (⌀ 4)	1 (⌀ 16)	0	0	1 (⌀ 3)	0	0	1 (⌀ 5)	1 (⌀ 2)

Explanations:

CL – corpus luteum, * – cavity filled, d. vel. – large, náz. – outline of cavity, lut. c. – luteal cyst, (⌀ 5) – diameter of the cavity = 5 mm, d – cavity, ⊖ – CL were not detected by the used method

including the assessment of the size of the formations in the ovaries. The ages of the formations in the ovaries (young CL, mid cycle CL, old CL as according to Pieterse et al. 1990) were intentionally not distinguished, because according to Kähn and Leidl (1986), Grygar (1990) and others there are only very limited and frequently no visible differences in the echogenicity of CL during the different phases of the sexual cycle.

It appeared during the study that some differences in evaluation of the size may occur. When using ultrasonic imaging the internal diameter of the follicles is usually measured, because in this way an accurate value can be obtained. At palpation the size of the follicle is perceived including its wall. The measurement of cross-sections in the excised ovaries cannot be always exact.

It is difficult to determine the threshold for diagnostic importance of the size of follicles and CL. This value varies around 10 mm (also according to our other so far unpublished results).

Although Pieterse (1989) mentions some advantages in transvaginal ultrasonic imaging, we consider the transrectal use of the probe being the essential method. Our results are also more accurate than the results of Pieterse et al. (1990).

When our results were compared to those of other authors it is apparent that despite the different approaches to the evaluation, our results with ultrasonic imaging are in many aspects more promising. We presume this is especially due to the experience of the examiner that had performed so far a relatively large number of examinations in cattle. Kähn and Leidl (1986) agree that with the growing expertise due to a longer training the number of errors in the interpretation of ultrasonic imaging is further reduced.

In agreement with Kähn and Leidl (1986) and Pieterse et al. (1990) we have demonstrated that the reliability of ultrasonic imaging is low in the detection of small follicles (< 10 mm). The reliability increases considerably in the detection of larger follicles (> 10 mm). The high reliability of this method was also demonstrated for the detection of large CL (> 10 mm) conforming to the results of Kähn and Leidl (1986). The detection of very small CL (< 10 mm) appeared as problematic. This applies, therefore, to the CL in an advanced stage of regression, or very young CL. Our experience is in agreement with Pieterse et al. (1990). This fact is determined not only by the smaller size of the older CL but also by small differences in the echogenicity of this group of CL and the ovarian stroma.

Except for CL 6 to 10 mm in size, ultrasonic imaging provided for better results in the detection of all ovarian formations compared to rectal palpation.

It should be mentioned that there was a considerable disadvantage for the palpatory examinations that were made just after the ultrasound examinations. This disadvantage could not be reflected in the evaluation, although the rectal mucosa was more sensitized than after a repeated rectal palpation. The assessment of the ovarian formations was more difficult in the second group of cows and a possibility for a false diagnosis in determination of the size and the nature of the formations was higher. Also the subjective factor of the evaluation should be considered. As it was mentioned in our previous work (Kudláč et al. 1979), it can happen that in the effort for the assessment of the ovarian conditions as correct as possible, a trend for the determination of the presence of the structure that is looked for occurs.

It appeared in our study that ultrasonic imaging is a very sensitive method

for the determination of the cavities inside the luteal formations larger than 2 to 3 mm, if the cavities are filled with clear (anechogenic) liquid. Problems may occur in the diagnostics of the cavities filled with blood clot. There may be no difference between the echogenicity of the blood clot and the echogenicity of the luteal tissue. However, in our other study (unpublished) we have found no CL with a cavity larger than 2 mm with the blood clot. Altogether 39 excised CL were examined in this study, with 17 CL (43.6%) containing a cavity. Our experience agree with the results of Kähn (1986), Pierson and Ginther (1988), Kähn (1989) and others. An extra attention should be paid to the cavities inside CL that are completely filled with blood clot and can be missed by a single examination.

Srovnání přesnosti diagnostiky fyziologických a patologických struktur na ováriích krav rektální palpací a ultrasonografií

U 33 krav (66 ovárií) byla zjišťována spolehlivost diagnostiky fyziologických a patologických struktur na ováriích pomocí sonografie a výsledky byly současně porovnávány s palpačním nálezem dvou vyšetřujících a nálezem na ováriích krav odporažených do 20 hodin po provedeném šetření. Při detekci folikulů menších než 5 mm je spolehlivost palpačního i sonografického vyšetření velmi nízká, zvyšuje se u folikulů velkých 6—10 mm, kde sonografií bylo zjištěno 88,9 % folikulů při předpovědní hodnotě 94,1 %, zatímco palpačně bylo zjištěno 44,4 a 41,7 % z těchto folikulů při předpovědní hodnotě 45,7 a 57,7 %. Folikuly větší než 10 mm byly sonograficky zjištěny všechny, palpačně bylo vyšetřujícími zjištěno nejvýše 2 pětiny těchto folikulů. Čím byly folikulární útvary větší, tím bylo jejich zjišťování přesnější. Folikulární cysty větší než 25 mm byly všemi vyšetřujícími určeny spolehlivě. Při zjišťování žlutých tělísek (CL) menších než 10 mm jich bylo sonograficky určeno 57 % při vysoké předpovědní hodnotě, palpačně bylo zjištěno 64,3 a 35,7 % při předpovědní hodnotě 40,9 a 55,6 %. U CL větších než 10 mm bylo sonograficky určeno všech 26 Cl, palpačně 24 a 19, při nižší předpovědní hodnotě než u sonografického vyšetření. Pro detekci dutin uvnitř žlutých tělísek se při jejich vyplnění čirou tekutinou ukázala spolehlivější sonografie, při vyplnění krevní sraženinou poukázalo na dutinu palpační vyšetření. Ultrasonografie se ukázala jako velmi spolehlivá metoda pro diagnostiku fyziologických, respektive patologických ovariálních struktur. Pro co nejpřesnější diagnózu je nezbytné vyšetření celého pohlavního aparátu oběma vyšetřovacími metodami.

Сопоставление точности диагностики физиологических и патологических структур на яичниках коров ректальной пальпацией и ультрасонографией

У 33 коров (66 яичников) выявляли надежность диагностики физиологических и патологических структур на яичниках с помощью сонографии и результаты одновременно сопоставляли пальпаторно анализом двух исследуемых и анализом яичников коров, умерщвленных до 20 часов после выполненных исследований. При выявлении фолликулов меньше 5 мм надежность пальпаторного и сонографического иссле-

дований весьма низкая, повышается она у фолликулов размером 6 - - 10 мм, у которых сонографией было выявлено 88,9 % фолликулов при прогнозе 94,1 %, между тем как пальпаторно установили 44,4 % и 41,7 % от данных фолликулов при прогнозе 45,7 % и 57,7 %. Сонографически полностью были выявлены фолликулы больше 10 мм, пальпаторно установили не более двух пятых упомянутых фолликулов. Чем больше фолликулярные формации, тем точнее их выявление. Фолликулярные кисты больше 25 мм были всеми исследуемыми определены надежно. При выявлении желтых тел CL меньше 10 мм сонографически определили 57 % при высоком прогнозе, пальпаторно - 64,3 % и 35,7 процента при прогнозе 40,9 % и 55,6 %. У желтых тел больше 10 мм сонографически определили все 26 тел, пальпаторно - 24 и 19 при более низком прогнозе по сравнению с сонографическим исследованием. Для высвления полостей внутри желтых тел при заполнении прозрачной жидкостью более надежной оказалась сонография, при заполнении коагулятом крови полость была выявлена пальпаторным исследованием. Ультрасонография оказалась весьма надежным методом для диагностики физиологических или патологических овариальных структур. Чтобы добиться предельно точного диагноза, необходимо исследование полового аппарата в целом с помощью обоих методов исследования.

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