The Veterinary Journal, 2000, 159 :161-170

RELATIVE ACCURACY OF THE IDENTIFICATION OF OVARIAN STRUCTURES IN THE COW BY ULTRASONOGRAPHY AND PALPATION PER RECTUM

Ch. Hanzen (1), M. Pieterse (2), O. Scenczi (3) and M. Drost (4)

(1) Department of Obstetrics and Reproductive Pathology, Faculty of Veterinary Medicine, State University of Liège, B41 Sart Tilman, B-4000 Liège, Belgium
(2) Department of Herd Health and Reproduction, Faculty of Veterinary Science, Utrecht University, PO Box 80,151, 3508 TD Utrecht, The Netherlands
(3) Department of Obstetrics and Reproduction, Faculty of Veterinary Science, University of Jozsef Nandor, Istvan ut 2, H-1078 Budapest, Hungary
(4) Department of Large Animal Clinical Sciences, College of Veterinary Medicine University of Florida, Gainesville FL 32610-0136, USA

1. Introduction

In the reproductive management of dairy and beef cattle, it is desirable to have heifers calving at 24 months of age, and to maintain the number of days open at 100 or less. To meet these goals, veterinarians should examine cows that have not been observed in oestrus after insemination at an early time to confirm the absence of pregnancy. Palpation of the reproductive tract is the most common approach to pregnancy diagnosis, as opposed to the use of a progesterone assay or ultrasonography. It is important to differentiate between non-cyclal (true anoestrus) and cyclic cows that have not been detected in oestrus. The latter is a pre-requisite to the rational use of treatment aimed at synchronization of oestrus and for fixed time insemination (Eddy, 1977; Thatcher *et al.*, 1997).

Early pregnancy diagnosis is also important in reproductive management in order to rebreed the non-pregnant animals as soon as possible. Treatment for cystic ovarian degeneration largely depends on accurate diagnosis (Dobson & Nanda, 1992). An accurate examination of the reproductive tract per rectum is also necessary to a synchronization programme (Hardin, 1984). Finally, it is important to assess the effect of the superovulatory treatment by estimating the number of corpora lutea and anovulatory follicles before attempting non-surgical collection of embryos.

The foregoing shows the importance of the accurate transrectal palpation. This review compares the potential and the limitations of transrectal palpation of the reproductive tract with that the determination of milk or plasma progesterone levels determination, ultrasonography and direct examination of the ovaries after slaughter.

2. Palpable and ultrasonographical characteristics of physiological and pathological ovarian structures

Bovine ovaries are spherical or oblong structures measuring 2 to 5 cm in length, 1.5 to 4 cm in height, and 1.5 to 3 cm in width. Follicles and corpora lutea are normal physiological structures whereas follicular or luteal cysts, and less frequently adhesions, parovarian cysts, abscesses and tumors, are abnormal.

2.1. Physiological structures - palpable characteristics

During prooestrus and oestrus, the normal palpable follicle is a round, smooth structure with a fairly firm consistency.with a diameter ranging from 7 to 20 mm. Except for nulliparous heifers the follicle generally represents only a small portion of the ovary. Fluctuations can be palpated and a ovulation approaches the follicle becomes soft. The increased tone of the uterus and the presence of mucus aid in recognizing these stages of the oestrous cycle. By retraction of the cervix and compression of the vagina, mucus can be expelled from the vagina. Pus-tinged mucus usually indicates some degree of vaginal, cervical or uterine infection. Watery mucus may be seen in cows with cystic follicles. Slightly opaque, thick, tenacious mucus is most commonly seen around day 17 to 18 of the oestrous cycle, or in animals that are ready to calve.

After ovulation, during metoestrus, the collapsed follicle is palpable as a depression but contains very little blood compared to that of the mare. Unless a cow has been palpated daily and the examinator knows exactly where the follicle was located, the ovulatory depression may be difficult to recognize, especially more than 12 hours after ovulation. When the ovulatory depression cannot be palpated, the ovaries can be classified as NSO (no structures on the ovaries).and at this time there will be uterine tone due to oedema. In addition, the mucus may be blood-tinged and not as cohesive as during oestrus. The corpus haemorrhagicum (developing, growing, young corpus luteum) is present from day 1 to day 5. It is rather diffi cult to identify, especially in the early stages. A soft papilla < 1 cm in height can be felt as a crepitant structure and can be differentiated from a follicle because its surface is less firm and smooth, and it is smaller than either a mature follicle or a mature corpus luteum.

During dioestrus the mature corpus luteum reaches a maximum size of 20 to 30 cm between days 6 and 18 after ovulation. The consistency has been described as "liver-like" (Zemjanis, 1970; Studer, 1975; Belling, 1986). An ovulation papilla or crown protrudes from the surface of the ovary. At the stage of maximum development, the corpus luteum often occupies more space than the remainder of the ovarian tissue.and has a clean outline. Follicles can generally be palpated in the presence of the corpus luteum. The uterus is pliable but not firm, and mucus cannot be expressed from the vagina. The corpus luteum of pregnancy is rounded and embedded in the ovary. Sometimes, it feels more rounded and smooth than the cyclical corpus luteum. A persistent corpus luteum is never observed except in pregnancy or where there are uterine lesions such as pyometra or congenital segmental hypoplasia (e.g. uterus unicornis). Corpora lutea with a fluid filled central cavity (lacuna) have been observed in an average 30 % of slaughter specimens (McEntee, 1958), by transrectal palpation (Morrow *et al.*, 1966, Donaldson & Hansel, 1968; Kaneda, 1980) and by ultrasonography (Kito *et al.*, 1986; Pierson & Ginther, 1987, Kastelic *et al.*, 1990a). The regressing corpus luteum at day 18 becomes increasingly firm (Zemjanis, 1970; Studer, 1975) and can be palpated until 1 to 3 days after the next ovulation. From then on, it is referred to as a corpus albicans.

2.2. Physiological structures - ultrasonographical features

Regardless of the stages of the oestrous cycle or the day post partum, follicles can readily be distinguished by ultrasonography (Pierson & Ginther 1984a,1988a; Edmondson *et al.*, 1986; Kahn & Leidl, 1989; Pieterse, 1989). They appear as dark, sometimes delineated, anechogenic structures, surrounded by a fine wall and with a diameter usually < 25 mm. Due to lack of attenuation of the ultrasound wave, an hyperechogenic border is usually seen at the distal zone of the follicle. Ultrasonography will however only show the follicular cavity, thus the real diameter of the follicle is often underestimated by 2 to 3 mm (Quirk *et al.*, 1986). Nevertheless, there is a strong correlation between anatomical and ultrasonographic measurements for follicles with a diameter > 3 mm (Pierson & Ginther, 1987). According to Pierson and Ginther (1984a) and Edmondson *et al.* (1986) it is possible to detect follicles with a diameter ≥ 6 mm with a 3.5 MHZ transducer and follicles with a diameter ≥ 2 mm with a 5 MHZ transducer. Follicles < 5 mm can be confused with cross sections of ovarian blood or lymph vessels (Pieterse, 1989). Precise counting of 2 to 5 mm follicles by ultrasonography is very inaccurate (Pieterse *et al.*, 1990). The presence of several follicles or a corpus luteum can cause compression of the follicles making them appear irregular in outline (Pierson & Ginther, 1988b).

During metestrus, ovulation can be indirectly detected with ultrasonography by the disappearance of the preovulatory follicle or by its quick decrease in size (Pierson & Ginther, 1984a, 1988a). It is possible to detect the corpus haemorrhagicum with a 5 MHZ transducer on the first day after oestrus although the routine examination usually takes place between days 3 and 5 after ovulation (Kastelic *et al.*, 1990a). The developing corpus haemorrhagicum is a poorly delineated, irregular, greyish-black structure with several echogenic spots within the ovary. A crown-like ovulatory papilla is occasionally seen (Pierson & Ginther 1984a; Omran *et al.*, 1988, Edmondson *et al.*, 1986; Pieterse, 1989; Kastelic *et al.*, 1990a; Ribadu *et al.*, 1994).

The echogenicity of luteal structures increases during dioestrus. A mature corpus luteum appears as a greyish echogenic area with a line of demarcation visible between it and the ovarian stroma. The ultrasonographic appearance of the corpus luteum is very similar in pregnant and non-pregnant animals (Pierson & Ginther, 1984a; Omran *et al.*, 1988; Edmondson *et al.*, 1986; Pieterse, 1989; Kastelic *et al.*, 1990a; Ribadu *et al.*, 1994) and is impossible to distinguish a particular day of dioestrous (Pieterse, 1989). According to a number of studies (Kito *et al.*, 1986; Pierson & Ginther 1987; Kastelic *et al.*, 1990a), the ultrasound appearance of the central cavity of a fluid filled corpus luteum can be similar to that of a follicle (Kahn & Leidl, 1989). Usually, it is less regular, surrounded by luteal tissue, rounded and presents more often highly echogenic bands or echogenic spots corresponding respectively to fibrin-like strands and accumulations of haemolyzed blood (Pierson & Ginther, 1987). The central cavity, or lacuna, of the corpus luteum may have a diameter of between 2 and 22 mm. According toKito *et al.*(1986), 31% and 24% of these lacunae have a diameter of 7 to 9 mm, or of 10 mm or more, respectively. Kastelic *et al.(*1990a) repoeted that 35% of these cavities have a diameter > 10 mm, with 52% ranging from 6 to 10 mm, and 13% from 2 to 5 mm with no difference between pregnant and non-pregnant animals This cavity may regress or persist through the cycle. Generally, the diameter is greatest on day 10 after ovulation, regardless of the maximum diameter (Kastelic *et al.*, 1990b), with.the largest cavities detectable for a longer period of time. Cavities > 10 mm take more than 21 days to disappear (Kito *et al.*, 1986). On average, smaller cavities regress within one week. Some authors have observed such cavities to persist until 20 or even 40 days of pregnancy (Kito *et al.*, 1986; Kastelic *et al.*, 1990a). In non-pregnant animals, the amount of luteal tissue is independent of the diameter of the lacuna. But in pregnant animals, the area of luteal tissue is considerably greater in the presence of a large cavity (>80 sq mm) as compared with a small (3 to 20 sq mm) or a medium (21 to 80 sq mm) sized one (Kastelic *et al*., 1990a). The presence or the size of the cavity has no influence on serum progesterone concentration (Ribadu et al., 1994, Kito et al., 1986, Quirk et al., 1986, Kastelic et al., 1990b), or on the delay of the return to oestrus, (Kaneda et al., 1980; Kito et al., 1986), or on the potential of the animal to become pregnant. Moreover there is also no tendency for a cavity to recur from one cycle to another in the same animal (Kito et al., 1986; Kastelic et al., 1990a). In a regressing corpus luteum, the line of demarcation is faint due to the slight difference in echogenicity between tissues (Pierson & Ginther, 1984a; Kastelic *et al.*, 1990a).

2.3. Pathological structures : ovarian cysts

A cyst is a fluid-filled space > 25 mm in diameter in an ovary that can persist for more than 10 days in the absence of a corpus luteum (Bierschwal et al., 1975; Seguin, 1980). The infrequent presence of a cyst-like structure in conjunction with a corpus luteum is usually non-pathological. The two types of ovarian cysts are the follicular and the luteal cyst. Based on progesterone concentrations or dissection of ovaries in different studies, the occurrence of luteal cysts ranges from 30 to 76% of cases (Zemjanis, 1970; Al-Dahash et al., 1977; Dobson et al., 1977; Farin et al., 1992).

On transrectal palpation follicular cysts have a thin wall, feel fluctuant, and are likely to rupture during manipulation. Luteal cysts on the other hand, have a thicker wall made up of luteal tissue, which makes them feel firmer. The mean plasma progesterone concentration of a cow with a luteal cyst has been reported to be 3.6 ng/mL (Ribadu *et al*., 1994) with a range from 3.0 to 10.4 ng/mL (Leslie & Bosu, 1983). These values are similar to values reported during the luteal phase of the oestrous cycle.

The follicular cyst presents the same ultrasonographic characteristics as a follicle. Its diameter is > 25 mm and the thickness of the wall < 3 mm (Edmondson *et al*., 1986; Carroll *et al*., 1990). Its configuration is spherical, oval or polygonal depending on the relative pressure exerted by other structures on the ovary (Kahn & Leidl, 1989). The spherical shape is usually seen when there is only one cyst. Follicular cysts are anechogenic. As for the follicle, a hyperechogenic zone can be seen at the distal wall of the luteal cyst due to the presence of luteal tissue. Some authors have proposed to base the differential diagnosis between a follicular and a luteal cyst on the thickness of the cyst wall, whereby the thickness of the wall of a follicular cyst is ≤ 3 mm, and the thickness of the wall of a luteal cyst is > 3 mm (Edmondson *et al*., 1986; Carroll *et al*., 1990). The anechogenic cavity sometimes presents additional echogenic strings (Pieterse, 1989).

Differential diagnosis between a corpus luteum with a cavity and a luteal cyst can be based on the following criteria (Kahn & Leidl, 1989):

- the lacuna of the corpus luteum usually has a diameter of less than 25 to 30 mm ;
- the thickness of the surrounding luteal tissue ranges from 5 to 10 mm;
- the cavity of a luteal cyst is usually regular and often shows some thin white lines (trabeculae);
- the edge of the luteal tissue is less regular than that of a follicle (Pieterse, 1989);
- luteal tissue usually is wider than the cavity.
- the lacuna of the corpus luteum tends to regress after day 10 of the oestrous cycle (Kastelic *et al*., 1990a).

3. Comparison of diagnostic methods for ovarian structures

The reliability of the diagnostic method and the accuracy of the diagnosis can be evaluated by using a 2x2 table for which data have to be obtained for all four cells (Smith, 1991; Table I).

Two parameters are traditionally used to describe the characteristics of a particular diagnostic method. The sensitivity (Se) can be defined as the likelyhood of a positive test result in animals known to have a particular normal or abnormal ovarian structure. For example, for a population of cows, sensitivity can determine the percentage of animals with a corpus luteum determined by a certain diagnostic method. An equation describing the sensitivity is: a/(a+c)x100.

Conversely, the specificity (Sp) is defined as the likelihood of a negative test result in animals known to lack the particular structure and is giving the equation d/(d+b)x100.

Although the sensitivity and specificity of the diagnostic method are important, practitioners should be more concerned with the predictive value of a diagnostic method, i.e. the probability that the diagnosis accurately reflects the true ovarian status. The positive predictive value (+PV) would then be the probability of the presence of an ovarian structure in an animal ie a/(a+b)x100 and the negative predictive value (-PV) being the probability that an animal does not have the particular ovarian structure as diagnosed correctly by the clinician ie d/(c+d)x100.

Table I : Outcome of Diagnostic Tests

	Result	
Diagnosis	Positive	Negative
Positive	a (true positive)	b (false positive)
Negative	c (false negative)	d (true negative)

3.1. Diagnosis of follicles

Diagnosis of follicles < 10 mm by palpation per rectum can be inaccurate, and may depend on the overall size of the ovary, the degree of relaxation of the rectal wall, body score of the animal, and the skill of the examinor. In one study, 22 to 28% of follicles of at least 10 mm were detected by palpation, whereas ultrasonography detected 76 to 89% of the follicles actually present (Pieterse *et al.*, 1990; Ribadu *et al.*, 1994). The diagnosis of a follicle > 10 mm is more accurate by ultrasonography than by palpation (Kahn & Leidl, 1986; Table II; Pieterse *et al.*, 1990).

Ultrasonographic determination of the presence of follicles < 5 mm is difficult with a 5 MHz probe (Pieterse *et al*., 1990). Accuracy can be improved by using a 7.5 MHZ transducer or by analyzing video recordings (Quirk *et al.*, 1986; Sirois & Fortune, 1988). Ultrasonography is capable of detecting 34% of follicles with a diameter of between 5 and 10 mm (Pieterse *et al.*, 1990), and is more accurate than palpation (Kahn & Leidl, 1986). Compared with palpation, ultrasonography offers the advantage of being able to measure the inner diameter of the follicle. Some authors obtained an 80 to 97% correlation between diameters measured with a 5 MHZ transducer and those obtained with a microscope (Pierson & Ginther, 1987).

3.2. Diagnosis of luteal structures

The presence and number of luteal structures, or their absence, can be determined by palpation, and their functional status implied by size and consistency. Inability to detect functional luteal tissue could result in failure to treat a significant number of cows capable of responding to a luteolytic agent.

The predictive values of the presence or absence of a corpus luteum as determined by palpation have been quite similar in several studies in which determination of progesterone concentrations was compared with palpation per rectum {78% (range 76 to 90), versus 75% (range 61 to 94) respectively; Table III}. Conversely, the sensitivity is greater (92%, range 71 to 90) than the specificity (65%, range 50 to 96) (Boyd & Munro, 1979; Watson & Munro, 1980; Mortimer *et al.*, 1983; Ott *et al.*, 1986; Pathiraja *et al.*, 1986; Kelton *et al.*, 1988; 1991; Ribadu *et al.*, 1994).

Compared with the dissection of ovaries collected at slaughter, the accuracy of palpation for the presence of a mature corpus luteum has reported as 86% (Kahn & Leidl, 1986; Pieterse *et al.*, 1990; Table II). Using the same methods of comparison, the accuracy of determining the absence of a corpus luteum by palpation per rectum was 85% (Pieterse *et al.*, 1990). Regression of the corpus luteum is difficult to ascertain by palpation with a positive predictive value of 64% (Pieterse *et al.*, 1990). Other studies confirmed that it is easier to determine the presence rather than the absence of the corpus luteum. The diagnosis of the presence of a corpus luteum of a size > 1 cm appears to be accurate in 89% (125/141) of cases. Of 61 cases of missed diagnoses, 44.4% of follicles > 7.5 mm and 15% of corpora lutea > 10 mm were not detected. Moreover, 10% of the corpora lutea were mistaken for follicles or cysts (Dawson, 1975). In a similar study, 40% of 81 errors reported after palpation were contributed to undetected corpora lutea, 17% to corpora lutea identified as follicles, and 16% to incorrect assessment of the status of the corpora lutea (El-Wishy & Ghoneim, 1995). Others (Landsverk & Kalberg, 1988) correctly classified the ovaries as prooestrous, oestrous, metoestrous and dioestrous in 54, 60, 72 and 90% of cases, respectively. Similar results were obtained by other authors (El-Wishy & Ghoneim, 1995) who correctly classified 242 ovaries as prooestrous, eostrous, metoestrous and dioestrous in 27, 71, 41 and 85% of cases, respectively.

Compared to dissection, the positive predictive value of a mature corpus luteum diagnosed by ultrasonography (CL2, Table IV) is lower (87%) than the negative predictive value (92%); (Kahn & Leidl, 1986; Pieterse *et al.*, 1990; Ribadu *et al.*, 1994). The correct diagnosis of a corpus haemorrhagicum by ultrasonography (positive predictive value 33%) or regressing corpus luteum (positive predictive value 57%) is difficult (Pieterse *et al.*, 1990).

Collectively, the studies show that the positive and negative predictive values obtained by ultrasonography are higher than those obtained by palpation. With either method it is difficult to diagnose a growing or a regressing corpus luteum. The difficulty to detect a corpus haemorrhagicum by palpation is due to its relatively small size and soft consistency. A corpus haemorrhagicum is also poorly echogenic. Conversely, identification of old (regressing or regressed) corpora lutea is slightly, although not significantly, better by palpation than by ultrasonography (Pieterse *et al.*, 1990) because the echogenicity of such firm corpora lutea resembles that of ovarian stroma. Differences may further be attributed to types of transducers (5.0 vs 7.5 MHZ), the approach (transrectal vs transvaginal) and the subjectivity of the operators.

3.3. Number of corpora lutea

Accurate estimation of the number of corpora lutea is difficult when the number exceeds five or six, or when follicles are simultaneously present. In a study of 20 cows superovulated with eCG, the number of corpora lutea was significantly underestimated by palpation when more than nine corpora lutea were present. Transrectal palpation also failed to correctly identify the number of follicles > 10 mm when there were more than four follicles present (Guay & Bedoya, 1981).

3.4. Size of the corpus luteum

Determination of the size of the corpus luteum can be important. Indeed, it has been reported that the corpus luteum is largest at the period of maximal luteal function (Stabenfeldt *et al.*, 1969; Shemesh *et al.*, 1971). Moreover, a decrease in the size of the corpus luteum coincides with decrease in the plasma progesterone concentration (Quirk *et al.*, 1986). Diameters of mature corpora lutea range from 19 to 35 mm (Roberts, 1986) and weights from 2.17 to 8.86g (Ribadu *et al.*, 1994). It is easier to measure the surface area, hence the size, of the corpus luteum by ultrasonography than to estimate it by transrectal palpation. The size of the corpus luteum determined by ultrasonography is strongly correlated (r= 0.68 to 0.85) to milk progesterone concentrations (Sprecher *et al.*, 1989; Rajamahendran & Taylor, 1990; Ribadu *et al.*, 1994). A luteal structure > 11 mm usually correlates with a progesterone concentration greater than 5 ng/mL (Sprecher *et al.*, 1989). Nevertheless, such a correlation appears to depend on the reproductive status of the animal. Thus, a strong and significant correlation exists between the surface area of the luteal tissue and plasma concentration during the first half of the oestrous cycle in non-pregnant animals (r=0.73) and in animals who become pregnant (r=0.85). A similar correlation exists during the second half of the cycle only in non-pregnant animals (r=0.77) but for unknown reasons, has not been observed for heifers who become pregnant following that cycle (r=0.33) (Kastelic *et al.*, 1990b). It has also been demonstrated that, after luteolysis, physical regression of the corpus luteum is slower than the decrease in progesterone production. The surface area of the image of the corpus luteum on ultrasonography decreases daily by 20% and the progesterone concentration is reduced by 28% (Kastelic *et al.*, 1990b). Finally, there is also a linear relationship between the weight of the mature corpus luteum and plasma progesterone concentration (r=0.87) (Ribadu *et al.*, 1994). Similar correlations have not been observed with transrectal palpation (Watson & Munro, 1980; Mortimer *et al.*, 1983).

3.5. Consistency of the corpus luteum

Consistency of the corpus luteum can only be evaluated by palpation. A positive correlation has been reported between the soft corpus haemorrhagicum and the firm regressing corpus luteum as determined by palpation and plasma progesterone concentrations. Such a correlation is not significant for the mature corpus luteum and there is no correlation between the size of the corpus luteum and its consistency. Collectively these studies show that determination of consistency has limited value for assessing the functional status of the corpus luteum (Watson & Munroe, 1980).

3.6. Diagnosis of cysts

A definitive differential diagnosis between follicular and luteal cysts can be helpful. Treatment of luteal cysts with prostaglandin (PG) F2α results in a shorter interval to the next oestrus than treatment with either gonadotropin releasing hormone alone or treatment with gonadotropin releasing hormone followed by prostaglandin PGF2α nine days later (Kesler *et al* 1978; Dinsmore *et al.*, 1989).

The accuracy of palpation or ultrasonography for the diagnosis of an ovarian cyst can be confirmed by measuring peripheral plasma progesterone concentration and a wide range of concentrations has been reported (Table V). On average, the positive predictive values for follicular cysts diagnosed by palpation (Dobson *et al.*, 1977; Sprecher *et al.*, 1989; Farin *et al.*, 1992) or by ultrasonography (Carroll *et al.*, 1990; Farin *et al.*, 1992) are 66% (range 39 to 78) and 74% (range 60 to 78), respectively. Conversely, the positive predictive value for luteal cysts diagnosed by palpation (Dobson *et al.*, 1977; Sprecher *et al.*, 1989; Carroll *et al.*, 1990; Farin *et al.*, 1992) or by ultrasonography (Carroll *et al.*, 1990; Farin *et al.*, 1992) are 66% (range 35 to 87) and 85% (range 50 to 90), respectively. Variations observed between different studies may be due to the frequency of the transducer used, but also to the considerable variation in the patterns of luteal cysts (Carroll *et al.*, 1990) or in the density of luteal tissue which range from an irregular pattern to a fairly well defined border (Al-Dahash *et al.*, 1977; Farin *et al.*, 1992). In a luteal cyst, the luteal tissue can be accompanied by a low concentration of plasma progesterone (Carroll *et al.*, 1990). Differences between clinicians are not a common feature although there is more agreement between diagnosis of luteal cysts than of follicular cysts (Farin *et al.*, 1992).

The use of on-farm milk progesterone kits do not appear to improve the accuracy of diagnosis by palpation (Dobson & Nanda, 1992). However, the combined use results in a higher predictive value, specificity and sensitivity than reliance on palpation alone (Sprecher *et al.*, 1988). In a separate study, the presence and the type of ovarian cysts was correctly diagnosed in 52% of the cases and the ultrasonographic classification was accurate in 93% (Ribadu *et al.*, 1994). Based on milk progesterone concentration (Nakao *et al.*, 1983), the follicular cysts can be correctly diagnosed by manual palpation in 65% of the time. Nineteen percent of luteal cysts and 16% of corpora lutea with lacunae were incorrectly diagnosed as follicular cysts (Nakao *et al.*, 1983).

4. Conclusions

Veterinarians involved in the management of bovine reproduction are frequently asked to assess ovarian status. They must be able to differentiate between physiological and pathological structures on the ovary and for accurate diagnosis, the size of the ovaries and the tone of the uterus have to be evaluated in relationship to the day post partum and the stage of the oestrous cycle. In addition, veterinarians must have the reproductive history of the animal(s) including oestrus detection, progesterone profiles, and observations made by the farmer and/or the veterinarian, as well as ultrasonographic findings. Each practitioner can improve his or her tactile skills with the aid of the supplemental information and the use of slaughter specimens has been found to be very useful for improving palpation and scanning skills. Large individual variations in size and consistency of ovarian structures make for difficult differentiation if the diagnosis is based on a single examination. In these cases, sequential examination will improve the accuracy of the diagnosis which may be further enhanced by the use of other modalities including ultrasonography and determination of progesterone concentrations.

5. Réferences

- AL-DAHASH, S.Y.A. & DAVID, J.S.E. (1977). Histological examination of ovaries and uteri from cows with cystic ovaries. *Veterinary Record.* **101**, 342-347.
- BELLING, T.H. (1986). The look and feel of normal bovine ovaries. *Veterinary Medecine*. **81**,455-463.
- BIERSCHWAL, C.J., Garverick H.A., Martin C.E., Youngquist, R.S., Cantley, T.C. & Brown, M.D. (1975). Clinical responses of dairy cows with ovarian cysts to GnRH. *Journal of Animal Science*. **41**, 1660-1665.
- BOYD, H. & MUNRO, C.D. (1979). Progesterone assays and rectal palpation in pre-service management of a dairy herd. *Veterinary Record*. **104**, 341-343.
- CARROLL, D.J., PIERSON, R.A., HAUSER, E.R., GRUMMER, R.R. & COMBS, D.K. (1990). Variability of ovarian structures and plasma progesterone profiles in dairy cows with ovarian cysts. *Theriogenology*. **34**, 349-370.
- DAWSON, F.L.M. (1975). Accuracy of rectal palpation in the diagnosis of ovarian function in the cow. *Veterinary Record*. **96**, 218-220.
- DINSMORE, R.P., WHITE, M.E. & GUARD, C.L. (1989). Effect of gonadotropin-releasing hormone on clinical response and fertility in cows with cystic ovaries, as related to milk progesterone concentration and days after parturition. *Journal of American Veterinary Medical Association.* **195**, 327-330.
- DOBSON, H., RANKIN, JEF. & WARD, WR. (1977). Bovine cystic ovarian disease: plasma hormone concentrations and treatment. *Veterinary Record*. 101, 459-461.
- DOBSON, H. & NANDA, A.S. (1992). Reliability of cysts diagnosis and effect of energy status on LH released by estradiol or GnRH in cows with ovarian cysts. *Theriogenology*. **37**, 465-472.
- DONALDSON, L.E. & HANSEL, W. (1968). Cystic corpora lutea and normal and cystic Graafian follicles in the cow. *Australian Veterinary Journal*. **44**, 304-308.
- EDDY, R.G. (1977) Cloprostenol as a treatment for nonvisible oestrus and cystic disease in dairy cows. *Veterinary Record*. **100**, 62-65.
- EDMONDSON, A.J., FISSORE, R.A., PASHEN, R.L. & BONDURANT, R.H. (1986). The use of ultrasonography for the study of the bovine reproductive tract. 1. Normal and pathological ovarian structures. *Animal Reproduction Science*. **12**, 157-165.
- EL-WISHY, A.B. & GHONEIM, I.M. (1995). Ovarian function in Buffalo cows with special reference to the accuracy of rectal palpation. *Reproduction Domestic Animal*. **30**, 39-41.
- FARIN, P.W., YOUNGQUIST, R.S., PARFET, J.R. & GARVERICK, H.A. (1992). Diagnosis of luteal and follicular ovarian cysts by palpation per rectum and linear-array ultrasonography in dairy cows. *Journal of American Veterinary Medical Association* . **200**, 1085-1089
- GUAY, P. & BEDOYA, M. (1981). A study of the equivalence between rectal palpation, laparoscopy, laparotomy and ovarian dissection for evaluation of the ovarian response of PMSG-superovulated cows. *Canadian Veterinary Journal*. **22**, 353-355.
- HARDIN, D.R. (1984). The benefits of palpation before synchronization. *Agri-Practice*. **5**, 29-32.
- KAHN, W. & LEIDL, W. (1986). Diagnosis of ovarian function in the cow by sonography. *Tierarztliche Umschau*. **41**, 3-12.
- KAHN, W. & LEIDL, W. (1989). Ultrasonic characteristics of pathological conditions of the bovine uterus and ovaries. In *Diagnostic ultrasound and animal reproduction*. Pp 53-65, eds M.M. Taverne & A.H. Willemse, Kluwer Academic Publisher.
- KANEDA, Y., DOMEKI, I. & NAKAHARA, T. (1980). Effects of removal of cystic fluid from cystic corpus luteum on luteinization and conception rate in dairy heifers. *Japanese Journal of Animal Reproduction*. **26**, 37-42.

- KASTELIC, J.P., PIERSON, R.A. & GINTHER, O.J. (1990a). Ultrasonic morphology of corpora lutea and central luteal cavities during the estrous cycle and early pregnancy in heifers. *Theriogenology*. **34**, 487-498.
- KASTELIC, J.P., BERGFELT, D.R. & GINTHER, O.J. (1990b). Relationship between ultrasonic assessment of the corpus luteum and plasma progesterone concentration in heifers. *Theriogenology.* **33**, 1269-1278.
- KELTON, D.F., WHITE, M.E., HODGES, R.J., GUARD, C.L., POWERS, P.M., DINSMORE, R.P., STEHMAN, S.M., HILLMAN, R.B. & YODER, S.S. (1988). The relationships among palpator experience, milk progesterone concertation and estrus and fertility in cows with palpable corpora lutea treated with cloprostenol. *Cornell Vet.*. **78**, 105-112.
- KELTON, D.F., LESLIE, K.E., ETHERINGTON, W.G., BONNETT, B.N. & WALTON, J.S. (1991). Accuracy of rectal palpation and a rapid milk progestreone enzymeimmunassay for determining the presence of a functional corpus luteum in subestrous dairy cows. *Canadian Veterinary Journal*. **32**, 286-291.
- KESLER, D.J., GARVERICK, H.A. & CAUDLE, A.B. (1978). Clinical and endocrine responses of dairy cows with ovarian cysts to GnRH and PGF2a. *Journal of Animal Science*. **46**, 719-725.
- KITO, S., OKUDA, K., MIYAZAWA, K. & SATO, K. (1986). Study of the appearance of the cavity in the corpus luteum of cows by using ultrasonic scanning. *Theriogenology*. **25**, 325-333.
- KRUIP, T.H.A.M. & DIELEMAN, S.J. (1982). Macroscopic classification of bovine follicles and its validation by micropmorphological and steroid biochemical procedures. *Reproduction Nutrition Developpement*. **22**, 465-469.
- LANDSVERK, K. & KARLBERG, K. (Dublin 1988). Accuracy of rectal palpation in the diagnosis of ovarian function in the cow. *Proceedings of 11th International Congress on Animal Reproduction and A.I*. p.99.
- LESLIE, K.E. & BOSU, W.T.K. (1983). Plasma progesterone concentrations in dairy cows with cystic ovaries and clinical res ponses following treatment with fenprostalene. *Canadian Veterinary Journal*. **24**, 352-356.
- MARION, G.B., GIER, H.T. & CHOUDARY, J.B. (1968). Micromorphology of the bovine ovarian system. *Journal of Animal Science*. **27**, 451-465.
- McENTEE, K. (1958) Cystic corpora lutea in cattle. *International Journal of Fertility*. **3**, 20-128.
- MORROW, D.A., ROBERTS, S.J., McENTEE, K. & GRAY, H.G. (1966). Postpartum ovarian activity and uterine involution in dairy cattle. *Journal of American Veterinary Medical Association*. **149**, 1596-1609.
- MORTIMER, R.G., OLSON, J.D., HUFFMAN, E.M., FARIN, P.W., BALL, L. & ABBITT, B. (1983). Serum progesterone concentration in pyometric and normal postpartum dairy cows. *Theriogenology.* **19**, 647-653.
- NAKAO, T., SUGIHASHI, A., SAGA, N., TSUNODA, N. & KAWATA, K. (1983). Use of milk progesterone enzyme immunoassay for differential diagnosis of follicular cyst, luteal cyst and cystic corpus luteum in cows. *American Journal of Veterinary Research*. **44**, 888-890.
- OMRAN, S.N., AYLIFFE, T.R. & BOYD, J.S. (1988). Preliminary observations of bovine ovarian structures using B-mode realtime ultrasound. *Veterinary Record*. **122**, 465-469.
- OTT, R.S., BRETZLAFF, K.N. & HIXON, J.E. (1986). Comparison of palpable corpora lutea with serum progesterone concentration in cows. *Journal of American Veterinary Medical Association*. **188**, 1417-1419.
- PATHIRAJA, N., OYEDIPE, E.O., VOH, A.A. & DAWUDA, P.M. (1986). Accuracy of rectal palpation in the diagnosis of corpora lutea in Zebu cows. *British Veterinary Journal*. **142**, 467-471.
- PIERSON, R.A. & GINTHER, O.J. (1984a). Ultrasonography of the bovine ovary. *Theriogenology.* **21**, 495-504.
- PIERSON, R.A. & GINTHER, O.J. (1984b). Ultrasonography for the detection of pregnancy and study of embryonic development in heifers. *Theriogenology*. **22**, 225-233.
- PIERSON, R.A.& GINTHER, O.J. (1987). Reliability of diagnostic ultrasonography for identification and measurement of follicles and detecting the corpus luteum in heifers. *Theriogenology*. **28**, 929-936.
- PIERSON, R.A. & GINTHER, O.J. (1988a). Follicular populations during the estrus cycle in heifers. 3. Time of selection of the ovulatory follicle. *Animal Reproduction Science*. **16**, 81-95.
- PIERSON, R.A. & GINTHER, O.J. (1988b). Ultrasonic imaging of the ovaries and uterus in cattle. *Theriogenology*. **29**, 21-37.
- PIETERSE, M.C., KAPPEN, K.A., KRUIP, TH.A.M. & TAVERNE, M.A.M. (1988). Aspiration of bovine oocytes during transvaginal ultrasound scanning of the ovaries. *Theriogenology*. **30**, 751-762.
- PIETERSE, M.C. (1989). Ultrasonic characteristics of physiological structures on bovine ovaries. In *Diagnostic Ultrasound and Animal Reproduction*, eds M.M. Taverne & A.H. Willemse, pp 53-65, Kluwer Academic Publisher.
- PIETERSE, M.C., TAVERNE, M.A.M., KRUIP, Th.A.M. & WILLEMSE, A.H. (1990). Detection of corpora lutea and follicles in cows: A comparison of transvaginal ultrasonography and rectal palpation. *Veterinary Record*. **126**, 552-554.
- QUIRK, S.M., HICHEY, G.J. & FORTUNE, J.E. (1986). Growth and regression of ovarian follicles during the follicular phase of the oestrous cycle in heifers undergoing spontaneous and PGF 2a induced luteolysis. *Journal of Reproduction and Fertility*. **77**, 211-219.
- RAJAMAHENDRAN, R. & TAYLOR, C. (1990). Characterization of ovarian activity in postpartum dairy cows using

ultrasound imaging and progesterone profiles. *Animal Reproduction Science*. **22**, 171-180.
- RIBADU, A.Y., WARD, W.R. & DOBSON, H. (1994). Comparative evaluation of ovarian structures in cattle by palpation per rectum, ultrasonography and plasma progesterone concentration. *Veterinary Record*. **135**, 452-457.
- ROBERTS, S.J. (1986). Veterinary Obstetrics and Genital Disease. N.Y. Ithaca.
- SEGUIN, BE. (1980). Ovarian cysts in dairy cows. In*: Current Therapy in Theriogenology*, Ed.Morow DA, pp 199-204, Philadelphia, WB Saunders.
- SHEMESH, M., LINDNER, H.R. & AYALON, N. (1971). Competitive protein-binding assay of progesterone in bovine jugular venous plasma during the oestrous cycle. *Journal of Reproduction and Fertility*. **26**, 167-179.
- SIROIS, J. & FORTUNE, J.E. (1988). Ovarian follicular dynamics during the oestrous cycle in heifers monitored by real-time ultrasonography. *Biology of Reproduction*. **39**, 308-317.
- SMITH, R.D. (1991). Evaluation of Diagnostic Tests. *In Veterinary Clinical Epidemiology. A problem-oriented approach*. Butterworth Heinemann, pp. 29-43.
- SPRECHER, D.J., NEBEL, R.L. & WHITTIER, W.D. (1988). Predictive value of palpation per rectum vs milk and serum progesterone levels for the diagnosis of bovine follicular cysts and luteal cysts.*Theriogenology*. **30**, 701-709.
- SPRECHER, D.J., NEBEL, R.L. & WHITMAN, S.S. (1989). The predictive value, sensitivity and specificity of palpation per rectum and transrectal ultrasonography for the determination of bovine luteal status. *Theriogenology*. **31**, 1165-1172.
- STABENFELDT, G.H., EWING, L.L. & McDONALD, L.E. (1969). Peripheral plasma progsterone levels during the bovine oestrous cycle. *Journal of Reproduction and Fertility*. **19**, 433-442.
- STUDER, E. (1975). Palpation of the genital tract for prediction of estrus in the cow. *Veterinary Medicine/Small Animal Clinician* . 1337-1341.
- THATCHER, W.W., de la SOTA, R.L., SCHMITT, E.P.-J., DIAZ, T.C., BADINGA, L., SIMMEN, F.A., STAPLES, C.R. & DROST, M. (1996). Control and management of ovarian follicles in cattle to optimize fertility. *Reproduction Fertility and Development*. **8**, 203-217..
- WATSON, E.D. & MUNRO, C.D. (1980). A re-assessment of the technique of rectal palpation of corpora lutea in cows. *British Veterinary Journal*. **136**, 555-560.
- ZEMJANIS, R. (1970). *Diagnostic and Therapeutic Techniques in Animal Reproduction* 2nd Edition, p57, Baltimore, Williams and Wilkins.

6. Tables

Table II
Predictive values (+ PV) of manual palpation and ultrasonography (E) for predicting the presence of follicles smaller (F<) or larger (F>) than 10 mm compared to dissection (D) of ovaries

N	MHz			a	b	+ PV	
25		MP vs D	F<	7	18	28	Ribadu *et al.* (1994)
274		MP vs D	F<	59	215	22	Pieterse *et al.* (1990)
67		MP vs D	F>	48	19	72	Pieterse *et al*. (1990)
274	5	E vc D	F<	94	180	34	Pieterse *et al.* (1990)
25	7.5	E vs D	F>	19	6	76	Ribadu *et al.* (1994)
67	5	E vc D	F>	64	8	89	Pieterse *et al.* (1990)

a : presence of follicle correct; b: presence of follicle incorrect

Table III
Sensitivity (Se), specificity (Sp) and predictive (+ PV, - PV) values of manual palpation (MP) for predicting the presence of growing (CL1), mid-cycle (CL2 or regressing CL3) corpus luteum compared to progesterone evaluation (P) or dissection (D) of ovaries

N			a	b	c	d	+ PV	- PV	Se	Sp	
142	MP vs P	CL2	48	13	20	61	79	75	71	82	Boyd & Munro (1979)
82	MP vs P	CL2	47	9	8	18	84	69	85	67	Watson & Munro (1980)
252	MP vs P	CL2	176	9	19	48	95	72	90	84	Kelton *et al.* (1991)

192	MP vs P	CL2	176	16			92				Kelton *et al.* (1988)
75	MP vs P	CL2	57	18			76				Pathiraja *et al.* (1986)
137	MP vs P	CL2	119	18			87				Archbald *et al.* (1992)
68	MP vs P	CL2	17	2	3	46	90	94	85	96	Ribadu *et al.* (1994)
124	MP vs P	CL2	80	17	10	17	82	63	89	50	Ott *et al.* (1986)
54	MP vs P	CL2	25	6	9	14	81	61	74	70	Mortimer *et al.* (1983)
			745	108	69	204	79	75	92	65	**Total**
62	MP vs D	CL0			9	53		85			Pieterse *et al*. (1990)
9	MP vs D	CL1	4	5			44				Pieterse *et al.* (1990)
13	MP vs D	CL2	12	1			92				Kahn & Leidl (1986)
36	MP vs D	CL2	30	6			83				Pieterse *et al.* (1990)
11	MP vs D	CL3	7	4			64				Pieterse *et al.*(1990)

a : presence of corpus luteum correct; b: presence of corpus luteum incorrect
c: absence of corpus luteum correct; d absence of corpus luteum incorrect

Table IV
Sensitivity (Se), specificity (Sp) and predictive values (+ PV, - PV) of diagnosis of the absence (CL0) or the presence of growing (CL1), mid-cycle (CL2 or regressing (CL3) corpus luteum made by ultrasonography (E) compared to dissection (D) of ovaries

N	MHz			a	b	c	d	+ PV	- PV	Se	Sp	
62	5	E vs D	CL0			5	57		92			Pieterse *et al.* (1990)
9	5	E vs D	CL1	3	6			33				Pieterse *et al*. (1990)
36	5	E vs D	CL2	29	7			81				Pieterse *et al.* (1990)
13	5	E vs D	CL2	11	2			85				Kahn & Leidl (1986)
68	7.5	E vs D	CL2	19	0	1	48	100	98	95	100	Ribadu *et al*. (1994)
7	5	E vs D	CL3	4	3			57				Pieterse *et al* . (1990)

a : presence of corpus luteum correct; b: presence of corpus luteum incorrect
c: absence of corpus luteum correct; d absence of corpus luteum incorrect

Table V
Sensitivity (Se), specificity (Sp) and predictive values (+ PV, - PV) of diagnosis of follicular and luteal cysts made by manual palpation (MP) or ultrasonography (E) compared to progesterone test (P)

N	MHz		a	b	c	d	+ PV	- PV	Se	Sp	
Follicular cysts											
89		MP vs P	39	13	24	13	75	35	62	50	Spre cher *et al.*(1989)
23		MP vs P	18	5			78				Dobson *et al.* (1977)
47		MP vs P	11	17	6	13	39	68	65	43	Farin *et al.* (1992)
			68	35			66				**Total**
47	5	E vs P	14	4	3	26	78	90	82	87	Farin *et al.* (1992)
5	5	E vs P	3	2			60				Carroll *et al.* (1990)
Luteal cysts											
89		MP vs P	13	24	13	39	35	75	50	62	Sprecher *et al.* (1989)
10		MP vs P	4	6			40				Carroll *et al*. (1990)
68		MP vs P	59	9			87				Dobson *et al.* (1977)
47		MP vs P	13	6	17	11	68	39	43	65	Farin *et al* . (1992)
4	5	E vs P	2	2			50				Carroll *et al.* (1990)
47	5	E vs P	26	3	4	14	90	78	87	82	Farin *et al.* (1992)

a : presence of ovarian cyst correct; b: presence of ovarian cyst incorrect
c: absence of ovarian cyst correct; d: absence of ovarian cyst incorrect