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Progesterone concentration when the future ovulatory follicle and corpus luteum are located in ipsilateral or contralateral ovaries in heifers

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ABSTRACT

Three studies were done on the effects of ipsilateral location (same ovary) versus contralateral location (opposite ovaries) of the future ovulatory follicle and CL in heifers. The numbers of heifers for the ipsilateral and contralateral groups, respectively, were: experiment (Exp) 1 (N = 4 and 4), Exp 2 (N = 6 and 4), and Exp 3 (N = 5 and 10). In the Exps with available data (Exp 2 and 3), the interval between ovulation and the end of luteolysis was significantly shorter in the ipsilateral group than in the contralateral group (Exp 2: 16.8 ± 0.3 vs. 19.8 ± 1.7 days; Exp 3: 16.9 ± 0.2 vs. 19.7 ± 0.9 days). In Exp 3, the interovulatory interval was shorter ($P < 0.01$) in the ipsilateral group (20.1 ± 0.4 days) than in the contralateral group (22.7 ± 0.7 days), but the interval from the end of luteolysis to ovulation was not altered significantly. Circulating progesterone (P4) concentration for 33 hours normalized to the beginning of luteolysis (Exp 1) and on Days 16 to 20 (Day 0 = ovulation; Exp 3) was significantly lower in the ipsilateral group than in the contralateral group (Exp 1: 3.7 ± 0.2 vs. 4.8 ± 0.3 ng/mL; Exp 3: 1.7 ± 0.4 vs. 5.9 ± 0.4 ng/mL). Area (cm^2) of the CL and percentage of CL with color Doppler signals of blood flow were lower and resistance index for a CL arteriole was greater in the ipsilateral group (Exp 3). The decreased P4 concentration in the ipsilateral group began by Day 16, but the decreased luteal area and vascular perfusion were not detected until Days 17 or 18. Results supported the hypothesis that the ipsilateral location of the future ovulatory follicle and CL was associated with lower P4 production and a shorter interovulatory interval.

1. Introduction

An intraovarian stimulatory effect of the corpus luteum (CL) on ovarian follicular development has been described in several species. In unilaterally ovulating ewes, follicles are larger during the mid-estrous cycle in the ovary that contains the CL (ipsilateral relationship) than when the CL and follicles are in the opposite ovaries (contralateral relationship) [1]. Four days after destruction of surface follicles in both ovaries, the follicles were more developed in the ipsilateral ovary [1,2]. In women, one report noted that the largest follicle at the time of maximal CL development was in the immediate vicinity of the CL [3], and another study found that the largest follicle during the midluteal phase was smaller in the ipsilateral ovary than in the contralateral ovary [4].

Results on CL/follicle intraovarian relationships have been contradictory in cattle. More medium-sized follicles are present in the ipsilateral ovary than in the contralateral ovary at all stages of the estrous cycle [5]. Heifers on a high plane of nutrition have more follicles <2 mm in the ipsilateral ovary at two stages of an estrous cycle [6]. Throughout the estrous cycle, more follicles 2 or 3 mm and >13 mm are located ipsilaterally than contralaterally [7]. In contrast, no relationship was found between the location of the CL and number of antral follicles on selected days of the estrous cycle [8]. A report on postpartum cows

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described follicles in the ipsilateral ovary as smaller than those in the contralateral ovary [9]. The CL in cows has a positive intraovarian relationship with the number of follicles during early pregnancy and a negative relationship during midpregnancy [10].

The spatial relationship between the CL and the dominant follicle in cattle also has been studied during the estrous cycle. No intraovarian relationships were found between the ovary containing the CL and the ovary containing the dominant follicle or between the location of the CL and the characteristics of the dominant follicle [11]. However, another study found more dominant follicles ipsilateral (45 of 72) than contralateral to the CL, using all follicular waves of the estrous cycle [12]; the follicle/CL relationship for the dominant follicle that became the ovulatory follicle was not reported.

The studies in sheep and cattle were assumed to represent an intraovarian effect of the CL on the follicles and did not consider the potential reciprocal effect of follicles on the CL. The CL was not used as an end point in that the CL was not assessed either structurally or functionally; progesterone (P4) assay was not done. An unexpected observation in heifers in a recent report was a lower P4 concentration when the future ovulatory follicle and CL were ipsilateral than when contralateral [13]. This apparent relationship was indicated by the lower P4 concentration 16 days postovulation and a 3-day shorter interovulatory interval (IOI) for heifers with the ovulatory follicle and CL in the ipsilateral ovary compared with the contralateral ovaries.

The unexpected observation of a decrease in P4 when the future ovulatory follicle and CL were in the ipsilateral ovary or conversely a P4 increase when the two structures were contralateral [13] was the impetus and rationale for the current studies in heifers. The hypothesis was that the ipsilateral location of the future ovulatory follicle and CL was associated with lower P4 concentration and a shorter IOI. The effect of ipsilateral versus contralateral follicle/CL locations on luteal vascular perfusion was also considered.

2. Materials and methods

2.1. Heifers and procedures

Data that were not previously considered or statistically analyzed were obtained from the records of two reported studies for experiments 1 and 2. In addition, appropriate plasma samples were assayed for P4 specifically for experiment 2. Only heifers that served as controls in each previous experiment were used. In addition, a planned study was done (experiment 3). Dairy heifers (Holsteins) aged 18 to 24 months were used in the three experiments in the northern temperate zone. The estrous cycles were natural in that they were not preceded by induced luteolysis, induced ovulation, or synchronization of estrus or ovulation. The heifers were kept under natural light in an open shelter and were maintained by *ad libitum* access to water, trace-mineralized salt, and primarily grass hay. Grain supplementation was provided in the winter months. Animals were handled in accordance with the United States Department of Agriculture Guide for Care and Use of Agricultural Animals in Research.

The day of ovulation preceding an experimental period was determined by transrectal ultrasound examinations [14]. Heifers were not used if more than one CL was present. Heifers were released from the holding chute after each blood collection and ultrasound examination and were given access to feed and water. Heifers were divided according to the locations of the future ovulatory follicle and CL in the same ovary (ipsilateral group) or in opposite ovaries (contralateral group).

2.2. Progesterone

Concentrations of P4 were used to define preluteolysis, luteolysis, and postluteolysis [15]. Preluteolysis occurred before the approximately progressive P4 decrease that characterizes luteolysis as illustrated in Figure 1. The transition between preluteolysis and luteolysis is manifested within 1 hour [16], indicating the advantage of hourly blood sampling in experiment 1. For standardization among laboratories, the end of luteolysis is commonly defined as the last P4 concentration $\geq$1 ng/mL and the beginning of postluteolysis as the first P4 concentration that reaches <1 ng/mL [17]. Luteolysis encompasses a mean of 24 hours, based on hourly P4 determinations [15]. Blood samples were collected every hour in experiment 1, and therefore the hour of transition between preluteolysis and luteolysis was located. Blood sampling was done every 8 hours in experiments 2 and 3 and therefore the periods of preluteolysis, luteolysis, and postluteolysis were delineated less precisely.

Blood samples were collected in heparinized tubes and immediately placed into ice water for 10 minutes before centrifuging (2000× *g* for 10 minutes). The plasma was decanted and stored (−20 °C) until P4 assay. The assay has been validated and described for bovine plasma in our laboratory [18]. Solid-phase Coat-A-Count RIA was used (Coat-A-Count Progesterone; Diagnostic Products Corporation, Los Angeles, CA, USA). For experiment 3, the intra- and interassay CV and sensitivity were: 9.2%, 9.0%, and 0.03 ng/mL.

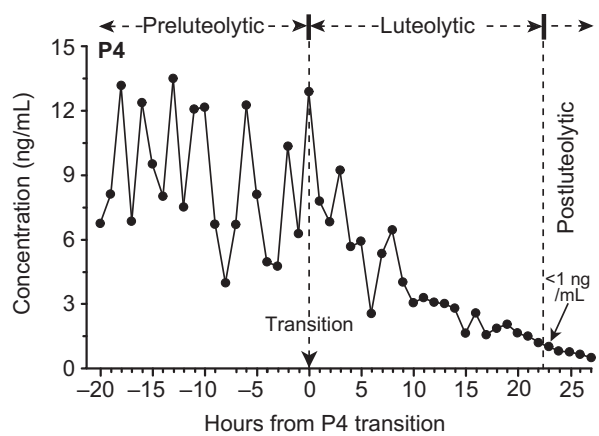

Fig. 1. Example in an individual heifer of the method for using peaks of progesterone (P4) oscillations to judge the common last hour of preluteolysis and the first hour of luteolysis. The hour of P4 transition between preluteolysis and luteolysis and the periods of preluteolysis, luteolysis, and postluteolysis are indicated.