ENDOCRINE PHYSIOLOGY OF THE PUERPERAL SOW 1, 2

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Summary

MEASUREMENT of plasma content of corticoids, progesterone, estrone (E₁), estradiol (E₂) and the Effective Thyroxine Ratio (ETR) was done on samples collected from day 7 prepartum to day 7 postpartum in 23 sows. Competitive protein-binding methods were used for the steroids and the ETR was determined using the Res-O-Mat ETR test (Mallinckrodt, St. Louis).

Corticoids reached a peak mean level of 101.8 ng/ml at day 0. There was a significant elevation of corticoids on days −1, 0 and +1 when compared to all other days. Progesterone levels began to decline on day −5, reached 0.5 ng/ml by day +1 and remained quite constant thereafter.

Estrone increased from 1,139 pg/ml at day 6 prepartum to 2,368 pg/ml at day 2 prepartum. The level of E₁ declined to 6 pg/ml by day 6 postpartum. During this same period E₂ levels were 46 pg/ml at day 6 prepartum, 75 pg/ml at day 2 prepartum and 5.5 pg/ml at day 6 postpartum.

During the postpartum period, the ETR value was significantly higher (P<0.001) than was observed for the prepartum period. This indicates an increase in thyroid output which coincides with parturition and the onset of lactation.

Introduction

There is a paucity of information on peripheral plasma levels of various reproductive steroids during the puerperal period in the sow. Plasma corticoid and estrogen levels have not been previously reported and Short (1960) studied the progesterone level only through day 114 of gestation.

The purpose of the present study was to concurrently analyze plasma corticoids, progesterone and estrogens during the periparturient period (7 days prepartum to 7 days postpartum) in the sow in order to determine the sequence or relationship of changes in these steroids during this period. This knowledge would help elucidate the possible role that these hormones play in the initiation of parturition in this species and, since these hormones are stated to have a role in lactogenesis (Folley, 1956; Meites, 1966), a knowledge of their levels under physiological conditions would provide a basis for the study of their possible roles in pathologic conditions affecting lactogenesis or galactopoiesis during the puerperal period such as the Metritis-Mastitis-Agalactia (MMA) complex. Changes in thyroid function were also studied because of the relationship to the intensity and duration of milk secretion (Sulman, 1970).

Materials and Methods

Animals used in this study consisted of 23 sows (11 Hampshire, seven Duroc, four Poland China and one Yorkshire) located in three swine herds owned by Iowa State University. Daily blood samples were collected beginning 7 days prior to expected farrowing date (based on 115 day gestation length) and continuing through day 7 postfarrowing. The day 1 postfarrowing sample was defined as the first sampling period after farrowing.

Indwelling vinyl catheters (Becton-Dickinson and Co., ID .058” X OD .080”) were placed in the anterior vena cava one day prior to start of blood sampling. Five 10 ml blood samples were collected from each sow per day between 0800 and 0900 at 15-min. intervals. Samples were immediately cooled, centrifuged at 4 C and plasma separated within an hour and stored at −20 C for hormone assay. All plasma samples were assayed for total glucocorticoids while only one sample per day was assayed for progesterone, estrone, estradiol and thyroxine.

The plasma corticoids and progesterone

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3 Veterinary Medical Research Institute.
4 The authors acknowledge the technical assistance of R. E. Strohbehn and P. A. Harris.
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TABLE 1. PLASMA HORMONE LEVELS IN SOWS DURING THE PERIPARTURIENT PERIOD (MEAN±S.E.) a

<table>
<thead>
<tr>
<th>No. of days to farrowing</th>
<th>Corticoids (ng/ml)</th>
<th>Progesterone (ng/ml)</th>
<th>Estrone (pg/ml)</th>
<th>Estradiol (pg/ml)</th>
<th>Thyroxine (ETR) b</th>
</tr>
</thead>
<tbody>
<tr>
<td>--7</td>
<td>65.4±11.1</td>
<td>12.0±1.2</td>
<td>1187.4±134.7</td>
<td>41.0±8.1</td>
<td></td>
</tr>
<tr>
<td>--6</td>
<td>69.0±14.5</td>
<td>10.9±1.7</td>
<td>1139.0±143.7</td>
<td>46.1±9.5</td>
<td>0.872±.009</td>
</tr>
<tr>
<td>--5</td>
<td>62.3±5.7</td>
<td>11.8±1.1</td>
<td>1224.2±106.0</td>
<td>45.3±4.3</td>
<td>0.874±.009</td>
</tr>
<tr>
<td>--4</td>
<td>61.4±6.8</td>
<td>11.0±1.2</td>
<td>1376.0±141.0</td>
<td>58.7±5.5</td>
<td>0.858±.007</td>
</tr>
<tr>
<td>--3</td>
<td>61.3±4.5</td>
<td>8.9±0.9</td>
<td>1740.0±218.2</td>
<td>60.4±5.5</td>
<td>0.862±.005</td>
</tr>
<tr>
<td>--2</td>
<td>63.8±4.1</td>
<td>8.9±1.0</td>
<td>2368.1±342.2</td>
<td>74.7±6.0</td>
<td>0.863±.007</td>
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<td>--1</td>
<td>80.9±10.2</td>
<td>6.7±0.9</td>
<td>2224.1±266.3</td>
<td>61.8±6.0</td>
<td>0.858±.004</td>
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<tr>
<td>0</td>
<td>101.8±11.7</td>
<td>2.5±0.8</td>
<td>2124.4±310.0</td>
<td>80.2±9.4</td>
<td>0.870±.009</td>
</tr>
<tr>
<td>+1</td>
<td>76.6±6.5</td>
<td>0.5±0.1</td>
<td>221.4±52.1</td>
<td>23.1±4.1</td>
<td>0.899±.008</td>
</tr>
<tr>
<td>+2</td>
<td>59.2±6.1</td>
<td>0.3±0.1</td>
<td>51.6±10.8</td>
<td>16.6±3.3</td>
<td>0.888±.007</td>
</tr>
<tr>
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<td>63.8±4.7</td>
<td>0.3±0.1</td>
<td>38.1±22.2</td>
<td>11.4±3.0</td>
<td>0.892±.010</td>
</tr>
<tr>
<td>+4</td>
<td>60.0±5.7</td>
<td>0.3±0.1</td>
<td>20.9±13.1</td>
<td>7.7±2.4</td>
<td>0.884±.008</td>
</tr>
<tr>
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<td>0.4±0.1</td>
<td>12.0±5.4</td>
<td>6.8±1.7</td>
<td>0.886±.008</td>
</tr>
<tr>
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<td>61.7±4.8</td>
<td>0.2±0.1</td>
<td>5.9±3.4</td>
<td>5.5±1.6</td>
<td>0.876±.008</td>
</tr>
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<td>+7</td>
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<td>0.3±0.1</td>
<td>6.8±3.5</td>
<td>3.6±1.3</td>
<td>0.898±.011</td>
</tr>
</tbody>
</table>

a Mean±standard error.
b Effective thyroxine ratio.

were assayed by the competitive protein binding methods as previously used in this laboratory (Wagner, Strohbehn and Harris, 1972).

Estrone and estradiol were assayed by the radio-ligand assay technique described by Korenman, Tulchinsky and Eaton (1970). This method utilized rabbit uterine cystosol as the binding protein following separation of estrone and estradiol on celite columns.

The thyroid function test involved determination of the Effective Thyroxine Ratio (ETR) which is a reflection of free plasma thyroxine rather than total plasma thyroxine. The Res-O-Mat ETR diagnostic Kit (Mal- linckrodt Nuclear, St. Louis) was used as described by Mincey, Thorson and Brown (1971).

Results

The mean plasma corticoid levels are shown in table 1 and figure 1. The corticoid level began to rise on day 3 prepartum. The rate of increase exceeded 20 ng per 24 hr. during the last 48 hr. prepartum, compared to an increase of only 2.5 ng during the preceding 24 hours. The level peaked at 101.8 ng/ml on day 0 and then decreased as rapidly as it had risen, returning to pre-farrowing levels by day +2. Plasma corticoid levels on days −1, 0 and +1 were significantly higher (P<0.001) than the levels for all other days sampled.

The mean progesterone level (table 1 and figure 2) started to decline on day 5 prepartum. This decline was very rapid from day 4 prepartum (11 ng/ml) to day 1 postpartum (0.5 ng/ml). The plasma level remained fairly constant at about 0.3 ng/ml from day 2 postpartum to the end of the experimental period.

The mean levels of estrone (E₁) and estradiol (E₂) are shown in table 1 and figure 3 (E₁) and figure 4 (E₂). These two estrogens were assayed by the competitive protein binding methods as previously used in this laboratory (Wagner, Strohbehn and Harris, 1972).
showed similar patterns of change. A steady increase in concentration was observed from day 6 (day 5 for E2) prepartum until day 2 prepartum. Estrone then steadily decreased through farrowing, finally reaching 6 pg/ml on day +6. Estradiol showed a brief rise on day 0 and then declined steadily thereafter reaching 3.6 pg/ml on day +7.

The estrogen:progesterone (E1+E2:P) ratio showed an increase which became increasingly rapid as the farrowing day was approached (figure 5). This ratio decreased postpartum, rapidly at first and then more gradually. There was a significant positive correlation (r=0.798, P<0.05) between this ratio and day prefarrowing.

The Effective Thyroxine Ratio (ETR) increased from 0.858 on day 1 prepartum to a peak of 0.899 on day 1 postpartum (figure 6). The ETR value for the period from day -6 to day 0 was significantly lower (P<0.001) than the value for the period day +1 to day +7 postpartum.
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The abrupt postpartum decline of progesterone observed in this study coincides with the rapid degeneration of the CL of pregnancy. Palmer, Teague and Venzke (1965) reported that by day 1 after farrowing the luteal cells were already showing degenerative changes and that immediately after farrowing the luteal cells were much smaller than just prior to parturition. Thus it appears that the changes observed in plasma progesterone in the present study would be consistent with the view that the CL are the major source of progesterone in the pregnant sow.

No previous study has been done on plasma levels of estrogens in the puerperal sow, but the pattern of changes observed in this study is similar to that found in the sheep (Challis, 1971; Bedford et al., 1972) and in the cow (Henricks et al., 1972). The changes in plasma estrogens also correlate with those found by Rombauts (1962) and by Rombauts, Fèvre and Terqui (1971) in urinary estrogens in the sow. Estrone was the principal estrogen in the plasma of puerperal sows (table 1) which agrees with the findings of Terqui (1971) for urine and Rombauts (1964) for the placenta.

Previous studies have demonstrated that estrogens are produced by the placenta in the

Discussion

A rise in plasma corticoid levels was observed at parturition in the sow and was similar to the report of Smith et al. (1972) in the cow. Adams and Wagner (1970) also observed a rise in corticoids but their results suggested the rise occurred 3 to 4 days prepartum. In the present study the corticoid rise began 2 days prepartum which was intermediate between the findings of Adams and Wagner (1970) (4 days prepartum) and Smith et al. (1972) (12 hr. prepartum). However, the plasma levels of corticoids during the periparturient period are higher in the sow (100 ng/ml) than in the cow (17 ng/ml).

The pattern of changes in progesterone levels observed in this study is in general agreement with the patterns noted in the sow by Short (1960) for plasma progesterone and by Edgerton and Erb (1971) for total urinary progesterone metabolites.

Many studies have indicated that the corporal lutea (CL) remain the main physiological source of progesterone all through pregnancy, and that the ovary is indispensable during gestation in the sow (Kimura and Cornwell, 1938; Short, 1956; Rombauts, Pupin and Terqui, 1965; Masuda et al., 1967).
sow (Bowerman, Anderson and Melampy, 1964; Rombauts, 1964). Fèvre, Léglise and Rombauts (1968) further showed that urinary estrogen content in the pregnant sow was not affected by ovariectomy or hypophysectomy. Fèvre, Léglise and Reynaud (1972), using adrenalectomized sows, demonstrated that estrogen synthesis in the pregnant sow was independent of the maternal adrenal. Fèvre (1970) reported convincing evidence of fetal involvement in this estrogen production by showing that administration of labeled C-19 steroids into the fetal compartment gave a greater conversion to estrone than when infused into the uterine artery of the dam. Since the fetoplacental unit appears to be responsible for estrogen production this accounts for the abrupt decline when this source is removed at parturition.

The estrogen (E1+E2):progesterone ratio changes based on blood levels are somewhat different than Edgerton and Erb (1971) reported for progestin-estrogen ratios in urine. They indicated that there was little change in relationships between the total urinary concentrations of these two steroid groups during the last 4 days while plasma values indicate that the estrogen-progesterone value continued to change until parturition occurred. This may indicate some alterations in metabolism of these steroids just prior to farrowing in the sow.

Thus, before parturition occurs, the plasma estrogen and corticoid levels rise well above the gestation levels, and the progesterone levels show a substantial decline. Nellor (1963) and Minar and Schilling (1970) were able to delay parturition in the sow by oral administration of progestagens or by parenteral administration of progesterone. This evidence would provide support for the "progesterone block" theory of initiation of parturition (Csapo, 1956) for the sow.

Since the prepartum elevation of corticoids lagged behind the prepartum decline of progesterone by 3 days, this does not support any possible luteolytic role near term for corticoids in this specie as was suggested by Schams et al. (1972) in the cow. Therefore the prepartum corticoid elevation in the sow is probably the result of the farrowing process.

The significant rise in ETR noted at parturition coincides with the onset of lactation. Since this increase was maintained through the first 7 days after farrowing it may be of importance to normal lactation and not related to the act of parturition itself.

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