Relationships among Plasma Concentrations of Estrone Sulfate during Pregnancy and Placental and Calf Weight at Birth in Dairy Cows

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Abstract Thirteen Holstein-Friesian cows were used to investigate relationship among concentrations of estrone sulfate (E1S) in maternal circulation during pregnancy and weight of calf and placenta at birth. Plasma samples were obtained from the tail vein of cows once every month from days 90 to 180 of gestation, every 2 weeks from days 181 to 270 of gestation, and every day from days 270 of gestation to parturition. Maternal plasma E1S concentrations were measured by a radioimmunoassay, and newborns and placentas were weighed at birth. E1S concentrations from days 225 of gestation to one day before parturition were correlated positively with weight of calf, cotyledons, intercotyledony membranes and total placenta at birth (P<0.05 or P<0.01). In addition, calf birth weight was correlated positively (P<0.01) with the weight of the cotyledons (r=0.81), intercotyledony membranes (r=0.93) and total placenta (r=0.93). These results suggest a close relationship among the fetal placental function, weight of calf and placenta at birth and concentrations of E1S in maternal circulation during late gestation, which provides useful and practical information for the development and function of fetoplacental unit.

Key words: Calf, Estrone sulfate, Placenta, Holstein-Friesian cows

Bovine conceptus and maternal endocrine systems interact throughout gestation to maintain the development and growth of the fetus. Lesioning in the placenta are known to affect directly on fetal well-being and perinatal mortality in fetuses and calves. Intrauterine fetal development and placental function, which can not be measured directly, may be monitored by steroid hormones in maternal circulation. Such a monitor will be of momentous significance for early detection of fetoplacental unit abnormalities in pregnant cows, which makes the management and successful treatment of affected cows challenging.

Echternkamp has reported that concentrations of estrone sulfate (E1S) in maternal
plasma between day 10 and 1 prepartum was correlated positively with calf birth weight and with the weight of the cotyledons, intercotyledonary membranes and total placenta, in beef heifers. However, in the previous studies, measurements of plasma E1S concentrations were only confined to late gestation\(^3, 7, 14\). Besides, since the mode of production and management of dairy cattle is different from that of beef cattle, there may be subtle regulatory difference between them. There is a dearth of information on the relationship between circulating estrogens and placental development in dairy cattle. The objective of this study was to investigate the relationships among fetal placental function during mid and late gestation and weight of calf and placenta at birth, in the Holstein-Friesian cows.

![Fig. 1. Changes in plasma concentrations of estrone sulfate in maternal circulation during pregnancy in dairy cows. a) Individual data of cows No. 1~13 in the order of the calf birth weight from the lowest. b) Mean±S.E.M. of 13 cows.](image)
E1S and its Relationship to Placental and Calf Birth Weight in Cows

Materials and Methods

Thirteen Holstein–Friesian cows, which were reared on Rakuno Gakuen University Dairy Farm and calved between July and November 1996, were used for the experiment. Parities of the cows varied from one to five.

Blood samples (10–20 ml) were obtained using 21 gauge needles from the tail vein into heparinized vacuum test tubes once every month from days 90 to 180 of gestation; every 2 weeks from days 181 to 270 of gestation and every day from days 271 of gestation to parturition. Blood samples were centrifuged (3,000 rpm for 15 min) immediately after collection. Plasma was decanted and stored at −20°C until assayed for E1S.

Plasma concentrations of E1S were quantified by a radioimmunoassay10). The intra- and inter-assay CVs were 12.3 and 11.0%, respectively. Sensitivity of the assay was 31.5 pg/ml. Crossreactivities of the anti–E1S serum with E1S, estrone glucuronide, estrone, estradiol–3–sulfate, estradiol–3–glucuronide and estriol sulfate were 100, 5.4, 4.0, 1.5, 0.8 and 0.8%, respectively.

Body weight of the calf at birth was measured with a pair of scales. Placentas were frozen immediately after collection at expulsion. After thawing placentas, the cotyledons and intercotyledonary membranes were separated, and weighed. Number of cotyledon per placenta was counted.

Pearson’s correlation coefficients among birth weight of the calf, number of cotyledons per placenta, weights of cotyledons, intercotyledonary membranes and total placenta, and maternal plasma E1S concentrations were evaluated by Fisher’s r to $z^{12}$. A one-factor ANOVA was used to examine the effect of gestation stage on the changes in E1S concentration$^{12}$. Comparisons of means of E1S concentrations between gestation stages were done using Scheffe’s test$^{12}$. Effects of sex of calf on the birth weight, gestation period and body weight of dam at parturition were analyzed by Student’s t-test.

Results

All the calves (5 males and 8 females) were singleton. The weight at birth and gestation period were $45.2 ± 1.5$ kg (mean ± S.E.M.) and $283.0 ± 1.5$ days for male calves, and $48.1 ± 4.2$ kg and $284.2 ± 1.7$ days for female calves, respectively. Maternal body weight at parturition was $701.0 ± 50.2$ kg (mean ± S.E.M.) for male calves and $733.8 ± 17.6$ kg for female calves. There was no difference in these parameters between dams with male and female calves.

Changes of E1S concentrations in maternal plasma during mid and late gestation are shown in Fig. 1. Concentrations of E1S at 90 days of pregnancy were low ($1.1 ± 0.3$, $n=12$)
and did not show any correlation with placental parameters. Concentrations of E1S increased significantly along with the progress of gestation (Fig. 1b, P<0.0001). Individual variation of E1S became obvious after 210 days of gestation (Fig. 1a).

Correlation of E1S concentrations at day 1 prepartum with calf birth weight, cotyledonary weight, membranal weight and total placental weight are shown in Fig. 2. Concentrations of E1S at day 1 prepartum represented positive correlation with these parameters (r=0.75, r=0.76, r=0.71 and r=0.77, respectively).

Correlation coefficients among concentrations of maternal E1S from 90 days of pregnancy to 1 day before parturition, calf birth weight and weight of placentla components are shown in Table 1. Concentrations of E1S in maternal circulation from 90 days to 210 days of pregnancy did not show significant correlations with calf weight at birth and placental parameters. After 225 days of pregnancy, concentrations of E1S showed positive correlation with parameters of calf birth weight (r=0.68), cotyledonary weight (r=0.66), membranal weight (r=0.71) and total placental weight (r=0.71). No correlation was observed between

Table 1. Correlations of E1S concentrations in maternal plasma during pregnancy with the calf weight and placental weight at birth

<table>
<thead>
<tr>
<th>Gestation stage (d)</th>
<th>E1S conc. (ng/mL)</th>
<th>Calf birth wt. (kg)</th>
<th>Cotyledonary wt. (g)</th>
<th>Membranal wt. (g)</th>
<th>Total placental wt. (g)</th>
<th>No. of cotyledons</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>1.1±0.3</td>
<td>0.16</td>
<td>0.05</td>
<td>0</td>
<td>0.02</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>1.8±0.2</td>
<td>0.37</td>
<td>0.43</td>
<td>0.29</td>
<td>0.08</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>2.0±0.4</td>
<td>0.39</td>
<td>0.48</td>
<td>0.40</td>
<td>0.48</td>
<td>-0.21</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>2.9±0.4</td>
<td>0.48</td>
<td>0.53</td>
<td>0.48</td>
<td>0.85</td>
<td>-0.05</td>
<td></td>
</tr>
<tr>
<td>195</td>
<td>3.4±0.5</td>
<td>0.38</td>
<td>0.51</td>
<td>0.46</td>
<td>0.52</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>210</td>
<td>4.6±0.5</td>
<td>0.48</td>
<td>0.56</td>
<td>0.49</td>
<td>0.55</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>225</td>
<td>4.8±0.7</td>
<td>0.68</td>
<td>0.66</td>
<td>0.71</td>
<td>0.56</td>
<td>0.71</td>
<td>0.13</td>
</tr>
<tr>
<td>240</td>
<td>6.8±1.3</td>
<td>0.74</td>
<td>0.71</td>
<td>0.75</td>
<td>0.71</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>255</td>
<td>8.5±1.4</td>
<td>0.82</td>
<td>0.86</td>
<td>0.85</td>
<td>0.90</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>270</td>
<td>12.0±1.3</td>
<td>0.71</td>
<td>0.75</td>
<td>0.65</td>
<td>0.74</td>
<td>-0.16</td>
<td></td>
</tr>
<tr>
<td>9 prepartum</td>
<td>12.3±1.4</td>
<td>0.79</td>
<td>0.78</td>
<td>0.68</td>
<td>0.76</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>8 prepartum</td>
<td>12.4±1.4</td>
<td>0.86</td>
<td>0.88</td>
<td>0.75</td>
<td>0.86</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td>7 prepartum</td>
<td>13.9±1.5</td>
<td>0.75</td>
<td>0.77</td>
<td>0.72</td>
<td>0.77</td>
<td>-0.11</td>
<td></td>
</tr>
<tr>
<td>6 prepartum</td>
<td>13.5±1.2</td>
<td>0.81</td>
<td>0.84</td>
<td>0.71</td>
<td>0.81</td>
<td>-0.15</td>
<td></td>
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<tr>
<td>5 prepartum</td>
<td>14.3±1.3</td>
<td>0.71</td>
<td>0.73</td>
<td>0.64</td>
<td>0.71</td>
<td>-0.10</td>
<td></td>
</tr>
<tr>
<td>4 prepartum</td>
<td>14.2±1.2</td>
<td>0.80</td>
<td>0.80</td>
<td>0.77</td>
<td>0.82</td>
<td>-0.16</td>
<td></td>
</tr>
<tr>
<td>3 prepartum</td>
<td>15.3±1.6</td>
<td>0.73</td>
<td>0.70</td>
<td>0.63</td>
<td>0.70</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>2 prepartum</td>
<td>16.2±1.5</td>
<td>0.75</td>
<td>0.78</td>
<td>0.68</td>
<td>0.77</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td>1 prepartum</td>
<td>17.2±1.4</td>
<td>0.75</td>
<td>0.76</td>
<td>0.71</td>
<td>0.77</td>
<td>-0.11</td>
<td></td>
</tr>
</tbody>
</table>

* a In days 90~270 of gestation n=12, and in days 9~1 prepartum n=13.
* P<0.05; ** P<0.01.
E1S and its Relationship to Placental and Calf Birth Weight in Cows

E1S concentrations and number of cotyledons at any stage of gestation. High positive correlations were observed among calf birth weight, cotyledonary weight, membranal weight and total placental weight.

Discussion

In this report, we found variations of maternal E1S concentrations after 225 days of gestation and positive correlations of calf weight at birth with E1S concentrations in the maternal circulation as early as 225 days of pregnancy in Holstein-Friesian dairy cattle. The fact that plasma concentrations of E1S during the last trimester of gestation correlated positively with weight of calf and placenta at birth suggests that monitoring E1S concentrations in maternal plasma provides a useful index for estimating placental development.

A strong positive correlation between the calf birth weight and placental weight intimates that fetal growth is under the influence of placental development and function. Alexander1) has reported that surgical removal of caruncles induced reduction both calf birth weight and placental weight in sheep.

In the present study, the number of cotyledons per placenta showed no correlation with either maternal E1S concentrations or calf birth weight, which was also observed in Hereford × Angus heifers5). This suggests that the total mass of placentomes per placenta is of greater biological significance than total number of placentomes, even though the two are partly related. Since placental villi in ruminants are limited to form at uterine caruncles, development of placenta to support fetal development along with pregnancy may necessitate growth of placentomes.

During the last trimester of gestation, placenta produces significant amount of estrogen in cows. The placenta relies on fetal cortisol production to induce placental enzymes to synthesize estrogen from progesterone8,9,10). Estrogen is necessary to increase nutrient uptake at placenta through the increment of blood flow5,6,11). We observed positive correlation of maternal E1S concentrations with calf birth weight starting from day 225 of gestation, when plasma levels of progesterone in maternal circulation begin to decline5).

In conclusion, the fetal growth and placental functional development can be assessed by measuring concentrations of E1S in maternal circulation during the last trimester of gestation in Holstein-Frisian cows.

Acknowledgments

We wish to acknowledge the help of the staff at the Rakuno Gakuen University Dairy Farm in obtaining these samples.

References

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