EFFECT OF PREPARTUM INJECTION OF VITAMIN E AND SELENIUM ON POSTPARTUM REPRODUCTIVE FUNCTION OF DAIRY CATTLE

C.F. Aréchiga, O. Ortíz, and P. J. Hansen

Department of Dairy and Poultry Sciences, University of Florida, Gainesville 32611-0920
Departamento de Reproducción, Facultad de Medicina Veterinaria y Zootecnia Universidad Nacional Autónoma de México, Cd. Universitaria, México, D.F.

Received for publication: May 28, 1993
Accepted: February 16, 1994

ABSTRACT

A total of 198 cows were randomly assigned to treatment with a single intramuscular injection of 10 ml of a preparation containing vitamin E and selenium or placebo 3 wk before expected parturition. Incidence of retained fetal membranes was 3.0% for the treated group and 10.1% for the control group (P=0.06). Administration of MU-SE also increased the percentage of cows pregnant to the first service (41.2 vs 25.3%; P=0.02), reduced the number of services per conception (2.3 vs 2.8; P=0.03), and reduced the interval from calving to conception (121 vs 141 days; P=0.06). The effect of MU-SE on fertility was apparent in cows with and without retained fetal membranes. There was no effect of MU-SE on the interval from calving to the first estrus. In conclusion, prepartum supplementation with vitamin E and selenium can decrease the incidence of retained fetal membranes, increase pregnancy rates and, thereby, reduce the interval from calving to conception in lactating dairy cows.

Key words: vitamin E, selenium, antioxidants, postpartum, fertility, dairy cow

INTRODUCTION

Free radicals can disrupt several processes associated with reproductive function including synthesis of steroids (34,36) and prostaglandins (13,14,22), sperm motility (1) and embryonic development (6). Given the potential role of products of oxygen metabolism in

Acknowledgments

Research was supported by the CONACYT/IIE Program (México), USDA-CBAG grant 92-04572 and the Florida Dairy Checkoff Program. The authors acknowledge the generous assistance of Schering Plough de Mexico (División Veterinaria), the workers and owners of the San Sebastián Dairy and Mrs. Mary Ellen Hissem for assistance with preparation of the manuscript. This is Journal Series No. R-03180 of the Florida Agricultural Experiment Station.

a Current address: Veterinary Medicine Teaching and Research Center, University of California, Tulare, CA 93274.
b Reprint requests to Dr. P. J. Hansen, Dept. of Dairy and Poultry Sciences, University of Florida, P.O. Box 110920, Gainesville, FL 32611-0920.
normal or pathological reproduction, administration of antioxidants might improve reproductive function. Two molecules involved in protection of animal tissues from free radicals and peroxide metabolites are vitamin E and selenium. Vitamin E is an intracellular antioxidant that maintains the integrity of membrane phospholipids against oxidative damage and peroxidation (23,24), while selenium is a cofactor of the enzyme glutathione peroxidase that acts in aqueous intracellular and extracellular compartments to catalyze the destruction of peroxides (26). The effects of administration of vitamin E and selenium on reproductive function of dairy cows have been inconsistent, probably due to variation in vitamin E and selenium contents in diets, as well as to variation in timing, dosage and methods of administration. Several studies have shown that administration of selenium, vitamin E or vitamin E and selenium in combination reduced incidence of retained fetal membranes (4,10,12,17,18,25,32,37,38) and metritis (10), improved fertility (30,33) and reduced incidence of cystic ovaries (10). In contrast, other studies have shown little or no beneficial effect of administration of vitamin E and/or selenium (8,15,16,19,28,35).

The objective of the present study was to determine whether a single intramuscular injection of a commercial formulation of vitamin E and selenium (MU-SE) in the late prepartum period would enhance postpartum reproductive function of lactating dairy cows. Intramuscular injection of MU-SE caused elevated blood and serum selenium concentrations for 28 d and elevated blood glutathione peroxidase activity for at least 84 d (21). Intramuscular injection of vitamin E increased amounts in serum for 14-21 d and in liver for at least 28 d (2).

MATERIALS AND METHODS

Holstein cows (n=198; 1-7 parities) calving from October, 1990 to May, 1991 were used in this study. The cows were from a commercial dairy (San Sebastián) of about 800 lactating cows located in Tequixquiac, Estado de México (elevation 2550 m). The region has an annual mean temperature of 15.4°C and annual mean precipitation of 688.2 mm. The weather is considered temperate with long and moderate summers. Cows were milked twice daily. Approximate 305-d average milk yield was 8000 kg.

Cows were randomly assigned to 1 of 2 groups before calving. One group received a single intramuscular injection of 10 ml MU-SE (Schering-Plough Corp., Kenilworth, NJ) at 21 d prior to anticipated calving. This dose is equivalent to 109.5 mg of sodium selenite (equivalent to 50 mg of selenium) and 500 mg of vitamin E as dl α-tocopheryl acetate (680 IU). The control group received an intramuscular injection of 10 ml of 0.9% NaCl as a placebo.

The pre- and postpartum ration for the cows was formulated to provide 500 IU of vitamin E and 0.3 ppm of selenium per cow per day. Lactating cows were fed 2 kg of alfalfa hay at each milking. Afterwards, the cows were given access to either fresh chopped alfalfa or, during cold periods (~December-January), alfalfa hay, and were fed a mixed ration composed of approximately 15 kg of corn silage, 6 kg of sorghum, 0.3 kg of bypass fat, 2 kg of hominy feed, 1.5 kg of whole cottonseed, 1.2 kg of soybean meal, 1.6 kg of poultry carcass meal, 50 g of urea and additional microminerals per cow per day.
The effectiveness of the treatment was evaluated by measuring the incidence of retained fetal membranes, days from calving to first service, number of services per conception and interval from calving to conception. Retained fetal membranes was considered as occurring when fetal membranes were retained after 24 h post partum. Cows with retained fetal membranes received treatment with oxytetracycline (10 mg/kg of body weight, im). Cows were placed in special pens for estrous detection when rectal examination indicated uterine involution was complete and there was absence of metritis. Typically, cows were deemed ready for breeding at 30-40 d post partum. Estrous detection was performed nearly continuously throughout the day. All cows were artificially inseminated with semen from bulls of high fertility. Artificial insemination was performed by only one person, approximately 12 h after the cows were first detected in estrus. Pregnancy was determined by palpation per rectum at 45 to 60 d after service.

Continuous data were analyzed by least squares analysis of variance using the General Linear Models Procedure of SAS (27). Additionally, discrete variables (incidence of retained fetal membranes and percent pregnant at first service) were analyzed using the CATMOD procedure of SAS. Initial analyses were performed including various measures of seasonal effects in the statistical models. These effects included month of calving, month of first service, season of calving (spring and summer vs autumn and winter), and season of first service. These effects and interactions of these effects with other treatments were nonsignificant and they were subsequently removed from analyses. Therefore, the final mathematical model used to analyze data included effect of treatment with parity as a covariate. For some traits, an additional model was analyzed that included effects of treatment, occurrence of retained fetal membranes (yes or no), and treatment by retained fetal membranes as class effects and parity as a covariate.

RESULTS

Results are shown in Table 1. Incidence of retained fetal membranes was reduced by MU-SE from 10.1% to 3.0% (P=0.06). There was no effect of MU-SE on interval from calving to first breeding. However, MU-SE improved (P=0.02) pregnancy rate at first service (41.2 vs 25.3%) and decreased (P=0.03) services per conception (2.3 vs 2.8). Therefore, days from parturition to conception tended (P=0.06) to be reduced by MU-SE (121 vs 141 d).

To determine whether effects of MU-SE on postpartum fertility were caused by decreased incidence of retained fetal membranes, data were reanalyzed including retained fetal membranes as a main effect in the model (Table 2). Cows with retained fetal membranes tended (P=0.01) to have longer intervals to first service but there was no effect of retained fetal membranes on the percentage of cows pregnant at first service, services per conception or interval from calving to conception. Treatment effects were significant or tended to be so for interval to first service (P=0.01), services per conception (P=0.10), and interval from calving to conception (P=0.02). There were treatment by retained fetal membranes interactions for interval from calving to first service (P=0.01) and interval from calving to
Table 1. Effect of prepartum administration of MU-SE on postpartum reproductive function of lactating dairy cows

<table>
<thead>
<tr>
<th></th>
<th>MU-SE</th>
<th>Control</th>
<th>Observed significance level (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence of retained fetal membranes</td>
<td>3/99 (3.0%)</td>
<td>10/99 (10.1%)</td>
<td>0.06</td>
</tr>
<tr>
<td>Interval from calving to first service (d)</td>
<td>67 ± 2.6 (97)</td>
<td>67 ± 2.6 (94)</td>
<td>N.S.</td>
</tr>
<tr>
<td>Pregnant at first service</td>
<td>40/97 (41.2%)</td>
<td>24/95 (25.3%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Services/conception</td>
<td>2.3 ± 0.17 (97)</td>
<td>2.8 ± 0.17 (95)</td>
<td>0.03</td>
</tr>
<tr>
<td>Interval from calving to conception</td>
<td>121 ± 7.6 (97)</td>
<td>141 ± 7.7 (94)</td>
<td>0.06</td>
</tr>
</tbody>
</table>

*aCows were either treated with 500 mg vitamin E and 109.5 mg sodium selenite 21 d before expected calving (MU-SE) or served as controls. Data for days to first service, services per conception and interval to conception represent least square means ± SEM (number of observations). For other variables, numbers represent fraction and percentage of animals.

conception (P=0.08). The interactions resulted because treatment improved interval to first service only for cows with retained fetal membranes and because the reduction in interval to conception caused by MU-SE was apparent for both groups but to a greater degree for cows with retained fetal membranes. Numbers of animals in the retained placenta group were very small, however, and caution should be used when interpreting the interactions.

In a third analysis, cows diagnosed positive for retained fetal membranes were excluded from the analysis. Treatment effects remained significant for pregnancy rate at first service (P=0.03) and services per conception (P=0.05).

DISCUSSION

In this study a single prepartum injection of a commercial formulation of vitamin E and selenium had a beneficial effect on postpartum reproductive function of dairy cows by causing a decrease in the incidence of retained fetal membranes and an increase in fertility. There was no beneficial effect of MU-SE on interval to first breeding. Nonetheless, interval from calving to conception was reduced by MU-SE treatment because of the beneficial effect on pregnancy rate. Accordingly, prepartum treatment of cows with MU-SE can improve overall reproductive function during the postpartum period.
Table 2. Effect of prepartum administration of MU-SE on postpartum reproductive function of lactating dairy cows with and without retained fetal membranes

<table>
<thead>
<tr>
<th>Retained fetal membranes</th>
<th>Treatment</th>
<th>Interval from calving to first service (days)</th>
<th>Pregnancy rate at first service (%)</th>
<th>Services per conception</th>
<th>Interval from calving to conception (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>MU-SE</td>
<td>67 ± 2.5</td>
<td>41.5</td>
<td>2.3 ± 0.17</td>
<td>122 ± 7.7</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>64 ± 2.6</td>
<td>25.6</td>
<td>2.8 ± 0.18</td>
<td>136 ± 8.0</td>
</tr>
<tr>
<td>Yes</td>
<td>MU-SE</td>
<td>57 ± 14.0</td>
<td>33.3</td>
<td>1.8 ± 0.97</td>
<td>89 ± 43.1</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>102 ± 8.0</td>
<td>22.2</td>
<td>3.2 ± 0.56</td>
<td>193 ± 24.8</td>
</tr>
</tbody>
</table>

| Treatment (Trt)          | Retained fetal membranes (Rfm) | 0.01 | N.S. | 0.10 | N.S. | 0.02 | N.S. | 0.08 |

aData represent least-squares means ± SEM or percent (% pregnant). Cows were either treated with 500 mg vitamin E and 109.5 mg sodium selenite 21 d before expected calving (MU-SE) or served as controls. The number of animals in each group are 94 (no retained fetal membranes/MU-SE); 85-86 (no retained fetal membranes/control); 3 (retained fetal membranes/MU-SE); and 9 (retained fetal membranes/control).

The reduction in incidence of retained fetal membranes caused by MU-SE is consistent with many other studies in which selenium was administered separately or in conjunction with vitamin E (4,10,12,17,18,25,32,37,38). The mechanism by which selenium enhances expulsion of the fetal membranes after parturition is not well-defined but could involve effects on steroidogenesis (34,36) or prostaglandin synthesis (13,14,22). Furthermore, MU-SE might act by promoting function of neutrophils; oral administration of selenium enhanced bactericidal activity of neutrophils (7) and cows which experienced retained fetal membranes had reduced neutrophil function post partum (5). Finally, selenium could influence contractility of the uterus after parturition during expulsion of the fetal membranes because injection of selenium or vitamin E and selenium increased contractile activity of the ovine uterus (32).
While beneficial effects of selenium supplementation on retained fetal membranes are a fairly consistent finding, effects of selenium, vitamin E and their combination on fertility are more variable. In some studies fertility was increased by vitamin E (33) or the combination of vitamin E and selenium (30) while in most studies vitamin E and selenium treatments had no effect on fertility (8,10,15,16,19,35). There are obvious differences between studies in the amount of vitamin E and/or selenium administered, the period of administration, and nutritional status of the experimental animals with respect to vitamin E and selenium intake that could explain some of these differential results. In addition, one study (25) suggests that vitamin E from fresh forage diets are important for realizing beneficial effects of selenium injection on reduced incidence of retained fetal membranes. In that experiment, a single injection of selenium reduced the incidence of retained fetal membranes in cows eating fresh forage but not in cows fed alfalfa haylage. Thus, the fact that cows in the present study were fed fresh chopped alfalfa during most of the trial may have been an important aspect of the successful fertility response to MU-SE.

The effect of MU-SE on fertility was not a simple consequence of the reduced incidence of retained fetal membranes in this group because beneficial effects of MU-SE were observed for cows without retained fetal membranes. The mechanisms by which selenium and vitamin E promote fertility is unclear. Effects on phagocytic cells could promote uterine tissue remodeling and involution. Prepartum treatment with selenium and vitamin E has been reported to hasten uterine involution in cows with metritis (11). Treatment with vitamin E and selenium increased fertilization rate in cattle (30) and sheep (29). This effect could reflect an action at the cellular level to regulate free radical generation in the ovaries (9), spermatozoa (1), ovulated oocytes or embryos. Recent evidence indicates that generation of free radicals is one potential cause of abnormal embryonic development (3,6,20). Moreover, vitamin E has been implicated in protecting steroidogenic enzymes from oxidative degradation (34,36). Thus, selenium and vitamin E could act at the level of the ovary, uterus, gamete or developing embryo to enhance pregnancy rate.

REFERENCES


