Effect of Prepartum Selenium Treatment on Uterine Involution in the Dairy Cow

JOSEPH H. HARRISON, DALE D. HANCOCK, NORMAND ST. PIERRE, H. R. CONRAD, and W. R. HARVEY
Ohio Agricultural Research and Development Center
The Ohio State University
Wooster 44691

ABSTRACT
Selenium injections and oral vitamin E supplementation prepartum were related to: 1) postpartum uterine involution (decrease in uterine size per unit time) and 2) days to minimum uterine size in a 2 x 2 factorial design. Complete data were analyzed from 64 cows. Groups were 1) selenium plus vitamin E, 2) vitamin E, 3) selenium, and 4) control. Factors significantly affecting uterine size between 14 and 50 d postpartum were cow weight, days postpartum-linear, days postpartum-quadratic, day x metritis, and day x metritis x selenium treatment. Days to minimum uterine size were significantly less in cows with metritis and selenium treated when compared with cows with metritis and not selenium treated (32.9 vs. 35.8).

INTRODUCTION
The importance of Se and vitamin E for prevention of reproductive disorders in agriculturally important animals has been reviewed (13). Selenium and vitamin E supplementation to dairy cows in Se-deficient areas of the United States has reduced the incidence of retained placenta (5, 6, 12), uterine infection (4), and mastitis (14).

Involution of the uterus (3, 8, 9, 17) and cervix (9, 10) has been characterized. Factors affecting the involution are milk fever (9), retained placenta (8, 9), season (1, 8), parity (1, 10), dystocia (9), and nutrition (18). Uterine involution was completed 8 d sooner in animals receiving supplemental Ca and vitamin D (18).

Objectives of this experiment were 1) to evaluate the effect of prepartum Se or vitamin E treatment on postpartum uterine involution, and 2) to define factors that affect uterine size during uterine involution. Incidence of retained placenta, uterine health, ovarian function, and reproductive performance measures have been reported (4).

MATERIALS AND METHODS
Cows and Rations
Seventy-eight multiparous dry cows were used in a 2 x 2 factorial experiment. Animals were assigned at random to one of two dietary groups for the entire prepartum period and subdivided for Se treatment at 21 d before projected calving. Treatments were 1) Se plus vitamin E, 2) vitamin E, 3) Se, and 4) control. All cows received a legume-grass haylage provided ad libitum and supplemented with .5 kg of concentrate per cow per day as a total mixed ration. Vitamin E-supplemented groups received supplemented d,1-α-tocopheryl acetate to provide an average of .74 g of vitamin E (d-α-tocopherol equivalence per cow per day) during the entire dry period. Ad libitum consumption of haylage provided an estimated .32 g vitamin E per cow per day. Selenium-treated groups were injected i.m. with Se at .1 mg/kg of body weight 21 d before predicted date of calving. Nutrient content of diets has been reported (4).

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2 This research supported by the United States Department of Agriculture Grant P. L. 89-106.
3 Department of Veterinary Science.
4 College of Veterinary Medicine, Washington State University, Pullman 99164.
5 Department of Dairy Science.
6 Western Washington Research and Extension Center, Department of Animal Science, Washington State University, Puyallup 98371.
Reproductive Criteria

Animals were diagnosed with retained placenta if fetal membranes were retained for 24 h postpartum and were observed daily for vaginal discharge during the first 12 wk postpartum. The initial reproductive examination was performed on all cows between 14 and 28 d postpartum, at which time they were diagnosed as normal or abnormal [metritis (MET)]. After 28 postpartum, animals received 1 additional reproductive examinations. Diagnosis of MET was based on uterine size (9), and, in most cases, confirmed by vaginal examination with a speculum and light source. Purulent material found during vaginal examination was considered diagnostic for MET (16, 17). Uterine infections were treated by intrauterine infusion (60 to 360 ml) of dilute iodine solution (0.0014%). The previously gravid uterine horn size (cm) was estimated at the external bifurcation at each examination. The identity of experimental treatments was not available to the diagnosing veterinarian, and one veterinarian performed all reproductive examinations.

Descriptive Characteristics

Percent incidence of retained placenta and metritis in groups 1 to 4 was 0, 57, 20, 84, 17, 65; and 16, 83 (4). Other characteristics were incidence of milk fever, none; season of the year animals calved, November to May; parity, two to seven; number of calves born, single calf parturitions; and breeds, Holstein and Jersey. Complete data were available for 64 animals (12 Jersey, 52 Holstein).

Statistical Analyses

Factors included in orginal models and deleted due to nonsignificant effect were vitamin E treatment, parity, retained placenta, and interactions of Se and vitamin E.

The following split model was used because it allows uterine size to decrease nonlinearly with time until minimum size is attained, after which uterine size remains constant.

\[
Y_{ijklm} = \mu + T_i + M_j + TM_{ij} + BW(A_{k:ij} - \bar{W}) + C_{k:ij} + B_L(X_{ij}^0) + BT_i(X_{ij}^i) + BM_j(X_{ij}^j) + BTM_{ij}(X_{ij}^i) + BQ(X_{ij}^0) + E_{ijklm}
\]

where:

\[
Y_{ijklm} = \text{uterine size},
\]

\[
\mu = \text{overall mean},
\]

\[
T_i = \text{effect of the } i\text{th Se treatment class},
\]

\[
M_j = \text{effect of the } j\text{th metritis class},
\]

\[
TM_{ij} = \text{effect of the } ij\text{th treatment } \times \text{metritis subclass},
\]

\[
BW(A_{k:ij} - \bar{W}) = \text{regression coefficient for cow weight expressed as a deviation from the mean},
\]

\[
C_{k:ij} = \text{effect of the } k\text{th cow within the } ij\text{th subclass},
\]

\[
(d_{ijkl} - \bar{d}) = \text{number of days after parturition expressed as a deviation from the mean},
\]

\[
B_L = \text{overall regression coefficient for days},
\]

\[
BT_i = \text{linear regression coefficient of days X of the } i\text{th treatment subclass},
\]

\[
BM_j = \text{linear regression coefficient of days X of the } j\text{th metritis subclass},
\]

\[
BTM_{ij} = \text{linear regression coefficient of days X of the } ij\text{th treatment } \times \text{metritis subclass},
\]

\[
BQ = \text{overall quadratic regression coefficient},
\]

\[
X_0 = \text{splitting time point for the } ij\text{th treatment } X \text{metritis subclass},
\]

\[
E_{ijklm} = \text{random error}.
\]

Forcing the function to be smooth and continuous implies:

\[
X_{ij}^0 = -\frac{(B_L + BT_i + BM_j + BTM_{ij})/2 \times BQ}{X_0}
\]
which defines a different number of days to minimum uterine size for each of the four metritis × Se treatment subclasses.

Nonlinear regression techniques must be used to fit jointly models [1] and [2]. However, the number of cows prohibits a one-step direct estimation of all parameters. Effects of Ck,jij were fitted under a linear model. The remaining parameters were estimated with PROC NLIN of SAS (2). Variance of days to minimum uterine size (X3) was approximated by the equation of (7).

RESULTS AND DISCUSSION

Regression analysis of uterine involution between 14 and 50 d postpartum is summarized in Table 1 and Figure 1. Factors that significantly affected uterine involution (change in uterine size per unit time) were cow weight (P = .008), day postpartum-linear (P = .053), day postpartum-quadratic (P < .0001), interactions of day × metritis (P = .013), and day × metritis × Se treatment (P = .024). Holstein and Jersey breeds utilized in this experiment account for the relationship between body weight and uterine size. Further study is warranted to characterize the allometric relationship of body size to uterine size. Comparing coxae width with uterine diameter may provide a more accurate description of the relationship between body size and uterine diameter, because each is a cross-sectional measure. The curvilinear relationship between day postpartum and uterine size (Table 1, Figure 1) agrees with results previously presented (3, 9).

Cows diagnosed with abnormal uterine health had greater uterine diameter than those cows diagnosed normal (Table 1, Figure 1) (9). The significant (P = .024) interaction of Se treatment × day postpartum × metritis was evaluated further by testing the differences between linear coefficients of regression equations and the day of plateau (minimum size of uterine diameter) by least significant difference test (15) (Table 2). Rate of uterine involution (cm/d) was significantly (P < .05) different in cows with metritis and not Se treated when compared with cows with metritis and Se treated. Selenium treatment had no significant effect on rate of uterine involution if cows were diagnosed with normal uterine health. Days to plateau of uterine diameter (minimum size) were significantly (P < .05) less in cows with metritis and Se treated when compared with cows with metritis and not Se treated (32.9 vs. 35.8). Selenium treatment had no significant effect on days to minimum uterine size if cows were diagnosed with normal uterine health. The mechanism of effect of Se on uterine involution

<table>
<thead>
<tr>
<th>Source</th>
<th>Estimate</th>
<th>SE</th>
<th>P (Ho)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall mean, cm</td>
<td>4.5295</td>
<td>.0685</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Treatment with Selenium</td>
<td>-.0742</td>
<td>.1974</td>
<td>.708</td>
</tr>
<tr>
<td>Metritis</td>
<td>-.1080</td>
<td>.1989</td>
<td>.589</td>
</tr>
<tr>
<td>Se × metritis</td>
<td>.0319</td>
<td>.1984</td>
<td>.873</td>
</tr>
<tr>
<td>Cow weight</td>
<td>.0030</td>
<td>.0011</td>
<td>.008</td>
</tr>
<tr>
<td>Day</td>
<td>-.0298</td>
<td>.0150</td>
<td>.053</td>
</tr>
<tr>
<td>Day × Se</td>
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<td>.024</td>
</tr>
<tr>
<td>Day × day</td>
<td>.0075</td>
<td>.0010</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

1 Treatment with Se: 1 for control, −1 for Se supplemented; metritis: 1 for normal, −1 for metritis diagnosis.
2 Overall error term had 47 degrees of freedom and mean square = .1395.
3 Cow (Se × metritis) was the appropriate error term to test Se treatment, metritis, Se × metritis, and cow weight. Other terms were tested with the remainder of the overall model.
4 Probability that the estimate equals zero.

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Figure 1. Regression lines for uterine involution between 14 and 46 d postpartum. Regression equations: 1) no selenium, metritis, uterine diameter (cm) = 14.20524 - .53906 d + .00752 d²; 2) selenium, metritis, uterine diameter = 12.56448 - .49290 d + .00752 d²; 3) selenium, normal, uterine diameter = 12.26999 - .48794 d + .00752 d²; and 4) no selenium, normal, uterine diameter = 11.15290 - .44884 d + .00752 d².

is not known; however, it has been reported (11) that Se-vitamin E treatment increased uterine contraction in ewes. Therefore, it is possible that the observed effect of Se on uterine involution in cows with metritis may be through improved muscle function.

CONCLUSIONS

Data indicated that 1) prepartum Se treatment significantly reduced the days to reach minimum uterine size in cows diagnosed with metritis, and 2) cow weight, as an indicator of cow size, was significantly related to uterine size. Further studies are warranted to: 1) determine the amount of supplemental Se that will provide optimum uterine involution, and 2) characterize the allometric relationship between body size and uterine diameter.

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TABLE 2. Summary of linear regression coefficients and days to minimum uterine diameter for metritis by selenium treatment subclasses.

<table>
<thead>
<tr>
<th>Se</th>
<th>No Se</th>
<th>Se</th>
<th>No Se</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear coefficient (cm/d)</td>
<td>-.48794_{ab}</td>
<td>-.44884_{a}</td>
<td>.49290_{b}</td>
</tr>
<tr>
<td>Days to minimum uterine size</td>
<td>32.4_{ab}</td>
<td>29.8_{a}</td>
<td>32.9_{b}</td>
</tr>
</tbody>
</table>

*Means in a row with different superscripts differ (P<.05) by least significant differences test (7).
REFERENCES