Effects of Exogenous Oxytocin on Production and Milking Variables of Cows

R. C. GOREWIT and R. SAGI
New York State College of Agriculture and Life Sciences
Departments of Agricultural Engineering and Animal Science
Cornell University
Ithaca, NY 14853

ABSTRACT

Five doses of oxytocin (.5, 1.0, 1.5, 2.0, 3.0 IU) were injected through the subcutaneous abdominal vein (milk vein) of 15 Holstein Friesian cows 1 min before machine attachment. After teat cup removal, cows were given 10 IU of oxytocin via the milk vein for measurement of residual milk 1. An additional 10 IU of oxytocin was given 15 min later for estimating residual milk 2. Total milk yield was slightly higher for cows receiving 2.0 and 3.0 IU oxytocin. Milk fat yield was highest for cows receiving 2.0 and 3.0 IU oxytocin. Percent milk protein was less for cows receiving higher doses. Administration of 2.0 or 3.0 IU oxytocin significantly reduced total residual milk yield as compared with other doses. Fat percent in total residual milk was not affected by administration of oxytocin. Machine-on time, peak flow rate, and average milk flow rate did not differ with oxytocin treatment. A dose of either 2.0 or 3.0 IU oxytocin given via the milk vein will lead to slightly higher milk yields but will not affect milk flow dynamics as compared with lower doses. Moreover, milk fat yield is increased and total residual milk yield is decreased with either 2.0 or 3.0 IU oxytocin, suggesting that these doses result in more efficient extraction of milk. Administering more than 3.0 IU of oxytocin intravenously to promote milk ejection should be of no advantage.

INTRODUCTION

Small doses of exogenous oxytocin, administered i.v., may mimic stimuli that normally promote milk ejection in cows. Efficacy of these amounts depends on criteria to determine milk ejection. Cleverly (1) found that .1 IU of oxytocin administered i.v. to cows elicited increased intramammary pressure equivalent to that during milking. Donker (2) found that .12 IU oxytocin was needed to elicit normal ejection in one cow; residual milk yield was an index. Peeters et al. (6) measured quantities of milk ejected from the left forequarter of cows after i.v. injection of oxytocin. They reported that the threshold concentration needed to elicit milk ejection was approximately .02 IU. By observing the presence or absence of bimodal milk flow patterns, Sagi et al. (8) reported that .02 IU oxytocin elicited milk ejection in 9 of 16 cows receiving this treatment and that .10 IU induced milk ejection in all cows. Increasing the dose to .30 IU resulted in greater peak milk flow rates and shorter machine on-time.

Peak oxytocin concentrations in blood sera of cows, as a result of milking stimuli, are in the range of 11 to 65 μU/ml by radioimmunoassay methods (4, 7). If mixing of oxytocin in blood after its release during milking is homogeneous, one can approximate the total amount of hormone released from the posterior pituitary into the blood from its peripheral concentration. An adult dairy cow having approximately 40 liters of blood would have to release about .4 to 2.6 IU of endogenous oxytocin to establish the range of concentrations mentioned.

The objective was to determine if increasing the dose of exogenous oxytocin to greater than .3 IU influences milk production and milking variables of lactating cows.
MATERIALS AND METHODS

Fifteen Holstein Friesian cows were approximately 160 days postpartum. They were divided equally among first, second, and third lactations. Five doses of synthetic oxytocin (.5, 1.0, 1.5, 2.0, 3.0 IU) were administered by injection of 2 ml of hormone through the subcutaneous abdominal vein (milk vein) 1 min before machine attachment. Treatment doses were prepared by dilution of a 20 IU/ml stock solution of oxytocin (Sussex Drug Products Co., NJ) with sterile .85% saline. Treatments followed the sequence of three orthogonal 5 x 5 Latin squares, yielding a double changeover design. Each treatment lasted 2 days and injections were given only once during each period (a.m. milking), allowing cows to rest for three consecutive milkings between injections. The whole sequence lasted 8 days, was repeated twice, and yielded 30 observations per treatment. Milking equipment and data acquisition were similar to those described in (8).

General Procedures and Data Collection

Milking was at 0800 and 2000 h. Precautions were taken to prevent conditioned release of oxytocin before milking and thus ensure that milk ejection was attributed to the particular stimuli tested, i.e., administration of oxytocin or milk evacuation. Some of these precautions were: personnel (samplers and milkers) were present and activities near cows started at least .5 h before actual milking; udders were not washed, massaged, or manipulated in any other way before milking units were attached; milking order was always random.

Residual milk was harvested in two stages according to the following routine. Sixty seconds after removal of teat cups (but not earlier than 10 min after initial injection of oxytocin) cows were given 10 IU oxytocin via the milk vein for determination of the first residual (RM1). Cows were not stripped prior to injection of oxytocin for measuring RM1. An additional 10 IU of oxytocin was given 15 min later for estimation of the second residual milk (RM2).

Total milk yields were calculated by adding the two residual milk yields (RM1 and RM2) to the yield at the milking proper. Fat and protein content of all milk samples were measured by Dairy Herd Improvement Association (DHIA) test procedures (infrared analysis).

Statistical Analyses

Analyses were by the Linear Model procedure of the SAS program (3). Tests of significance were on adjusted least square means generated for each dependent variable.

RESULTS AND DISCUSSION

Least square means of production and milking variables, as affected by doses of exogenously administered oxytocin, are in Table 1. Milk yield of milking proper (kg/milking) was less for cows treated with .5 IU of oxytocin than for cows receiving larger doses. More milk was harvested from cows receiving 2.0 and 3.0 IU oxytocin than from cows receiving less. However, these differences were not significant. Administration of 2.0 and 3.0 IU of exogenous oxytocin significantly reduced total residual milk yield (RM1 + RM2) compared with other doses. Also, residual milks as percentages of total yield were significantly less for cows receiving 2.0 and 3.0 IU of oxytocin than for lower doses. This indicated that the 2.0 and 3.0 IU doses were more effective in extracting milk from the udder. Treatment milking times and peak and average rates of milk flow did not differ significantly (Table 1). Total yield including yields from both residual milkings was not affected significantly by oxytocin. This suggested that the method in this experiment for harvesting residual milk was effective and consistent between treatments.

Least square means of milk composition variables as affected by doses of exogenous oxytocin are in Table 2. Treatment of cows with 1.5, 2.0, or 3.0 IU of oxytocin significantly elevated fat percent as compared with cows given .5 IU oxytocin. Protein percent milk was less for cows given 2.0 or 3.0 IU oxytocin than for cows given either .5 to 1.0 IU. Differences between protein percent of milk of cows given .5, 1.0, or 1.5 oxytocin were not significant. This further indicated that either 2.0 or 3.0 IU of oxytocin was more effective in removing milk from udders compared with other doses. Milk fat yield was highest for those cows that received 2.0 or 3.0 IU oxytocin compared with other treatments. Cows receiving .5 IU of oxytocin yielded less fat than cows.
### TABLE 1. Least square means of production and milking variables as affected by dose of exogenous oxytocin.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>F</th>
<th>Covariable</th>
<th>Effect of covariable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.5 IU</td>
<td>1.0 IU</td>
<td>1.5 IU</td>
<td>2.0 IU</td>
</tr>
<tr>
<td>Milk yield, kg/milking</td>
<td>13.46b</td>
<td>13.79ab</td>
<td>13.66ab</td>
<td>14.15b</td>
</tr>
<tr>
<td>Total residual yield, kg/milking</td>
<td>2.39a</td>
<td>2.27a</td>
<td>2.25a</td>
<td>.88b</td>
</tr>
<tr>
<td>Total yield, kg/milking</td>
<td>15.85a</td>
<td>16.06a</td>
<td>15.92a</td>
<td>16.03a</td>
</tr>
<tr>
<td>Residual milk, % of total yield</td>
<td>14.93a</td>
<td>13.93a</td>
<td>13.82a</td>
<td>11.67b</td>
</tr>
<tr>
<td>Milking time, min</td>
<td>6.03a</td>
<td>6.11a</td>
<td>6.11a</td>
<td>6.21a</td>
</tr>
<tr>
<td>Peak milk flow rate, kg/min</td>
<td>3.37a</td>
<td>3.41a</td>
<td>3.55a</td>
<td>3.41a</td>
</tr>
<tr>
<td>Average milk flow rate, kg/min</td>
<td>2.39a</td>
<td>2.39a</td>
<td>2.36a</td>
<td>2.36a</td>
</tr>
</tbody>
</table>

*a,b,c Means with the same letter in the same row are not significantly different from one another.*

*Least square means were adjusted for effects of covariance when applicable.*

### TABLE 2. Least square means of milk composition variables as affected by doses of exogenous oxytocin.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>F</th>
<th>Covariable</th>
<th>Effect of covariable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.5 IU</td>
<td>1.0 IU</td>
<td>1.5 IU</td>
<td>2.0 IU</td>
</tr>
<tr>
<td>Fat in milk, %</td>
<td>3.36b</td>
<td>3.52ab</td>
<td>3.54a</td>
<td>3.68a</td>
</tr>
<tr>
<td>Protein in milk, %</td>
<td>3.21a</td>
<td>3.21a</td>
<td>3.19ab</td>
<td>3.17b</td>
</tr>
<tr>
<td>Milk fat yield, kg/milking</td>
<td>.45c</td>
<td>.48b</td>
<td>.48b</td>
<td>.52a</td>
</tr>
<tr>
<td>Total residual fat, %</td>
<td>10.73a</td>
<td>10.73a</td>
<td>10.44a</td>
<td>10.52a</td>
</tr>
<tr>
<td>Total residual protein, %</td>
<td>2.48a</td>
<td>2.43a</td>
<td>2.50a</td>
<td>2.44a</td>
</tr>
<tr>
<td>Total residual fat yield, kg/milking</td>
<td>.26a</td>
<td>.25ab</td>
<td>.24ab</td>
<td>.26b</td>
</tr>
</tbody>
</table>

*a,b,c Means with the same letter in the same row are not significantly different from one another.*

*Least square means were adjusted for effects of covariance when applicable.*
given other treatments. There was a trend toward increased yield of fat harvested at milking proper with increased dosage of oxytocin (Table 2). An opposite trend was observed for residual fat yields. Fat and protein percentages in the total residual milk (RM1 + RM2) were not affected by treatments. Total residual fat yield was significantly greater for cows receiving .5 IU as compared to cows receiving 2.0 and 3.0 IU oxytocin.

Least square means of yield and composition of residual milk 1 (RM1) and residual milk 2 (RM2) of cows given various doses of exogenous oxytocin are in Table 3. Yields for RM1 were significantly less for cows receiving 2.0 and 3.0 IU oxytocin than for cows receiving .5 IU of oxytocin. There were no significant differences between RM1 yields of cows receiving 1.0, 1.5, 2.0, and 3.0 IU oxytocin. Cows receiving either 2.0 or 3.0 IU oxytocin had less RM2 than cows receiving lower doses of oxytocin (Table 3). These residual milk yield data further suggest that a dose of 2.0 or 3.0 IU oxytocin leads to more complete extraction of milk from the udder.

A single injection of oxytocin after routine milking, for RM1, led to removal of 65 to 72% of complementary milk (Table 3). As much as 30% more residual milk was left in the udder after the first injection of oxytocin. A second injection of oxytocin was necessary to obtain the remaining 30%. Residual milk may be overestimated slightly because some instantaneous milk secretion could have taken place between harvesting of RM1 and RM2. Our data support the contention of (5, 9, 10, 11) that more than one oxytocin injection is necessary to remove all complementary milk.

In RM1, fat percent was slightly higher and protein percent slightly lower for cows receiving 2.0 or 3.0 IU of oxytocin than for lower doses (Table 3). In RM2, fat percent was slightly lower for cows receiving 2.0 IU of oxytocin than for cows receiving lower doses. Variations of protein percent in RM2 were not significant.

**CONCLUSION**

A dose of either 2.0 or 3.0 IU oxytocin given via the milk vein will lead to slightly higher milk yields but will not affect milk flow dynamics as compared with lower doses (.5, 1.0, 1.5 IU). Moreover, milk fat yield is in-
creased and total residual yield is decreased with either 2.0 or 3.0 IU oxytocin. Our data suggest that 2.0 or 3.0 IU exogenous oxytocin results in more efficient extraction of milk, and administering more than 3.0 IU of hormone i.v. to promote milk ejection should offer no advantage.

ACKNOWLEDGMENTS

The authors express their appreciation to LaFawn Maxwell for typing the manuscript. This study was financed by grants from the Alfa-Laval De-Laval Group, the New York State Agricultural Experiment Station, and a Bi-national Agricultural Research and Development Grant.

REFERENCES