Effects of Unstable Milking Vacuum on Some Measures of Udder Health

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Abstract

Two groups of 15 cows each were milked for one year with two separate vacuum systems, one of which provided stable line vacuum, while the other showed moderate vacuum fluctuation on the line. During the experimental period, no differences were observed between the two groups in the mean of the logarithms of milk leucocyte counts, number of quarters newly infected with *Streptococcus agalactiae* or hemolytic staphylococci, or in number of attacks of clinical mastitis.

It is widely believed that poor milking techniques and improperly operating milking machines may have harmful effects on mammary gland health and may predispose to attacks of clinical mastitis. Various aspects of milking machine systems as related to udder health have been investigated by many workers. This work has recently been reviewed (5). One factor for which there is evidence to suggest a role in the etiology of mastitis is that of vacuum instability.

Stanley et al. (11), using a modified milking machine in which vacuum within the teat cups varied from 17.8-38.1 cm (7 to 15 inches) Hg at a rate of approximately 53 fluctuations per minute, showed that California Mastitis Test scores and direct microscopic leucocyte counts increased, and the number of samples with alkaline reactions increased in comparison to those from cows milked with a standard machine. In each of two experiments, two of six cows milked with the modified machine suffered attacks of clinical mastitis during the 21- and 26-day trials, while none of the control cows was so affected.

In a field survey Braund and Schultz (4) found a significant correlation between the magnitude of vacuum fluctuation on the line and the percentage of CMT-positive quarters and cows in the herd. Beckley and Smith (2) reported a positive correlation between the degree of vacuum fluctuation at the teat end and the percentage of positive CMT reactions in the bucket milk.

In a study of 26 herds Nyhan and Cowhig (7) found that in herds milked with inadequate vacuum reserve, which presumably led to vacuum fluctuations during milking, there were higher leucocyte counts in bulk milk, higher CMT scores in individual quarters, greater incidence of infection, and greater incidence of clinical mastitis.

Schmidt et al. (10) milked two groups of eight cows with a milking machine in which the milk was elevated to a height of 1.82 m (6 ft) above the level of the udder before the milk entered the milker pail. This modification produced a lower average vacuum level as well as greater vacuum fluctuations as measured close to the teat end. No significant effects on California Mastitis Test scores or leucocyte counts due to this modification of the milking machine were found in 25-day trials.

The work reported here was undertaken to compare the long-term effects on udder health of a stable vacuum system as measured on the vacuum line with those of a system with a moderate degree of vacuum fluctuation.

Materials and Methods

Thirty purebred Guernsey cows in their first through ninth lactations were studied over a 20-month period. During an initial eight-month baseline period, all cows were milked with the same milking system. At the end of this baseline period, the cows were divided on the basis of the data already collected into two groups as nearly alike as possible with respect to age, milk leucocyte counts, type and incidence of existing udder infections, and history of clinical mastitis. A comparison of the two groups at the end of the baseline period is shown in Table 1.

During the baseline period all cows were milked similarly. Cows were housed in a stall barn and milked in their stalls with a DeLaval pail-type milker. The milking system included a Model 73 DeLaval vacuum pump with a rated...
TABLE 1. Characteristics of two groups of cows during the eight-month baseline period when both groups were milked with the same vacuum system.

<table>
<thead>
<tr>
<th>Group</th>
<th>Stable vacuum</th>
<th>Fluctuating vacuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of cows</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Average age (years)</td>
<td>5.6</td>
<td>4.8</td>
</tr>
<tr>
<td>Mean of logarithm of leukocyte counts</td>
<td>5.215</td>
<td>5.164</td>
</tr>
<tr>
<td>Attacks of clinical mastitis</td>
<td>18*</td>
<td>11</td>
</tr>
</tbody>
</table>

* One cow suffered eight of these attacks, five in one quarter, three in another.

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capacity of .24 m³/minute at 38.1 cm of vacuum and a 2.54 cm id vacuum line. Pulsation was provided by Sterling vacuum-operated pulsators at 60 pulsations/minute and a vacuum: release ratio of 1.5:1. The vacuum controller was a DeLaval Model 0259. Teat cups were fitted with DeLaval 01 narrow bore inflations.

At the end of the baseline period a second vacuum system was installed which included a Model 75 vacuum pump with a rated capacity of 0.42 m³/minute at 40.6 cm of vacuum and a 3.17 cm id vacuum line. The vacuum controller on this system was similar to that on the old system.

Also at the end of the baseline period a magnetically controlled pulsation system was installed to replace the vacuum-controlled system previously in use. During the experimental period, pulsation for both the stable and fluctuating vacuum systems was provided by this pulsation device. This magnetic system, like the vacuum-controlled system previously in service, delivered 60 pulsations/minute with a 2.5:1 vacuum:release ratio.

There were now two complete vacuum systems in the barn, but only one pulsation system. At each stall the stallcock for only one of the vacuum lines was connected to the timer-converter so that a particular cow could be milked only with the vacuum system to which she was assigned. Throughout the one-year experimental period, one group of cows was milked with the new vacuum system which had stable line vacuum; the other group was milked with the old vacuum system, which had a moderate degree of vacuum fluctuation.

Vacuum levels and fluctuations on the vacuum lines were measured and recorded at intervals throughout the experimental period using a Statham P23AC strain gauge pressure transducer and a Grass Model 7 Polygraph. Although this transducer was not specifically designed to measure vacuum levels, it was found that over the range of 0 to 40.6 cm of vacuum, linear calibration curves were obtained.

Representative tracings of the vacuum fluctuations which occurred on the two vacuum lines when a milking unit was placed in operation are shown in Figure 1. The vacuum fluctuations during an entire milking were so recorded and the average vacuum drop and recovery time computed. The average drop in line vacuum when a machine was placed in operation was 3.3 ± 0.1 cm (mean ± std dev) and 1.0 ± 0.1 for the stable system. The mean recovery time for the fluctuating system was 20.5 ± 1.0 seconds and for the stable system 5.4 ± 2.8 seconds. The vacuum levels with no load were 35.6 cm in the fluctuating system and 39.1 cm in the stable system.

During the experimental period this difference in vacuum systems was the only difference in the way the two groups were milked. All cows were milked by the same operators using the same sanitary procedures and the same milking machines and pulsation system for both groups of cows. Since the cows were randomly placed in the barn, it was assumed that the degree of exposure to new infection carried on the milking machines from previously milked cows would be similar.

Examination of milk samples. Throughout
both the baseline and experimental periods, individual quarter samples were collected from lactating cows just before the morning milking at biweekly intervals. Theudder and teats were washed with individual paper towels soaked in Iodophor solution, and the ends of the teats and teat orifices swabbed vigorously with gauze sponges soaked in 70% ethanol before sample collection. Samples were collected as aseptically as possible into sterile Hotis tubes.

The California Mastitis test (8) and direct microscopic leucocyte counts were carried out on these samples (8). A 0.01-ml volume of milk was streaked on to one quarter of an agar plate containing 5% washed bovine red cells. In samples which had a high California Mastitis test result, or which came from quarters previously infected with pathogenic organisms, the milk was incubated at 34°C for 20 hours and then streaked again on blood agar. An organism was considered as being present in an established mammary gland infection only if it was isolated a) in the presence of clinical mastitis, b) from milk with a leucocyte count of one million/milliliter or higher, or c) from two or more successive samples.

Staphylococcal isolates were considered hemolytic, and presumably pathogenic, if the colonies produced a zone of alpha or beta hemolysis greater than 1 mm in width. Streptococcus agalactiae isolates were distinguished from other streptococci by the Hotis and CAMP reactions (8).

In computing mean leucocyte counts at each sampling period, it was found that one or two very high counts in one sampling period would produce a large variation in the arithmetic mean. For this reason, leucocyte counts were converted to their logarithms and the mean of the logarithms of the leucocyte counts used in compiling data.

Clinical mastitis was defined as those cases called to the attention of the attending veterinarian by the milkers and which, in his opinion, required medical treatment.

Statistical procedures were carried out according to Alder and Roessler (1).

Results

The means of the logarithms of the leucocyte counts of the individual quarter samples of the two groups of cows at each of the biweekly samplings are presented graphically in Figure 2. The average of these mean values over the baseline period, when both groups of cows were milked in identical fashion, was 5.125 for the stable vacuum group and for the fluctuating vacuum group, 5.164. During the experimental period the value was 5.501 for the stable vacuum group and 5.442 for the fluctuating vacuum group. When tested by analysis of variance the differences between the two groups were not significant during either the baseline or experimental period. However, both groups had significantly higher (P < .01) values during the experimental period than during the baseline. Figure 2 shows that leucocyte counts for both groups increased at the beginning of the experimental period and then tended to decrease, although the mean value at any one sampling period seldom reached the average baseline level.

The numbers of new infections with S. agalactiae and hemolytic staphylococci, the common mastitis pathogens in this herd, are shown in Table 2. When tested by adjusted Chi square, the incidence of new infections with either of these pathogens was not significantly different between the two groups during the experimental period. When the data from both groups were combined, the incidence of new infection with S. agalactiae was not significantly different between the baseline and experimental periods, but the incidence of new infection with hemolytic staphylococci was significantly higher (P < .05) during the experimental period than during the baseline.

The numbers of cases of clinical mastitis occurring in the two groups of cows are shown in Table 3. When tested by adjusted Chi square the numbers of attacks were not significantly different between the two groups either during the baseline or experimental period. When data from both groups were combined the incidence of clinical mastitis was lower (P < .01) during the experimental period than during the baseline period. To test the possibility that this difference was due to one cow who suffered eight attacks during the baseline and none during the experimental period, the results were re-evaluated omitting the data from this one cow; the incidence was still significantly lower (P < .02) during the experimental period.

This investigation was undertaken to compare the effects of a milking system with stable line vacuum with a system which had a moderate degree of vacuum fluctuation on the line during the milking operation. No significant differences were found in the logarithms of leucocyte counts, incidence of new infections with S. agalactiae or hemolytic staphylococci.

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*Agway, Inc., Syracuse, New York. Diluted to provide 25 ppm available iodine.*

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or incidence of clinical mastitis between two similar groups of cows milked for a period of one year on the two systems. It should be noted, however, that the degree of vacuum instability even in the fluctuating system was less than is seen in some farm installations. It is possible that more marked fluctuations than those present in this experimental system may have harmful effects.

Significant differences were noted, however, in both groups between the baseline and experimental periods. The one change in the milking system which occurred between the baseline and experimental period and which applied to both groups of cows was the installation of a magnetically controlled pulsation system to replace the vacuum pulsation previously in use. It is tempting to assume that this factor may have produced the differences observed. However, this variable was entirely uncontrolled, and no experimental data on the relative performance of the two pulsation systems were obtained. Since the manufacturer's specifications indicate that both systems have the same pulsation rate and vacuum-release ratio, no conclusions concerning the effect of this factor on udder health have been drawn.

The increase in leucocyte counts during the experimental period may have been associated with environmental factors other than the milking system. The abrupt increase at the beginning of the experimental period was noted at the 16th sampling period, samples for which were collected on May 11. Leucocyte numbers remained elevated until about the 29th sam-

**Table 2. Number of newly infected quarters.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Baseline period (8 months)</th>
<th>Experimental period (12 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococcus agalactiae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stable vacuum</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Fluctuating vacuum</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Hemolytic staphylocoeci</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3. Number of attacks of clinical mastitis.**

<table>
<thead>
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<th>Group</th>
<th>Baseline (8 months)</th>
<th>Experimental (12 months)</th>
</tr>
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<tr>
<td>Stable vacuum</td>
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</tr>
<tr>
<td>Fluctuating vacuum</td>
<td>11</td>
<td>6</td>
</tr>
</tbody>
</table>
pling, which took place on November 9. The period of marked elevation of leucocyte concentrations therefore spanned the pasture season, but it is not known whether these factors are related. This apparently seasonal increase could not be attributed to a disproportionately large number of cows drying off and calving during this period.

The increase in leucocyte counts during the experimental period was probably not caused by increased levels of infection in the herd. While new *S. agalactiae* infections did occur during the experimental period, some infections were lost, either spontaneously or as the result of antibiotic treatment of clinical mastitis, so that the level of *S. agalactiae* infection remained fairly constant. There was an increase in hemolytic staphylococcal infection during the experimental period. However, this occurred primarily during the last five months of the experimental period, while the increase in leucocyte counts was most marked early in the experimental year. The increase in staphylococcal infections was probably not an important factor in the increase in leucocyte counts.

A surprising finding was that while leucocyte counts were generally higher during the experimental period for both groups, the incidence of clinical mastitis was lower. Recent work has tended to emphasize the protective effects of milk leucocytes (3, 6, 9). It has been suggested, in fact, that three-times-daily milking, which tends to maintain a higher leucocyte count throughout the day, might be a means of controlling staphylococcal mastitis (12). This work is cited here to suggest the possibility that the reduced incidence of clinical mastitis during the experimental period may have been due, at least in part, to the higher level of leucocytes.

During the course of the experiment some recordings of vacuum levels in the teat cup during milking were made. It was noted that on both vacuum systems, including the control system which had very stable line vacuum, vacuum levels in the teat cups commonly fluctuated by 10.2 cm or more during the period of peak milk flow. Vacuum fluctuations of more than 7.6 cm were considered by Beckley and Smith (2) as indicative of poor vacuum stability. If this criterion is accepted, even the stable vacuum line provided unsatisfactory stability at the teat end. Good vacuum stability on the vacuum line does not ensure stability within the teat cups.

**References**


