Evaluation of an Experimental Milking Pulsation System for Effects on Milking and Udder Health

D. J. Wilson,* R. N. Gonzalez,* L. H. Southwick,* and C. L. Guard†
*Quality Milk Promotion Services and
†Ambulatory and Production Medicine Service,
Department of Population Medicine and Diagnostic Sciences,
College of Veterinary Medicine
Cornell University, Ithaca, NY 14850

ABSTRACT

This study was to test whether cows milked by an experimental pulsation method differed from cows milked with conventional pulsation milking in somatic cell count (SCC), intramammary infections (IMI) defined by milk bacteriological culture results, teat end condition, or milk flow rate. The study design was a 1-yr trial with a completely randomized block crossover. Holstein cows were blocked into 15 pairs of contemporaries. Both cows from each pair were milked with experimental pulsation and with conventional pulsation for 6 mo, in reverse order from each other. The SCC (217,000/ml) of experimentally milked cows was not significantly different from SCC of conventionally milked cows (175,000/ml). Mean milk flow rate was 5.2 lb/min (2.4 kg/min) for experimentally milked cows and 5.3 lb/min (2.4 kg/min) for conventionally milked cows, not significantly different. Differences among the experimentally and conventionally milked cows, respectively, in new (13.5 and 12.7%), chronic (12.9 and 8.9%), and negative (73.6 and 78.4%) quarter culture results were not significant. New IMI per 100 d of lactation were 1.50 and 1.46, and chronic IMI per 100 d were 1.85 and 1.27, for experimentally and conventionally milked cows, respectively. These IMI rates were not significantly different between pulsation types. There were more new *Staphylococcus aureus* IMI associated with conventional pulsation, but overall cases of *Staph. aureus* were similar between the two types of pulsation. Teat end scores for the experimentally and conventionally milked cows, respectively, were good (6.5 and 11.7%), intermediate (68.2 and 66.9%), and poor (25.3 and 21.4%), not significantly different. These results support previous studies, which have found that except for complete failure of pulsation, differences in pulsation characteristics apparently have little effect on milking and udder health.

(**Key words:** milking system, pulsation, bovine, mastitis, udder health)

Abbreviation key: CFM = cubic feet per minute (US standard); **CNS** = coagulase-negative staphylococci.

INTRODUCTION

The CoPulsation™ Milking System (Lisle, NY) is a new pulsation method with a rapid transition between milk and massage phase of the milking liner (inflation). The manufacturer has stated that teat end condition, milkout, and control of mastitis are improved by this method (W. Gehm, Lisle, NY, personal communication; 1). The objective of this study was to test whether cows milked with this experimental pulsation differed from cows milked with conventional pulsation (single-pulsation electric pulsators, Babson Bros.-Surge, Naperville, IL) in SCC, IMI defined by milk bacteriological culture results, teat end condition, or milk flow rate. The study was conducted for 1 yr using a completely randomized block crossover design.

MATERIALS AND METHODS

A herd of Holstein dairy cattle is maintained for teaching and research purposes at the Cornell University College of Veterinary Medicine. Cows are housed in a tie-stall barn and milked with an around the barn highline milking system. During the year of the trial, milk production was 10,450 kg (23,018 lb)/305 d per cow, and mean SCC was 198,000/ml in bulk tank milk. Cows were fed a TMR including corn silage, mixed grass haylage, ground shelled corn, and a protein supplement; in addition to the TMR they were fed alfalfa hay. Water was free choice from automated drinking bowls. From the herd of 53 lactating cows, 30 cows were selected that were considered most likely to remain in the herd for the next year. They were blocked into 15 pairs of contemporaries based on parity, DIM, baseline milk culture results, and—if already pregnant—expected dry off and calving dates. Five blocked pairs of first lactation Holstein heifers and 10 pairs of older

Received October 12, 1999.
Accepted March 26, 2000.
Corresponding author: D. J. Wilson; e-mail: djwll@cornell.edu.

cows (lactation 2 or higher) were identified. Each pair of cows was approximately 6 mo apart in DIM and, therefore, were milked with each type of pulsation at similar stages of lactation. The cows were also similar in total IMI. Each pair was randomly divided, and one cow was assigned to a conventional pulsation group, while the other cow was assigned to an experimental pulsation group. Eight new CoPulsation™ pulsators were installed in a section of the barn where 15 cows were milked; the rest of the barn was left suitable for conventional pulsation milking with four milking units. After 6 mo, all cows were reversed between milking groups; each cow was milked for 6 mo with one type of pulsation, and then for 6 mo with the other.

Once each month from September 1997 through September 1998, milk samples from each quarter of all cows enrolled in the study that were lactating were aseptically collected for bacteriological culture, and SCC were measured (Fossomatic, Hillerød, Denmark) from milk samples collected using milk meters obtained from the Dairy Herd Improvement Association (DHIA, Dairy One Cooperative, Ithaca, NY). Bacteriological procedures have been described previously (9). Isolation of three or more types of bacteria was defined as contamination; however, isolates of *Staphylococcus aureus* were always defined as IMI. A cow was eligible to have more than one case of mastitis from the same quarter milk sample. Multiple isolates were counted as one mastitis case caused by each different pathogen, and each isolate was evaluated separately regarding whether it was subsequently spontaneously cured or repeated as a chronic case. Contaminated samples were excluded from analysis.

IMI were defined as new or chronic. Case definition of a new IMI was when a quarter milk sample was culture positive for a mastitis pathogen that was not detected in the previous month's milk sample for that quarter (or when the cow had not been lactating the previous month and a pathogen was found in the first milk sample of a new lactation). Chronic IMI was defined by finding a quarter milk sample positive for the same pathogen that had been isolated from the same quarter in the previous month's milk sample.

Also once per month, teat end condition of all lactating teats of the subject cows was scored by four investigators who had standardized a teat end scoring method by comparing teat end scores of many cows with each other before the start of the trial. At least two of these four investigators scored teat end condition each month. Teat ends were scored as good, intermediate, or poor using objective criteria. Good teat ends were very smooth with no raised ring or roughness. Intermediate teat ends had a raised ring, any palpable roughness, or slight hyperkeratosis. Poor teat ends had injuries, papillomas (warts), cracks, markedly raised rings, or marked roughness. Teat end scores of each evaluator were not known to the others until after teats were scored each month.

At one milking per month, each cow's milk production was measured with the milk meters and the time from milking machine attachment until milk flow ceased was determined with digital stopwatches. Mean milk flow rate in kilograms (pounds) per minute was calculated.

Performance of the milking system—including vacuum pump output measured as cubic feet per minute (US) (**CFM**), vacuum reserve as CFM, regulator response test, pulsation rate, ratio, and graphs of pulsation vacuum, and teat end vacuum using a vacuum recorder—was evaluated once per month during the study.

Statistical Analyses

Differences in SCC and milk flow rate (continuous variables) among cows while milked with the experimental or conventional pulsators (categorical variable) were tested for significance using ANOVA. The association between pulsation type and whether cows had new or chronic cases of mastitis defined by positive milk culture and their teat end condition scores (all categorical variables) were evaluated using chi-square.

RESULTS

Twenty-four of the 30 animals (80%) remained in the herd until the end of the study. During the year, one cow died suddenly, two had musculoskeletal injuries, and three were culled due to reproductive failure. The two groups of cows were similar in DIM at the beginning of the trial and at crossover to the other type of pulsation, in all cases averaging approximately 160 DIM (Table 1). Each cow went through similar stages of lactation while being milked with each type of milking system as her partner did (the cows were approximately 6 mo apart in lactation/reproduction status). The number of IMI per cow were similar in each group initially and at crossover to the other type of pulsation (Table 1).

All milking system test results met industry standards for performance. The pulsation rate for the CoPulsation™ pulsators was 43 cycles/min, and the pulsation ratio ranged from 56:44 to 62:38; most of these experimental pulsators had a ratio of 60:40. For conventional milking units, the pulsation rate was 49 cycles/min and the pulsation ratio ranged from 51:49 to 59:41; most conventional pulsators had a ratio of 55:45.

The total number of quarters identified with mastitis pathogens isolated from quarter milk samples at the start of the trial in cows initially assigned to be milked

Table 1. Summary of blocking cows into randomized pairs for study.

	Cows in each lactation group		DIM		IMI/cow	
	1st	2nd+	Initial	Crossover	Initial	Crossover
Experimental[1]	5	10	158	160[2]	1.0	1.0
Conventional[3]	5	10	165	140[4]	0.6	0.5

[1]Cows milked with experimental pulsation for first 6 mo of trial.
[2]After crossover, "experimental" cows were milked with conventional pulsation for 6 mo.
[3]Cows milked with conventional pulsation for first 6 mo of trial.
[4]After crossover, "conventional" cows were milked with experimental pulsation for 6 mo.

with experimental and conventional pulsators, respectively, were: coagulase-negative staphylococci (**CNS**) 7, 6; *Staph. aureus* 5, 0; *Streptococcus* spp. (other than *agalactiae*) 1, 2; yeast 1,1; *Corynebacterium* spp. 1, 0 (Table 2). New IMI per 100 d of lactation were 1.50 and 1.46, and chronic IMI per 100 d were 1.85 and 1.27, for experimentally and conventionally milked cows, respectively. Overall new and chronic IMI rates were not significantly different between pulsation types. While overall cases of *Staph. aureus* were similar between the two types of pulsation, there were more new *Staph. aureus* IMI associated with conventional pulsation (cellular chi-square, $P < 0.05$) (Table 2).

During the study period, the mean of individual monthly SCC for all cows was 198,000/ml. Experimental pulsation-milked cows' SCC (217,000/ml) was not significantly different from SCC of conventionally milked cows (175,000/ml). Mean milk flow rate was 5.2 lb/min (2.4 kg/min) for all cows, 5.2 lb/min (2.4 kg/min) for experimentally milked cows, and 5.3 lb/min (2.4 kg/min) for conventionally milked cows; these flow rates were not significantly different (Table 3).

The proportion of quarters with new IMI, chronic IMI, and negative culture results were 13.1, 11.1, and 75.8%, respectively, for all cows. Differences among the experimentally and conventionally milked cows, respectively, in new (13.5 and 12.7%), chronic (12.9 and 8.9%), and negative (73.6 and 78.4%) quarter culture results were not significant (Table 3).

Teat ends were scored as good, intermediate, or poor in 8.9, 67.6, and 23.5% of all quarters of all cows during the course of the trial. Differences among the experimentally and conventionally milked cows, respectively, in good (6.5 and 11.7%), intermediate (68.2 and 66.9%), and poor (25.3 and 21.4%) teat end scores were not significant (Table 3).

DISCUSSION

There were no differences between conventionally milked cows and cows milked with CoPulsation™ milking in SCC, milk flow rate, proportion of quarters with new mastitis infections, chronic infections, and negative bacteriological culture results, or teat end condition. There was no overall difference between pulsation types in IMI caused by any pathogen, but new *Staph. aureus* IMI were higher with conventional pulsation.

Table 2. Comparison of mastitis bacteriology and new infection rates for cows while milked with experimental and conventional pulsation.

	IMI initially		New IMI per 100 d of lactation		Chronic IMI per 100 d of lactation	
Agent	Experimental[1]	Conventional[2]	Experimental[3]	Conventional[4]	Experimental[3]	Conventional[4]
Coagulase-negative staphylococci	7	6	0.96	0.82	0.33	0.46
Staphylococcus aureus	5	0	0.02*	0.31*	0.79	0.46
Streptococcus spp.	1	2	0.23	0.17	0.10	0.02
Yeast	1	1	0	0.02	0.12	0.02
Corynebacterium spp.	1	0	0.23	0.07	0.44	0.19
E. coli	0	0	0.02	0.02	0.02	0.02
Corynebacterium bovis	0	0	0.04	0.05	0.04	0.10
Total	15	9	1.50	1.46	1.85	1.27

[1]Mastitis bacteriological status of cows initially assigned to the experimental pulsation group.
[2]Mastitis bacteriological status of cows initially assigned to the conventional pulsation group.
[3]Results combined for all cows while they were milked with experimental pulsation.
[4]Results combined for all cows while they were milked with conventional pulsation.
*Significantly different, cellular chi-square, $P < 0.05$.

Table 3. Comparison of results for cows while milked with experimental and conventional pulsation.[1]

Variable	All cows	Experimental pulsation milking	Conventional pulsation milking
SCC/ml (mean of 13 monthly tests)	198,000	217,000	175,000
Milk flow rate (lb/min)	5.2	5.2	5.3
Quarter with new IMI	13.1%	13.5%	12.7%
Quarter with chronic IMI	11.1%	12.9%	8.9%
Quarter with negative culture	75.8%	73.6%	78.4%
Teat end score Good	8.9%	6.5%	11.7%
Teat end score Intermediate	67.6%	68.2%	66.9%
Teat end score Poor	23.5%	25.3%	21.4%

[1]No statistically significant differences were found.

Previous studies on the effect of pulsation on mastitis and udder health are relatively few. Two studies, each with the cooperation of approximately 300 farms, evaluated the relationship between various milking machine performance measures and mastitis and found that milking machine performance was not strongly related with prevalence of contagious mastitis (2), or SCC (4), respectively. Pulsation parameters were not significantly associated with mastitis (2, 4).

In a study of 1234 Norwegian dairy herds, a pulsation rate greater than 55 cycles/min was found to be associated with lowest SCC and clinical mastitis rate, and best control of *Staph. aureus* (6). Another study found that a 70:30 pulsation ratio resulted in a small increase in milking parlor throughput compared with pulsation at a 50:50 ratio. However, the rates of clinical mastitis, milk production, cull rate, and bulk tank SCC were not affected by pulsation ratio (8). A report from Japan found that "faulty pulsation" and changes in pulsation rate did not affect SCC or electrical conductivity of milk (5).

A prospective study of 24 Holstein cows comparing right and left quarters found that absence of pulsation markedly increased SCC and IMI compared with any pulsation (3). A review article regarding milking machines and mastitis concluded that pulsation rate and ratio "had little effect" on mastitis, but that complete failure of pulsation leads to new IMI (7).

It is acknowledged that pulsation during milking is important, in that complete failure of pulsation has been associated with increased mastitis. However, the results of the present study support many previous studies, which have concluded that differences in pulsation rate and ratio apparently have little or no effect on milking and udder health.

ACKNOWLEDGMENTS

This project was sponsored by Cornell University Veterinary Alumni Funds. We appreciate the help of the staff of the Research Barn at Cornell University College of Veterinary Medicine.

REFERENCES

1 Anonymous. 1996. Milking system works as promised. Focus on Farming, Moravia, NY, Nov. 4, 1996.
2 Benda, P. 1997. The effect of pipeline milking equipment on the incidence of the main mastitis pathogens (*Staphylococcus aureus*, *Streptococcus agalactiae*) in samples of milk from tanks. Vyzkum v Chovu Skotu 39:16–20.
3 Capuco, A. V., G. A. Mein, S. C. Nickerson, L.J.W. Jack, J.D.L. Wood, S. A. Bright, R. A. Aschenbrenner, R. H. Miller, and J. Bitman. 1994. Influence of pulsationless milking on teat canal keratin and mastitis. J. Dairy Sci. 77:64–74.
4 Hanus, O., and A. Tichacek. 1997. Analysis of milking technique effect on somatic cell counts. Stocarstvo 51:121–128.
5 Ichikawa, T., I. Notsuki, Y. Aoki, M. Ichikawa, and T. Fujishima. 1988. Effects of milking machine deformities on udder health. J. Soc. Agric. Struct. 18:49–57.
6 Osteras, O., O. Ronningen, L. Sandvik, and S. Waage. 1995. Field studies show associations between pulsator characteristics and udder health. J. Dairy Res. 62:1–13.
7 Spencer, S. B. 1988. The milking machine as a cause of mastitis. Agric. Pract. 9:45–49.
8 Thomas, C. V., D. R. Bray, and M. A. DeLorenzo. 1993. Evaluation of 50:50 and 70:30 pulsation ratios in a large commercial dairy herd. J. Dairy Sci. 76:1298–1304.
9 Wilson, D. J., P. M. Sears, R. N. Gonzalez, B. S. Smith, H. F. Schulte, G. J. Bennett, H. H. Das, and C. K. Johnson. 1996. Efficacy of florfenicol for treatment of clinical and subclinical bovine mastitis. Am. J. Vet. Res. 57:526–528.