Effect of Abraded Intramammary Device (IMD) on Milk Somatic Cell Count and Intramammary Infection

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Introduction

Two key components of current mastitis control practices which are used to reduce large economic losses are dipping teats in sanitizing solution after each milking and intramammary antibiotic therapy of all quarters at drying off. In herds where these practices are routinely carried out, incidence of mastitis is greatly reduced. Yet a major limitation of these control practices is that the cow is only protected against selected mastitis pathogens such as *Strep. agalactiae* and *S. aureus* but infections due to other species of streptococci are not usually reduced at all (6). These other streptococci and coliform bacteria are thought to reach the teat end from the environment between milking when germicidal activity of teat dip is diminished. Thus, new methods of mastitis prevention are needed which will reduce susceptibility of bovine mammary gland between milking.

Prophylaxis and therapy tend to protect and maintain in the herd dairy cows of relatively high susceptibility to mastitis. Thus, the present control approach is regressive. A farsighted mastitis research approach would have as its ultimate objective a dairy cow population with heightened natural resistance to the disease. The phagocytic activity of polymorphonuclear neutrophils (PMN) in eliminating microbial pathogens as they invade the mammary gland is a natural defense mechanism of the cow which seems accessible to enhancement by human intervention. The function of PMN has generally been characterized by providing a phagocytic barrier against pathogens which have penetrated streak canal. They are also believed to be instrumental in activating other mechanisms which lead to rapid infiltration of additional PMN during bacterial challenge (3, 4, 7).

In an effort to increase the natural defense mechanism of the udder, Paape et al (9) used a mechanical means to produce a sterile inflammation and thus induce leukocytosis by inserting a smooth polyethylene device (IMD) into the gland cistern. The polyethylene coil, 2.0 mm in diameter and 115 mm long, took the form of a loop of 25 mm which allowed it to float freely in the lactiferous sinus. The principle involved in this study was to induce a leukocytosis in that fraction of milk (foremilk or strippings) closest to a potential pathogen's point of entry. Thus a localized pre-existing high concentration of PMN would, in theory, be available to compensate for the reported (8) inefficiency of milk PMN. Several studies (1, 2, 9, 10) showed that indeed the somatic cell count (SCC) increased in milk from quarters fitted with an IMD and that milk production was not adversely affected.

The effectiveness of the smooth IMD against naturally occurring infections under field conditions was evaluated in 3 Maryland dairy herds over a 1-year period (2). Twenty-nine primiparous cows and 78 multiparous cows were selected and assigned alternatively to IMD and control groups. The average rate of new infection in IMD and control quarters of all primiparous cows was 18 and 27% ($P<0.10$). Although new infection rate in herd C primiparous cows was less ($P<0.05$) in IMD quarters (Table 1), this was solely due to fewer *C. bovis* infections. New infection rates in quarters of primiparous cows in herd C were 14 and 49% for IMD and control quarters ($P<0.05$). New infection rates of primiparous cows in herds A & B were similar in IMD and control groups and no differences were observed in new infection rates between IMD (38%) and control groups (40%) of the multiparous cows. It was subsequently revealed that the inability of smooth IMD to reduce new infection was due to a failure of IMD to increase milk SCC in strippings to levels needed for protection, considered to be 900,000/ml or greater. Examination of IMD removed from mammary glands of cows by scanning electron microscopy revealed plaque formation over areas of IMD that became abraded by the cannula during insertion of IMD. The plaque appeared to be chemotactic in that large numbers of leukocytes were found adhered to the surface of the plaque.

The purpose of the present report was to determine if abrading the surface of IMD would increase SCC in foremilk and strippings that would be protective against experimental infection and in the field.

TABLE 1. Effect of smooth IMD on new IMI rate in primiparous cows.

	All Infections						Excluding C. bovis					
	IMD			Control			IMD			Control		
Herd	n*	%	SE	n	%	SE	n	%	SE	n	%	SE
A	128	8	6.1	136	14	6.1	128	8	5.4	136	10	5.4
B	152	32	6.1	152	20	6.1	152	32	5.4	152	16	5.4
C	149	14	6.1	114	49	6.1	149	0	5.4	114	3	5.4
Avg.	429	18	3.6	402	27	3.6	429	14	3.1	402	10	3.1

* Total number of observations (quarter months of lactation) from which means were calculated.

Materials and Methods

Experimental Infection

Abraded and smooth IMD were inserted into separate bacteria free quarters of each of 5 cows. The remaining quarters served as controls. The IMD was abraded over the entire surface with medium grade emery cloth. Cows were milked with a quarter milker and foremilk, bucket and stripping samples were collected 2 wks after IMD insertion for 3 consecutive days and the SCS was determined electrometrically. All quarters were challenged 2 mos after IMD insertion with 250 colony forming units (CFU) *Strep. uberis,* and the status of infection was determined.

Abraded IMD was inserted into 2 diagonally opposed quarters of each of 9 other cows and a smooth IMD was inserted into diagonally opposed quarters of each of 8 other cows. Cows were challenged 3 wks later in both front or both rear quarters with 30 CFU of *E. coli* per quarter. Three wks thereafter, the other quarter pairs were similarly challenged. The status of infection was determined one week later.

Field Studies

a. The effect of abraded IMD on SCC in foremilk, bucket or jar milk and strippings from72 non-infected primiparous cows was examined. A group of 36 cows were fitted with IMD at 3 wks after calving and 36 cows served as control. The SCC was determined electrometrically 2 wks, and 1, 3, 6, and 9 months later. This study was conducted in 3 commercial herds.

b. In a completely randomized-split herd study currently underway in 9 commercial Israeli dairy herds abraded IMD were inserted into the 4 quarters of the udder of 553 lactating cows with odd number identification marking. In the same herds 577 cows with even number identification marking serve as control. Herds selected are typical for the national dairy herd; all are free from *Strep. agalactiae* and the levels of infections due to other streptococci and *S. aureus* range between 5 and 12% and 8 and 26%, respectively. Quarter milk samples for bacteriological analysis are collected from IMD and control cows at 90 day intervals for comparing the new infection rate. Streps are taken to ascertain that all clinical mastitis cases are recorded by the owners and that milk samples are to be submitted for bacteriological analysis from as many cases as practicably possible. This study will be continued for the next 3 years.

c. In a similarly designed split-herd study conducted in 2 Israeli dairy herds abraded IMD were fitted at drying off into the 4 quarters of the udder of 186 cows whereas 194 cows served as control. All cows were treated at drying off with Orbenin D.C. The udders of IMD and control cows were examined at 2 wk intervals during the dry period and any abnormalities were noted. Milk samples for bacteriological analysis were taken at drying off, 2-3 wks after calving and 3 mos later. New infections acquired during the dry period and the incidence of clinical mastitis during the 3 mos post-calving period were determined.

Results

Experimental Infection

Mean SCC in stripping milk from abraded IMD quarters increased to 912,000/ml 2 weeks after insertion and was significantly greater than the mean SCC in strippings from control quarters or quarters containing smooth IMD. Although the SCC in bucket milk was higher in IMD quarters when compared to control quarters, the magnitude of the difference was small.

The outcome after experimental challenge of mammary quarters containing abraded IMD and smooth IMD with *Strep. uberis* and *E. coli* is shown in Table 2. Among quarters containing abraded IMD 60% never became infected after experimental challenge with either *Strep. uberis* or *E. coli.* Control quarters or quarters containing smooth IMD were considerably less protected.

Field Studies

a. The effect of abraded IMD on the SCC in milk from the primiparous cows during 9 months (Table 3) can be characterized as follows: (1) SCC>1,000,000/ml were found among 95.3% of strippings from IMD quarters 2 weeks after insertion and the proportion of quarters having SCC>1,000,000/ml in strippings gradually decreased to 36.6% by 9 months. (2) Mean SCC in foremilk and stripping milk from IMD quarters were >1,000,000/ml during the entire 9 months observation period but bucket milk SCC from the IMD cows were never >500,000/ml. (3) Foremilk and strippings milk SCC from the IMD quarters were significantly ($P<0.01$) greater than foremilk and strippings SCC from the control cows. (4) The differences in mean bucket milk SCC from IMD and control cows were not significant at the 95% confidence level.

b. The incidence of new IMI due to non-*agalactiae streptococci, S. aureus* and *C. bovis* in herds 7, 8 and 9 during an observation period of 90 days was the same in IMD and control cows (Table 4) but fewer *E. coli* infections were diagnosed in IMD cows. With the exception of *C. bovis* infections, the incidence of new subclinical IMI was lower in IMD cows than in control cows in herds 1 and 6 during a 6 months observation period.

TABLE 2. Outcome after experimental challenge with either 250 CFU **Strep. uberis** or 30 CFU **E. coli.**

	Quarters Infected					
	Abraded IMD		Smooth IMD		Control	
Organism	No.	%	No.	%	No.	%
Strep. uberis	2/5	40	4/5	80	8/9	90
E. coli	7/17	41	14/16	88	33/33	100

TABLE 3. Effect of Abraded IMD on somatic cell count (SCC) in milk fractions from 72 noninfected primiparous cows; 36 cows with IMD and 36 cows serving as control.

		% quarters with SCC ≥10^6/ml milk		SCC X 10^3/ml milk			
				IMD		Control	
		IMD	Control	Mean	S E	Mean	S E
Before IMD							
	F*	0	0	180	38	228	41
(72 cows)	S*	0	0	75	72	311	65
	B*	0	0	92	16	76	20
2 wks after IMD							
	F	88.6	0	3774	181	217	19
(72 cows)	S	95.3	0	5960	265	386	45
	B	0	0	390	48	108	12
4 wks after IMD							
	F	68.0	0	2967	138	240	25
(68 cows)**	S	83.3	0	4980	318	385	62
	B	0	0	388	65	260	27
3 mos after IMD							
	F	54.2	0	1905	250	318	36
(63 cows)	S	79.4	0	2876	311	412	51
	B	0	0	406	72	318	46
6 mos after IMD							
	F	42.1	0	1625	278	420	47
(52 cows)	S	71.8	0	2150	196	617	38
	B	0	0	480	52	327	50
9 mos after IMD							
	F	23.6	8.6	1077	311	890	97
(49 cows)	S	36.6	17.2	1566	289	1072	160
	B	0	0	511	120	473	88

*F — fore milk; S — strippings; B — bucket or jar milk.
**Number of cows progressively reduced due to culling or drying.

c. The incidence of clinical mastitis among cows fitted with abraded IMD at drying off and at 3 wks after calving was significantly ($P<0.01$) lower than in the corresponding groups of control cows (Table 5) and these differences were largest for clinical mastitis cases from which *E. coli* was isolated. Although data are still limited, a trend towards fewer new IMI acquired during the dry period was noted among the IMD cows when compared to the control cows (Table 6). The bacteriological cure rate for *S. aureus* infections after drying off therapy with Orbenin DC was generally low (45%) in both IMD and control cows.

Side Effects

Differences were not observed in milk production between IMD and control primiparous cows. Data are still insufficient for analyzing the differences in milk production between IMD and control cows in the split-herd trials.

Few clots and flakes were found in 5-10% of quarters during 2-3 days after lactating cows in the split-herd study were fitted with IMD. Clinical signs suggesting increased local sensitivity to palpation of the udder were noted in several of the cows with clots and flakes, which subsided in a few days. An analysis of the infection status revealed that all IMD cows in which clots were found were subclinically

TABLE 4. Incidence of new subclinical intramammary infections (IMI) during 3 and 6 months after placing Abraded IMD in lactating cows.

				No. of new IMI in cows (and quarters) due to			
		No. of cows at day					
Herd		0	90*	Non-agal. strep.	S. aureus	E. coli	C. bovis
7	IMD	146	139	4 (7)	5 (8)	0 (0)	0 (0)
	Cont	152	144	3 (7)	6 (8)	2 (0)	0 (0)
8	IMD	132	116	2 (2)	6 (9)	1 (1)	1 (1)
	Cont	126	109	2 (3)	4 (7)	3 (3)	0 (0)
9	IMD	145	120	2 (3)	2 (4)	0 (0)	1 (1)
	Cont	148	126	1 (1)	3 (6)	2 (2)	1 (2)
All	IMD	423	375	8 (21)	13 (21)	1 (1)	2 (2)
	Cont	426	379	6 (11)	13 (21)	7 (7)	1 (2)
1-6	IMD	130	114**	7 (8)	6 (9)	1 (1)	4 (3)
	Cont	151	127	20 (23)	19 (24)	9 (9)	5 (4)

*Differences are due to cows culled or drying up.
**180 days after IMD placing.

TABLE 5. Incidence of clinical mastitis in lactating cows after placing Abraded IMD either early in lactation or at drying off.

Time of placing IMD		No. of cows	Incidence of clinical mastitis		Cases bacteriologically examined		Bacteriological diagnosis		
			No.	%	No.	%	Coli-forms	Gram-pos.	Neg.
A*	IMD	130	10	7.7	8	(80%)	2	5	1
	Cont	151	50	33.1	39	(78%)	17	13	9
B**	IMD	255	9	3.5	6	(67%)	1	3	2
	Cont	239	19	7.9	11	(58%)	7	8	4

*A — Early in lactation, observation period — 6 months.
**B — At drying off time, observation period — 3 months postcalving.

TABLE 6. New intramammary infections (IMI) acquired during the dry period after Abraded IMD were placed at drying off time. All cows were infused at drying off with Orbenin D.C.

			Percent new IMI due to				
Herd		No. of cows	Non agal. strep.	S. aureus	Others	Total	Total P<
7	IMD	95	1.58	2.63	0.53	2.11	0.01
	Cont	91	3.03	3.57	0.27	6.87	
8	IMD	91	1.10	4.95	0.81	6.86	0.05
	Cont	103	1.70	6.31	1.21	9.22	

infected with either *S. aureus* or non-*agalactiae* streptococci.

Clinical examination of the udders of cows fitted with abraded IMD at drying off did not reveal any abnormalities. Slightly bloody secretions were found in samples removed 2-8 wks after drying off in 6 (1.5%) quarters of 98 IMD cows and in 4 (1.36%) quarters of 73 control cows examined. Slightly pink-tainted colostrum was observed in 11 (1.5%) of the 186 cows fitted with IMD at drying off but also in 6 (0.77%) quarters of the 194 control cows.

Discussion

The experimental challenge studies indicate that abrading the surface of IMD increases SCC in stripping milk to concentrations that provide good protection against intracisternally inoculated *Strep. uberis* and *E. coli* (Table 2). These potentially protective concentrations of PMN in stripping milk were near 1,000,000/ml. Results from the Israeli field study where a larger number of non-infected primiparous cows were observed for 9 mos (Table 3) indicate that abraded IMD was capable of eliciting and maintaining these potentially protective levels of PMN in strippings from at least 70% of quarters for at least 6 mos without causing an unacceptable rise in bucket milk SCC.

The incidence of new subclinical IMI, particularly *E. coli* IMI, in IMD fitted quarters of lactating cows was slightly lower than in the control cows (Table 4). Of special interest is the significantly lower incidence of clinical mastitis, particularly coliform mastitis, observed in cows fitted with abraded IMD during lactation and at drying off (Table 5). These field observations, however limited, provide additional supporting evidence for the claimed importance of the state of preexisting leukocytosis in minimizing the likelihood of coliform mastitis and the lesser efficacy of the leukocytic barrier in the prevention of IMI due to Gram-positive pathogens (3, 4).

The abraded IMD quarters appears to be well tolerated and safe in non-infected quarters of lactating cows. A low yet transient incidence of clots and flakes in foremilk and strippings can be expected after abraded IMD are fitted into subclinically infected quarters of lactating cows. The latter observation complement earlier findings (1, 2, 10) on the effect of smooth IMD on the SCC in strippings from quarters infected with specific pathogens; in *S. aureus* and non-*agalactiae* streptococci-infected quarters the mean SCC were 2,400,000/ml and 4,000,000/ml, respectively.

It was also reported that 85% of smooth IMD quarters infected with streptocci and staphylococci developed the highest California Mastitis Test score in bucket milk within 6 mos of calving (5). The safety of abraded IMD fitted at drying off requires further studies.

The Israeli field studies, which started on August 1983, are planned for 3 years to include approx. 3000 cows fitted with abraded IMD and a comparable number of suitable control cows. The interim findings shown in the present communication are encouraging. Hopefully, a more comprehensive report will be presented at the next Buiatrics Congress.

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