THE EFFECT OF INCOMPLETE MILKING ON CHRONIC MASTITIS CAUSED BY STREPTOCOCCUS AGALACTIAE

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Field observations by the senior author suggested that incomplete milking of cows affected with chronic mastitis may perhaps aggravate the infection. Judging from the literature, this question has been little investigated. München, Schmidt-Hoensdorf, and Schmidt (2–4) studied the practice of stripping versus nonstripping in 50 cows artificially infected with streptococcal mastitis. According to them, the clinical symptoms became more intense in the animals not stripped after machine-milking, whereas with the cows that were stripped, the secretion soon assumed a normal appearance. Woodward, Hotis, and Graves (6), however, experimenting with 15 cows, of which 11 were infected with Str. agalactiae, failed to find that incomplete milking aggravated the infection. To obtain further information concerning the effect of incomplete milking on chronic mastitis, the experiments here reported were undertaken.

The University dairy herd, which provided the animals, consisted of 60 cows, milked by machine and thoroughly stripped afterwards. Data on the extent and severity of mastitis in this herd were accumulated for three years prior to this special investigation. Though the incidence of infection with Str. agalactiae averaged 30 per cent during this time, the infected animals rarely produced a visibly abnormal milk; for, out of a total of 419 strip-cup examinations made on the infected cows in this herd during the three-year period, visible particles were found in the foremilk in only 6.9 per cent of the tests.

METHODS

The cows selected for these special studies were harboring Str. agalactiae in one or more quarters, but were producing a visibly normal milk. A strip-cup test, chlorine determination, cell count, bacteriologic analysis, and palpation of the milked-out udder for indurations were made at weekly intervals on every quarter of each cow, beginning 3 weeks before incomplete milking and continuing throughout the experimental period.

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Strip-cup test. The first milk from each quarter was examined for visible particles or other abnormalities by drawing it into a shallow dish with a black bottom. A single flake was not regarded as significant; but shreds, clots, thick pus, watery milk, or 2 or more flakes were considered as evidence of a positive test.

Chlorine test. A rapid volumetric method was used to determine the percentage of chlorine. With a Babcock pipette, 17.6 cc. of milk was placed in a beaker; 2 cc. of a 10 per cent potassium chromate solution was added; and this was titrated with a twentieth-normal silver nitrate solution until the color changed from yellow to orange. The percentage of chlorine was determined directly from the number of cubic centimeters of silver nitrate solution used, since each cubic centimeter of twentieth-normal silver nitrate is equivalent to 0.01 per cent chlorine in 17.6 cc. of milk.

Bacteriologic analyses. After the strip-cup test and the drawing of milk for the chlorine test, the teats were washed with a freshly prepared solution containing about 400 ppm. of available chlorine. Milk samples from the individual quarters were collected in sterile vials and were iced or refrigerated until plated. One cubic centimeter of a 1-100 dilution in saline of each milk sample was plated with veal infusion agar containing 5 to 7 per cent fresh horse blood and was incubated at 37° C. for 48 hours. The remainder of the milk sample was incubated overnight to be used in the microscopic examination for streptococci and in the determination of the cell count. Colonies suspected of being streptococci were transferred from the blood-agar plates to serum broth; after 24 hours at 37° C., smears were made. Cultures proving to be streptococci were classified by the method described in a previous publication (3).

Cell count. To determine the number of leucocytes and epithelial cells per cubic centimeter of milk, 0.01 cc. of incubated milk was spread over 1 square centimeter of a slide. The smear, stained by the Broadhurst-Paley (1) method, was examined with a calibrated microscope. The cell count and an examination for streptococci in the milk sample were made at the same time.

Palpation for fibrosis. The milked-out quarters were palpated in the manner described by Udall (5). Scores of 1, 2, 3, and 4 were given to show the degree of tissue firmness. A score of 1 was used to indicate a soft, pliable quarter; 2, a pliable quarter having a deep but not extensive firmness in the lower cistern area. Quarters, meaty throughout or exhibiting distinct and extensive firmness of the cistern region, were scored as 3, and those with a marked firmness throughout as 4. Scores of 3 and 4 represented a distinct abnormality.

EXPERIMENTAL

The effect on chronic mastitis of leaving approximately 2 pounds of milk in the udder at each milking. Five cows, with 8 quarters infected with Str.
agalactiae, were selected. The time, in minutes, required for the milking machine to remove all but about 2 pounds of milk from the udder was determined for each cow. Incomplete milking was then practiced for 13 weeks, after which stripping was again carried out for 1 month with 4 of the cows before they were dried off. To check the amount of milk left in the udders, they were stripped after one morning and one evening milking each week. As the experiment progressed and production diminished, the milking-machine time was shortened correspondingly to leave about 2 pounds of milk in the udder.

Table 1 shows the history of each cow, the duration of infection with Str. agalactiae in each quarter, the average amount of milk left in the udder, the results of strip-cup tests during the period of incomplete milking, and the palpation score of each quarter.

The 8 quarters infected with Str. agalactiae on these 5 cows were producing normal-appearing milk before incomplete milking was initiated, and all developed readily-visible symptoms of mastitis when about 2 pounds of milk was left in the udders at each milking. With 2 of these Str. agalactiae-infected quarters, the first evidence of a positive strip-cup reaction occurred during the first week of incomplete milking; with 4 such quarters during the second week; with 1 infected quarter during the third week, and with another infected quarter during the fifth week.

Two quarters developed acute attacks of mastitis, and with 3 quarters the parenchyma became firmer during the experiment. When complete milking was resorted to again with 4 of the cows, the visible particles tended to disappear from the foremilk; but with 3 quarters the secretion was greatly diminished and remained watery. Staphylococci were being shed by 5 quarters, 4 of which showed visible particles in the foremilk on one or more occasions during the period when milk was left in the udders.

Figure 1 (graphs I, II and III) shows the mean effect of leaving about 2 pounds of milk in the udder on the chlorine content, cell count, and bacterial count of milk from normal quarters and those infected with Str. agalactiae. Two quarters of cow 617 and 1 quarter of cow 1026, infected with Str. agalactiae, were producing, before incomplete milking, a secretion that was abnormal with respect to chlorine content and cell count. These data, therefore, were not used in preparing the respective graphs, nor were the data on the 5 quarters shedding staphylococci included.

According to graph I (fig. 1), the chlorine content of the milk from the infected quarters increased significantly as soon as incomplete milking was initiated and it remained high throughout the experiment as compared with a gradual minor rise in the milk from normal quarters. Graph II (fig. 1) shows that an immediate and marked increase took place in number of cells per cc. of infected milk, whereas no change was observed in the milk from normal quarters. According to graph III (fig. 1), the mean bacterial count
### TABLE 1

*Strip-cup tests and palpation scores of normal and infected quarters during the period of incomplete milking*

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<th>Av. pounds milk left in udder</th>
<th>Quarter</th>
<th>Duration of infection with Str. agalactiae (months)</th>
<th>Palpation score</th>
<th>Strip-cup tests during incomplete milking†</th>
<th>Weeks during which positive tests were obtained</th>
<th>Severity of strip-cup reaction‡</th>
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* Shedding staphylococci.
† Strip-cup tests were negative prior to incomplete milking.
‡ Code for strip-cup test: 0 – Milk normal.
+ – Few flakes.
++ – Many clots and shreds.
+++ – Many clots, shreds and often thick pus.
§ Acute mastitis during 8th and 9th weeks of incomplete milking.
¶ Production greatly diminished by experiment.
†‡ Acute mastitis from 2nd to 4th weeks of incomplete milking.
of the milk from the infected quarters was erratic; and since half of the mean counts were less than the highest before incomplete milking, apparently the bacterial count was not much affected by leaving milk in the udder. These data, together with results of the strip-cup and palpation tests, demonstrate that the infections with *Str. agalactiae* were aggravated by leaving an average of 2 pounds of milk in the udders at every milking over a period of 13 weeks; also that a stimulating effect on the infections was apparent within the first week of incomplete milking and became more pronounced as this method of milking was continued.

**The effect of nonstripping after normal machine-milking on normal quarters and on quarters infected with *Str. agalactiae*.** Leaving 2 pounds of milk in the udder at every milking is an extreme and probably uncommon procedure. Some dairymen, however, are milking by machine without stripping the cows afterwards. Tests were made, therefore, to determine the effect of nonstripping on chronic mastitis.

Four cows, having 6 quarters infected with *Str. agalactiae*, and 2 control cows free of infection, were chosen for this second experiment. Two of
the infected cows, 1006 and 1026, had been used in the first trial. They had been dried up at the termination of that experiment; and, after 6 and 7 weeks, respectively, they freshened again. They were milked in the normal manner by machine and were thoroughly stripped until being placed on nonstripping. Their milk, as well as that of the other cows in this experiment, was free of visible particles before nonstripping. They were then milked twice daily by machine in a normal manner, but were not stripped afterwards during a period of 17 weeks. For a brief interval before removing the milking machine from a cow, the operator manipulated the udder and pulled down gently on the machine cups in an attempt to remove as much more milk as possible. To check on the amount remaining in the udder, each cow was stripped by hand after two evening milkings each week. The mastitis tests employed in the first trial on incomplete milking were also made at weekly intervals on these cows. In addition throughout the period of study, the milker, at every milking, examined the foremilk of each quarter with a strip cup.

Table 2 shows the history of each cow, the duration of infection with \textit{Str. agalactiae} in each quarter, the average amount of milk left in each quarter, the strip-cup reactions during the period of nonstripping, and the palpation score of each quarter.

Nonstripping after machine-milking resulted in leaving averages of 0.52 to 1.1 pounds of milk in the udders. The average quantity of milk retained by the individual quarters varied from 0.03 to 0.4 of a pound. Nonstripping caused no detectable changes in the structure of the quarters or in the appearance of the milk from normal udders. The quarters infected with \textit{Str. agalactiae}, however, reacted in a variable manner to nonstripping. Surprisingly, the degree of response could not be correlated with the amount of milk left in the quarters. The right rear quarter of cow 185 retained an average of 0.4 of a pound of milk per milking, and visible particles were found in the foremilk of this quarter in only 4.6 per cent of the examinations. The parenchyma of this quarter increased in firmness, however, and the palpation score changed from 3 to 4. On the other hand, the left front quarter of cow 1006 and cow 1026 retained as little as 0.10 and 0.05 of a pound of milk per milking, respectively; yet the foremilk of each was abnormal in over 40 per cent of the strip-cup examinations. The latter quarter, which retained less milk than any other infected quarter, exhibited the most pronounced symptoms of clinical mastitis shown in this experiment. Six quarters were shedding staphylococci; and, of these, four revealed visible particles in their foremilk in 0.5 to 5.0 per cent of the examinations made.

Figure 2 (graphs IV, V and VI) shows the mean effect of nonstripping on the chlorine content, the cell count per cc., and the bacteria count per cc. of milk from normal and infected quarters. The data from the 6 quarters
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<th>Month of lactation</th>
<th>Quarter</th>
<th>Average pounds of milk left in each quarter per milking</th>
<th>Duration of infection with <em>Str. agalactiae</em> (months)</th>
<th>Palpation score</th>
<th>Strip-cup tests during nonstripping†</th>
<th>Weeks during which positive tests were obtained</th>
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* Shedding staphylococci.
† Meaty quarter.
‡ Strip-cup tests were negative prior to nonstripping.
§ Code: 0 - Milk normal.
   ++ - Few flakes.
   + - Many clots and shreds.
   +++ - Many clots, shreds, and often thick pus.
shedding staphylococci were not used in preparing the graphs. The milk from the left front quarter of cow 1026, infected with \textit{Str. agalactiae}, had a chlorine content above normal; and that from the left rear quarter of cow 722, also infected with \textit{Str. agalactiae}, had a cell count above normal before nonstripping. The data relative to these tests were, therefore, not used in preparing the respective graphs.

![Graphs showing chlorine content, cell count, and bacteria count](image)

**Fig. 2.** The effect of nonstripping after machine milking on the chlorine content, (graph IV), the cell count, (graph V), and the bacteria count, (graph VI), of milk from normal quarters and quarters infected with \textit{Streptococcus agalactiae}.

According to graph IV (fig. 2), the mean chlorine content of the milk from both the infected and normal quarters increased gradually during the first 9 weeks of nonstripping and then dropped gradually during the next 6 weeks; an abrupt rise followed during the last 2 weeks of the experiment. The difference between the mean chlorine content of the milk from infected and normal quarters is not great enough to be significant. As graph V (fig. 2) reveals, a considerable increase in body cells occurred in the milk of the infected quarters as soon as stripping was no longer practiced, while the mean cell count in the milk of the normal quarters was not affected. Graph VI (fig. 2) shows an erratic mean bacterial count in the milk from
the infected quarters. Since half the mean counts during the nonstripping period were less than the highest prior to incomplete milking, apparently the bacterial count of the infected milk was not altered significantly.

**DISCUSSION AND SUMMARY**

The effect of incomplete milking on chronic mastitis caused by *Streptococcus agalactiae* was studied with infected cows that were producing a visibly normal secretion at the time they were placed on experiment.

Five cows, having 8 quarters infected with *Streptococcus agalactiae*, 5 quarters shedding staphylococci, and 7 quarters free of any infection were selected for the first trial on incomplete milking. An attempt was made to leave about 2 pounds of milk in the udder of each cow at every milking over a 13-week period. Under this system of milking, the noninfected quarters continued to produce a normal milk, 4 of the 5 quarters shedding staphylococci infrequently showed visible particles in their foremilk, while every quarter harboring *Streptococcus agalactiae* developed readily visible symptoms of mastitis. The strip-cup test became positive with 2 *Streptococcus agalactiae*-infected quarters during the first week of incomplete milking, with 4 such quarters during the second week, with 1 infected quarter during the third week, and with another during the fifth week. With 7 of the 8 infected quarters, flakes, clots, shreds, and sometimes thick pus, were found in the foremilk with great regularity as long as incomplete milking was continued. Two quarters developed acute mastitis; and their parenchyma, as well as that of another quarter, increased in firmness. The chlorine content and the cell count of the *Streptococcus agalactiae*-infected milk increased significantly as soon as the incomplete milking was started, whereas no appreciable changes were observed in the secretion of the normal quarters. The total bacterial count of both normal and infected milk was not affected to any great extent. When thorough milking was resumed, there was a definite tendency toward a return to a visibly normal secretion, although with 3 quarters production was considerably reduced and the milk was somewhat watery.

Leaving 2 pounds of milk in the udder represents an extreme procedure. Some dairymen, however, do not strip their cows after machine-milking. The effect of this form of incomplete milking on normal and infected quarters was studied on 2 cows with noninfected udders and 4 cows having a total of 6 quarters infected with *Streptococcus agalactiae*, 6 quarters shedding staphylococci, and 4 quarters free of any infection. These animals were not stripped after normal machine-milking over a period of 17 weeks, except after 2 evening milkings each week to ascertain the quantity of milk left in the udders. The average amount of strippings per udder varied from 0.52 to 1.1 pounds per milking and the average quantity retained by the individual quarters per milking varied from 0.03 to 0.4 of a pound. The noninfected quarters continued to produce a normal secretion, 4 of the 6 quar-
ters shedding staphylococci infrequently contained visible particles in their foremilk, and the quarters harboring \textit{Str. agalactiae} reacted in a variable manner to nonstripping. A surprising result was that, among the \textit{Str. agalactiae}-infected quarters, the two retaining the smallest average quantity of strippings, 0.05 and 0.10 of a pound of milk per milking, developed the most pronounced clinical symptoms of mastitis, while quarters retaining from 0.2 to 0.4 of a pound of milk per milking only infrequently showed mild evidence of mastitis. In every case, however, the inflammatory process in the \textit{Str. agalactiae} quarters was aggravated to some degree, as indicated by a significant rise in cell count when nonstripping was practiced. The chlorine content and the bacterial count of both normal and infected milks were not affected materially.

The number of cows studied was small. The results, though not conclusive, especially those of the second experiment, indicate that incomplete milking may lead to increased severity of the clinical manifestations of \textit{Str. agalactiae} infections. Conversely, thorough milking of cows affected with chronic mastitis seemed to reduce the severity of the disease. It is hoped that the results reported here will motivate further study of this important aspect of the mastitis problem.

\section*{REFERENCES}


