Clinical Mastitis: The First Eight Days

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Abstract

Clinical mastitis represents one of the most common reasons for antibiotic usage on a dairy farm, especially if a dairy uses a blanket mastitis treatment program. With a blanket mastitis treatment program, many cows are treated unnecessarily or treated with an ineffective antibiotic. The first eight days represent a time period in which, if the antibiotic is effective, a bacterial cure due to an antibiotic should take place. Daily culturing of the clinical mastitis case and the use non-treated controls (for research) is really the only way to determine the effect of an antibiotic, as self-cures can occur with any organism. In this study, cows that developed naturally occurring clinical mastitis were treated with various antibiotics and methods and had the following monitored for the first eight days, then once a week until completely cured, culled, or dead: temperature, pulse, respiration, hydration status, rumen status, secretion color, udder firmness, somatic cell count (SCC), culture, and colony forming units (cfu). Conclusions: It is usually safe to wait for culture results (one to two days) before determining if antibiotic treatment is necessary for cows with mild to moderate clinical mastitis. The majority of clinical mastitis cases are mild to moderate. About 25% of clinical mastitis cases are no-growth and require no treatment. Mild cases of *Escherichia coli* do not require antibiotic treatment. Intramammary antibiotics are warranted for streptococcal clinical mastitis. First lactation cows with *Staphylococcus aureus* mastitis should be treated with an intramammary antibiotic. While these results and conclusions are based on findings from a single dairy, utilizing culture-based therapy and following up with daily culturing on clinical mastitis cases will help any dairy to develop the most prudent and justified mastitis treatment plan. It will also result in savings through decreased milk loss due to improper treatment, milk discard due to drug withholding periods, and drug costs.

Résumé

La mammite clinique est l'une des raisons les plus fréquentes de l'usage d'antibiotiques dans une ferme laitière, particulièrement si celle-ci applique un traitement préventif généralisé contre la mammite. Dans ce type de traitement préventif contre la mammite, de nombreuses vaches sont traitées sans devoir l'être ou avec un antibiotique inefficace. C'est au cours des huit premiers jours suivant le traitement qu'un antibiotique remédiera à une infection bactérienne, s'il est efficace. L'analyse quotidienne des cultures bactériennes, combinée à l'utilisation de vaches témoins non traitées (pour la recherche), demeure le seul moyen d'évaluer l'effet d'un antibiotique, puisque la guérison spontanée peut se produire peu importe l'organisme. Dans la présente étude, nous avons traité des vaches atteintes naturellement de mammite clinique avec divers antibiotiques et par diverses méthodes. Pendant les huit premiers jours après le traitement et tous les sept jours par la suite jusqu'à la guérison complète, la réforme ou la mort des vaches, les facteurs suivants ont été évalués: température corporelle, pouls, respiration, hydratation, état du rumen, couleurs des sécrétions, fermeté du pis, compte de cellules somatiques, culture bactérienne et unités formant des colonies (cfu). Nos conclusions sont que dans le cas de vaches affectées par une mammite clinique de légère à modérée, il est généralement sûr d'attendre les résultats de l'analyse des cultures bactériennes (un à deux jours) avant de décider s'il faut traiter avec un antibiotique. La majorité des cas de mammite clinique sont de légers à modérés. De plus, environ 25 % des cas de mammite clinique ne se manifestent pas par une croissance bactérienne décelable et ne requièrent aucun traitement. Les infections légères dues à Escherichia coli ne nécessitent aucun traitement antibiotique. Toutefois, il est justifié d'administrer des antibiotiques par voie intramammaire en cas de mammite clinique à streptocoques. De même, les vaches en première lactation souffrant d'une mammite à Staphylococcus aureus doivent être traitées avec un antibiotique administré par voie intramammaire. Ces résultats et ces conclusions proviennent d'essais réalisés dans une seule ferme laitière. Cependant, ils nous permettent de conclure qu'avec une thérapie basée sur l'analyse et le suivi quotidiens des cultures des cas de mammite clinique, toutes les fermes laitières peuvent élaborer le plan de lutte à la mammite le plus prudent et le plus approprié qui soit. Cette approche permettra aussi d'éviter des pertes de lait associées à un traitement inutile ou à la période de retrait due aux résidus médicamenteux, tout en réduisant le coût des médicaments.

Introduction

When one treats a case of clinical mastitis with an antibiotic and the cow recovers, we like to think that the antibiotic was effective. This is no doubt true sometimes,

but it could be that the antibiotic had no or little effect and the cow cured herself. If an antibiotic is effective, the colony forming units (cfu) of the cultured organism should decrease on a daily basis. Even if this occurs, it does not necessarily mean that the antibiotic is effective. One needs to know what happens when a cow is not treated and undergoes self-cure. One thing that we can know is that if a cow is treated with an antibiotic and there is no effect on the cfu, the antibiotic is not effective. Mastitis is one of the few diseases in which we can actually and easily document the effectiveness of the antibiotic on the bacteria. Collecting milk samples daily is much easier than daily collection of a transtracheal wash. The objective of the following studies was to determine the efficacy of various clinical mastitis treatments on naturally occurring clinical mastitis cases.

Materials and Methods

Studies

Data presented was derived from two studies with slightly different methodologies. In the first study of only mild to moderate clinical mastitis, one of four treatments was assigned on the day of presentation (without knowledge of culture result).[6] Cows in Study One were followed for 36 days. In Study Two (all severity levels), treatment was assigned on day 2 of clinical mastitis based on culture results. Cows were followed until completely cured, culled, or dead.

Study Animals

The studies were conducted over a six-year period utilizing Holstein and Jersey cows from a university dairy. Cows were milked twice a day and housed in free-stalls bedded with shavings or straw. Some of the cows were maintained on native grass pastures during the summer months. The rolling herd somatic cell count (SCC) was consistently below 200,000 cells/mL. Mastitis control consisted of single-service paper towels, pre- and post-dip with a germicidal iodine teat dip, a backflush system, and dry-cow intramammary antibiotic (IMMA). No mastitis vaccines were being used at the initiation of the study or during the study. Cows with naturally occurring clinical mastitis were detected by dairy personnel during routine milking procedures. A study collaborator examined the cow with clinical mastitis in order to classify the cow's condition as mild, moderate or severe based on a protocol previously described.[6] Systemically ill cows with more than one abnormal parameter at the time of initial examination were not used in Study One. Cows with other concurrent diseases that required treatment were excluded from both studies. Cows with clinical mastitis that were included in the study were eligible for a new case of clinical mastitis 36 days after the previous case, providing that a microbiological cure occurred. If a cow was previously used in the study and a microbiological cure was not obtained, the cow was not eligible for inclusion again unless a different quarter was involved.

Treatments and Method of Treatment Assignment

In Study One, cows were systematically assigned one of four treatments. Prior to initiation of the study, the four treatments were drawn out of a hat and identified as Treatments 1 to 4. Treatment 1 consisted of an IMMA (amoxicillin[a]) administered according to manufacturer's directions. Treatment 2 consisted of no treatment of any kind (control: CX). Treatment 3 consisted of frequent milk-out (FM) of the affected quarter(s) at least two hours apart during the day for three days in addition to the two regular milkings in the parlor, for a total of six milk-outs/infected quarter/24 hour period. Treatment 4 consisted of a combination of Treatments 1 and 3 (FM/IMMA). Intramammary (IMM) amoxicillin was given only after the night milking for three treatment periods (24-hour intervals). Frequent milk-out began at least eight hours after IMMA therapy following the protocol of Treatment 3. The first cow in the study received Treatment 1, and so forth. If a cow had more than one clinical quarter, all quarters received the same treatment.

In Study Two, cows with clinical mastitis were alternately assigned one of two therapeutic protocols based on culture results and severity level. Treatment 1 (T1) included an IMMA that varied by culture result (see below). In most cases, cows assigned to Treatment 2 (T2) did not receive IMMA; only exceptions are listed below. All cows with severe clinical mastitis were treated with a standard severe treatment (SST) beginning on day 1 and continuing daily as needed (listed below) and were alternatively assigned IMMA or no IMMA. Treatment with IMMA did not start until day 2 of the study, regardless of mastitis severity.

Standard Severe Therapy (SST)

1) Fluids (2 liters 7.2% saline IV; 6-10 gallons of warm water with electrolytes orally)
2) Flunixin meglumine[c] @ 0.5 mg/lb (1.1 mg/kg)
3) 1 tube (390 g) Calcium gel[d]
4) Intramuscular ceftiofur sodium[e] @ 0.5 mg/lb (1.1 mg/kg) BID

Study Two IMM Treatments (T) (T2 was no IMMA unless noted otherwise)

- *E. coli* (mild and moderate)
  T1: IMM cephapirin sodium[f] two treatments at 12-hour intervals
- *E. coli* (severe)
  T1: IMM ceftiofur hydrochloride[g]: 300 mg, 12-hour intervals, six treatments

- *Citrobacter* and *Serratia*
  T1: IMM cephapirin sodium[f] by label
- *Staphylococcus aureus* and *Arcanobacterium pyogenes*
  T1: IMM cephapirin sodium[f] six total treatments at 12-hour intervals
- Coagulase-negative *Staphylococci* (CNS)
  T1: IMM amoxicillin[a] three infusions at 12-hour intervals
- No growth
  T1: IMM cephapirin sodium[f] two infusions at 12-hour intervals
- *Pasteurella multocida*
  T1: IMM ceftiofur hydrochloride[g]: 300 mg, 12-hour intervals, six treatments
- *Streptococcus* spp
  T1: IMM amoxicillin[a] three infusions at 12-hour intervals

Assessment Days and Parameters

The parameters were assessed on study cows on days 1 through 8, then once per week until day 36, then once per month until the cow cured, was culled, or died (Study One assessments only occurred through day 36). Additional parameters collected on each assessment day included the California Mastitis Test (CMT), clinical cure assessment, a milk sample for culture, and in Study Two quarter milk SCC were determined.

Cure Definitions and Microbiological Methods

Outcome variables examined were clinical cure, bacterial cure, and CMT scores or quarter SCC cures, defined as being scored trace or less or a SCC less than 500,000 cells/mL. A clinical cure was defined as no clots or flakes in the milk for three consecutive assessment days, or two consecutive weeks without a relapse. A microbiological cure was defined as no growth of the originally isolated pathogen for three consecutive assessment days or two consecutive weeks without a relapse.

Fifty µl of milk were plated on blood agar immediately upon return to the mastitis laboratory. Cultures were incubated for 24 to 48 hours at 98.6°F (37°C). All organisms were initially identified by colony characteristics. Gram-negative organisms were identified by biochemical test strips[b]. Streptococcal organisms were identified by catalase, gram stain, esculin, and CAMP reactions. Staphylococcal organisms were differentiated by the tube-coagulase test and hemolytic patterns. Antibiograms were also performed.[1]

Results and Discussion

The severity of clinical mastitis cases by culture result is presented in Figure 1. One hundred percent of cows with no growth on culture were classified as mild clinical mastitis on day 1. Of organisms cultured, 62-64% were classified as mild clinical mastitis, 21-28% were moderate, and 8-14% were classified as severe. Although *E. coli* is probably most well-known for creating severe clinical mastitis, it is important to recognize that the majority of *E. coli* cases are mild. In one study, 95% of acute coliform mastitis were systemically mild cases.[8]

E. coli

The first eight days of cfu data from cows with mild to moderate clinical mastitis due to *E. coli* that received no treatment is presented in Table 1. Fourteen of the 19 cows obtained a bacterial cure by day 5, and all cows obtained a bacterial cure by day 15. The data supports the premise that mild to moderate cases of *E. coli* mastitis do not require treatment. It is also likely that even effective treatment would not shorten the time to bacterial cures (Figure 2).

The first 36 days of cfu data from cows with clinical mastitis due to *E. coli* that received various treatments is presented in Table 2. Cows treated with amoxicillin or cephapirin had mild to moderate clinical mastitis. Seven of eight cows treated with IMM amoxicillin by label obtained bacterial cures by day 5 and day 36. Eight of 14 cows treated with IMM cephapirin by label obtained bacterial cures by day 5, and 13 of 14 cows obtained bacterial cures by day 15 even though eight of the *E. coli* strains were resistant to cephapirin. This data also supports the premise that mild to moderate cases of *E. coli* mastitis do not require IMMA. It is also suspected that even effective treatment would not decrease the time to bacterial cures for mild to moderate *E. coli* mastitis. Figure 2 provides visual evidence that mild to moderate *E. coli* clinical mastitis does not require any treatment. Thus, no treatment may be the preferred method of managing cows with mild to moderate clinical *E. coli* mastitis. Only one cow in the mild-to-moderate severity level (IMM amoxicillin) developed a chronic intramammary infection (IMI) due to *E. coli*. Two of the three cows that survived severe *E. coli* mastitis

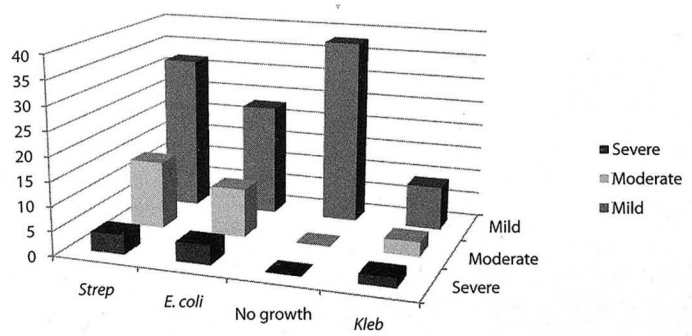

Figure 1. Number of clinical mastitis cases by organism and severity level.

Table 1. Mild to moderate clinical *E. coli* mastitis receiving no treatment: colony forming units (number of colonies per 50 µl) for the first eight days.

Cow no.	Mild[1] Mod	D1 cfu	D2 cfu	D3 cfu	D4 cfu	D5 cfu	D6 cfu	D7 cfu	D8 cfu[2]
2959	Mild	5	1	0	0	0	0	0	0
3059	Mild	22	5	0	0	0	0	0	0
3064	Mild	4	0	0	0	0	0	0	0
3086	Mild	100[3]	6	0	1	0	0	0	0
2792	Mild	100	7	1	5	0	0	0	0
2860	Mild	80	100	10	0	0	0	0	0
3113	Mod	100	100	100	100	100	64	13	10
3208	Mild	48	100	8	0	0	0	0	0
3259	Mod	4	0	0	0	0	0	0	0
3305	Mild	56	76	0	0	0	0	0	-
3312	Mild	100	15	4	0	1	0	0	0
3314	Mild	100	54	6	1	0	0	-	0
3350	Mild	34	14	0	0	0	0	0	0
3366	Mod	100	100	100	34	20	-	3	1
3379	Mild	9	0	-	0	0	0	0	0
3432	Mod	73	33	0	-	0	0	-	0
3510	Mod	100	100	100	16	34	7	4	7
3554	Mild	6	-	-	0	0	0	0	0
3585	Mod	24	23	9	12	10	0	1	0

[1] Mild cases: no systemic signs, only abnormal milk. Moderate cases: only one systemic sign of illness.
[2]All cultures obtained after D8 (day 8) were negative.
[3] cfu greater than 100 were not counted (100 cfu = at least 2000 cfu/ml).

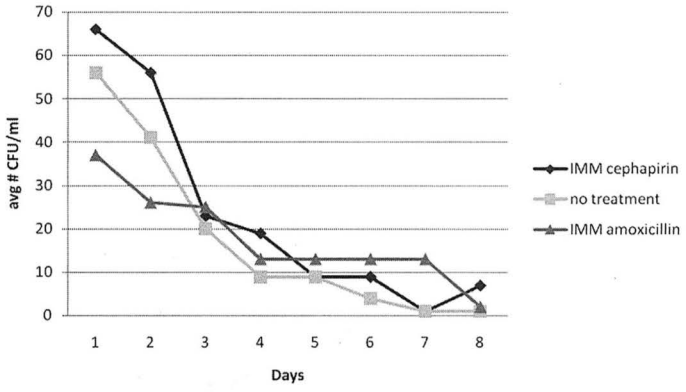

Figure 2. Average # cfu/50 µl by treatment through days 1-8 of mild to moderate clinical *E. coli* mastitis.

were bacteriologically cured by sampling day 22; the other cow did not receive IMM ceftiofur and was still *E. coli*-positive when culled. Although only two cases of severe *E. coli* were treated with IMM ceftiofur, the data suggests that this antibiotic is efficacious against *E. coli*. Both cows 2962 and 3164 maintained "lawns" of *E. coli* on culture until the second sampling after treatment began (3164 became a downer and did not receive IMM ceftiofur until day 5). Data from a 2008 study also indicates that IMM ceftiofur can be efficacious against coliform pathogens.[3]

Staphylococcus aureus

The first 96 days of cfu data from cows with *S. aureus* mastitis by various treatments is presented in Table 3. In all, 10 cows (12 quarters) were evaluated for clinical mastitis due to *S. aureus*. Mastitis due to *S. aureus* was not common on the dairy studied; therefore, firm conclusions cannot be reached. Six of 10 cows became clinical during the first week of lactation. All cases were classified as mild. Only three cows (three quarters) achieved bacterial cures (all within seven days) and one of these was a first-lactation cow that received no treatment. Of four first-lactation cows, two were cured. Only one of five cows in lactation two or later cured. The sporadic shedding nature of *S. aureus* can be seen in the cows that received no treatment. Because of this sporadic shedding, it is difficult to determine if an IMMA has a true effect on the bacterial population. The one clear exception is cow 3255, in which both affected quarters yielded no growth on days 4 and 5 after having high bacterial counts on days 1 and 2. Despite this, the cow returned to shedding high levels of *S. aureus*, which is again consistent with this organism being difficult to cure. Based on this limited data, treatment of

Table 2. Clinical *E. coli* mastitis by treatment category and cfus (number of colonies per 50 µl) for the first eight days.

Cow no.	Tx[1]	S: I: R[2]	D1 cfu	D2 cfu	D3 cfu	D4 cfu	D5 cfu	D6 cfu	D7 cfu	D8 cfu	D15 cfu	D22 cfu	D29 cfu	D36 cfu[4]
2834	A	-	100	2	0	0	0	0	0	0	0	0	0	0
2864	A	S	45	0	0	0	0	0	0	0	0	0	0	0
2977	A	S	35	3	1	0	0	0	0	0	0	0	0	0
2992	A	S	8	0	0	0	0	0	0	0	0	0	0	0
3032	A	-	100	100	100	100	100	100	100	19	-	21	2	10
3038	A	-	2	24	2	0	0	0	0	0	0	0	0	0
3168	A	S	2	4	0	0	0	0	0	0	0	0	0	0
3206	A	S	5	75	100	0	0	0	0	0	0	0	0	0
2977	C	S	75	42	0	0	0	0	0	0	0	0	0	0
3142	C	I	100	100	100	78	-	94	5	100	27	7	0	0
3171	C	R	11	1	0	0	0	0	0	0	0	0	0	0
3208	C	R	13	7	3	-	0	0	0	0	0	0	0	0
3227	C	R	100	100	4	-	0	0	0	0	0	dry	-	-
3237	C	R	100	100	100	33	72	0	-	0	0	0	0	0
3290	C	R	100	78	0	3	0	0	0	0	0	0	0	0
3299	C	-	100	100	45	96	35	9	0	0	0	0	0	0
3312	C	R	6	0	0	2	0	2	0	0	0	0	0	0
3394	C	I	25	27	30	6	2	0	-	0	0	0	0	0
3406	C	I	100	100	-	5	0	1	-	0	0	0	0	dry
3415	C	R	100	25	0	0	-	-	-	0	0	0	0	dry
3422	C	R	10	2	0	0	0	0	0	0	0	0	0	0
3471	C	I	80	99	15	6	0	-	0	0	0	0	0	0
2962[3]	Cf	-	100	100	100	2	45	5	1	3	0	0	0	0
3194[3]	Cf	I	100	-	100	100	100	100	45	23	100	0	0	0
3152[3]	S	-	100	100	45	100	10	1	10	10	34	cull	-	-
3399[3]	S	R	100	died	-	-	-	-	-	-	-	-	-	-

[1]Tx = treatment; A = mild to moderate cases treated with IMM amoxicillin by label (treatment began on D1); C = mild to moderate cases treated with IMM cephapirin by label (treatment began on D2); Cf = severe cases treated with IMM ceftiofur (300 mg) every 12 hours for three days (began D2) and S (began D1); S = standard severe therapy.

[2]S,I,R = antibiotic sensitivity, S = sensitive, I = intermediate, R = resistant, - = not done.

[3]These three cows were considered to have severe *E. coli* clinical mastitis. 3194 became a "downer" and was not treated IMM until day 5; this cow cured but lost her quarter.

[4]Culture results were known to be negative after day 36 for cows that survived, except for cow 3032 that was only followed for 36 days.

first-lactation cows early in lactation appears warranted, at least more so than treating older cows. The greater likelihood of obtaining a bacterial cure of *S. aureus* among first-lactation cows has previously been reported.[7] Extended IMMA therapy with cephapirin or amoxicillin cannot be accurately assessed with this limited data, but does not look promising in that only two of seven (29%) quarters cured, and self-cure is a possibility.

Streptococci

The cfu data for cows with clinical mastitis due to an environmental *Streptococcus* (primarily *Streptococcus uberis* and *Streptococcus dysgalactiae*) that were treated with IMM amoxicillin, FM or nothing is presented in Table 4. Cows receiving no treatment, FM, and the first five cows receiving IMM amoxicillin were followed for 36 days. Of the six cows (seven quarters) that received no treatment, only two quarters of two cows (29% and 33%, respectively) obtained a bacterial cure, which occurred on day 2. This finding is consistent with other studies that reported bacterial cure rates for untreated cases of clinical environmental streptococci mastitis ranging from 0 to 32%.[2,4,5] Evidence for intermittent shedding is apparent as well. Of 32 quarters of 27 cows that were treated with IMM amoxicillin by label, 15 quarters were cured by day 8 (47%; 44% of cows) and 20 quarters were cured by day 36 (62%; 67% of cows). In the FM group, only one of 12 quarters (8%) and one of 11 (9%) cows obtained a bacterial cure by day 7, and three of 10 quarters and cows (30%) obtained a bacterial cure by day 36. The data supports the premise that streptococcal mastitis benefits from IMMA which is illustrated further in Figure 3. Cows being treated with an IMMA show a dramatic decrease in cfu/50 µl the

Table 3. Daily colony forming units (cfu) of *Staphylococcus aureus* (number of colonies per 50 µl) by cow and treatment category.

Cow no.	Tx[1]	P: DIM[3]	D1 cfu	D2 cfu	D3 cfu	D4 cfu	D5 cfu	D6 cfu	D7 cfu	D8 cfu	D15 cfu	D22 cfu	D29 cfu	D36 cfu	D66 cfu	D96 cfu
3062	N	2:128	22	38	58	52	100	100	10	100	6	1	54	5	-	-
3064	N	2:2	100	100	100	100	100	100	75	49	100	100	100	27	-	-
3436	N	1:2	100	100	100	-	100	32	20	6	31	100	14	42	100	29
3592	N	1:6	100	100	4	4	1	1	0	0	0	0	0	0	0	0
2874	FM	2:158	100	36	17	100	100	50	6	50	50	50	100	100	-	-
3255	C[2]	2:96	100	100	1	0	0	0	1	7	78	100	100	100	100	100
3255	C	2:96	100	100	0	0	0	1	58	100	100	100	100	100	100	100
3393	C	1:7	100	25	-	19	0	-	0	0	0	0	0	0	0	0
3600	C	1:4	100	100	100	100	75	100	23	5	0	3	0	2	100	18
3600	C	1:4	100	100	100	100	100	100	40	11	0	2	3	7	100	100
3128	A[2]	2:181	100	35	0	0	0	0	0	0	0	0	0	cull		
3280	A	3:3	100	100	100	55	22	21	10	0	25	-	58	-	100	100

[1]Treatments: "N" = no treatment, FM = frequent milk-out four extra times per day for three days, C = IMM cephapirin for six treatments at 12-hour intervals, A = IMM amoxicillin for nine treatments at 12-hour intervals (clinical mastitis due to a *Streptococcus* specie in a separate quarter occurred at the same time and because streptococcal mastitis was more common, the streptococcal treatment was used).
[2]All cultures were sensitive to cephapirin and amoxicillin *in vitro*. Antibiotic treatments began after the second culture.
[3]P = parity; DIM = days-in-milk

day after treatment has begun, compared to cows not treated or receiving FM. Figure 3 also provides some evidence that FMO may actually increase the time to bacterial cure. Previous work also suggests that the time to clinical cures is increased by FM when compared to no treatment or IMMA.[6]

SCC by Culture Result

Individual quarter SCC of clinical mastitis cases was consistently more than 4 million cells/mL at the onset of the clinical mastitis case (Figure 4). The level of SCC tends to decrease in the first eight days regardless of the etiology or treatment used, yet remained above 1 million cells/mL at the end of eight days. The SCC of no-growth cultures, although still considerably elevated, were noticeably lower than positive-growth cultures.

Arcanobacterium pyogenes

Two cows developed clinical mastitis due to *Arcanobacterium pyogenes*. Somatic cell count and cfu data are presented in Figure 5. Both cases were treated with IMM cephapirin every 12 hours for a total of six treatments, as one case was classified as moderate and the other as severe. Intramammary treatment began on day 2, and the last IMMA treatment was given on day 5. Thus, the first two cfu data points were obtained prior to IMMA therapy. On day 3, neither cow's culture revealed any growth, suggesting antibiotic efficacy. The milk was too thick to obtain an actual SCC level on the severe cow, but the CMT was a score of three through sample day 28 (thus the average CMT 3 score equivalent of 8,100 x 1000 SCC/mL was used). The cfu data suggests that cephapirin was effective, but because the cfu counts increased to maximum levels after the IMMA, more prolonged treatment might be justified. The cow classified as moderate cured bacteriologically by day 15, was clinically cured by day 33, and her quarter SCC on day 66 had decreased to 273,000 cells/mL. The cow classified as severe ceased to lactate in the affected quarter after day 29.

Misc Gram-negative

Three cases of clinical mastitis due to rarer gram-negative pathogens are presented in Figure 6. One case was due to *Citrobacter koseri* and two cases were due to *Serratia marcescens*. All cases were classified as mild and yielded quarter SCC greater than 1 million for the first eight days. Although the *Citrobacter* case was not treated with anything, a bacterial cure was evident on day 5, quarter milk appeared normal (clinical cure) by day 12, and the quarter SCC was less than 500,000 cells/mL by day 36. One of the *Serratia* cases was treated with IMM cephapirin by label and one was not treated, but neither achieved a bacterial cure through day 96. The quarter SCC remained more than 1 million cells/mL through day 96 for both *Serratia*-infected cows. A clinical cure did occur by day 3 in one of the *Serratia* cows; the other cow appeared to achieve a clinical cure on day 6, but upon subsequent evaluation days would sporadically be clinical. Little is known about *Citrobacter* IMI but this data suggests that *Citrobacter* IMI is not severe and does not require treatment. *Serratia* IMI is

Table 4. Colony forming units (cfus) of *Streptococcus* (number colonies per 50 µl) by cow and treatment category.

Cow no.	Tx[1]	D1 cfu	D2 cfu	D3 cfu	D4 cfu	D5 cfu	D6 cfu	D7 cfu	D8 cfu	D15 cfu	D22 cfu	D29 cfu	D36 cfu	D66 cfu	D96 cfu
2871	N	20	0	0	0	0	0	0	0	0	0	0	0	-	-
2891	N	2	100	100	100	100	0	26	100	100	100	100	4	-	-
2914	N	100	0	0	0	0	0	0	0	0	0	0	0	-	-
2953	N	6	50	2	37	17	100	75	100	50	2	16	100	-	-
3038	N	100	100	100	100	100	100	100	100	100	40	100	1	-	-
3038	N	7	-	-	100	6	100	15	100	100	90	0	3	-	-
3062	N	13	5	100	100	100	53	18	32	5	100	28	31	-	-
2666	A	25	0	0	0	0	0	0	0	0	0	0	0	-	-
3014	A	100	2	0	30	50	9	100	100	100	2	0	0	-	-
3168	A	100	5	16	10	1	0	0	0	0	0	0	0	-	-
3197	A	100	83	100	100	57	100	100	100	100	100	100	100	-	-
3206	A	36	0	0	0	0	0	0	0	0	0	0	0	-	-
2946	A	100	100	0	12	88	100	100	83	100	100	100	100	100	0
3098	A	100	100	0	0	0	0	0	-	-	0	0	0	0	0
3105	A	24	2	-	0	0	0	0	2	0	0	0	0	41	0
3159	A	100	100	0	0	0	100	100	100	-	100	100	100	100	26
3175	A	100	100	-	0	0	-	0	100	32	0	100	100	100	23
3338	A	100	100	15	0	0	0	0	0	0	0	dead			
3344	A	100	100	20	17	0	0	100	100	56	33	100	100	100	100
3344	A	100	100	26	12	2	100	100	100	100	100	100	100	100	84
3360	A	100	100	0	0	0	0	0	0	0	0	0	0	0	0
3368	A	100	100	0	0	-	-	89	73	14	100	100	84	13	100
3374	A	100	100	4	0	12	12	0	0	0	0	0	0	0	0
3383	A	100	100	0	0	0	-	0	0	0	0	0	0	0	0
3437	A	29	32	0	0	-	0	-	0	0	con	0	0	0	-
3440	A	100	100	0	5	-	-	11	80	con	0	0	0	cull	
3440	A	100	100	0	0	-	-	0	0	0	0	0	0	cull	
3451	A	100	100	-	0	0	0	0	0	0	0	0	0	0	0
3459	A	60	100	0	0	0	0	0	0	0	0	0	0	0	0
3498	A	96	96	0	13	100	100	100	100	100	100	100	100	100	100
3536	A	100	-	100	con	100	con	100	100	100	100	100	fail	-	-
3538	A	100	100	28	0	0	0	8	1	0	0	0	25	0	0
3538	A	100	100	0	0	34	100	100	100	100	100	100	100	100	100
3538	A	100	100	0	0	0	100	100	0	0	0	0	0	0	0
3558	A	100	100	0	100	100	100	-	100	100	100	100	cull	-	-
3567	A	100	100	100	90	28	8	3	0	100	100	55	22	0	0
3591	A	100	100	100	2	0	0	0	-	-	2	0	0	0	0
3597	A	100	100	100	72	73	56	24	0	-	0	0	0	0	0
3597	A	100	100	100	57	55	20	8	0	-	0	0	0	0	0
2609	FM	33	0	100	30	23	1	1	1	0	0	0	0	-	-
2646	FM	16	50	100	50	100	100	100	100	100	100	100	100	-	-
2726	FM	100	100	100	100	100	100	100	100	100	100	100	100	-	-
2779	FM	5	0	3	6	100	18	100	100	6	100	100	100	-	-
2905	FM	4	50	26	100	50	53	0	3	8	7	3	1	-	-
2935	FM	14	2	100	66	98	100	100	dry	.	.	.	.	-	-
2935	FM	11	100	1	24	0	0	3	dry	.	.	.	.	-	-
2937	FM	100	100	100	100	100	100	100	100	100	100	100	100	-	-
3052	FM	16	0	0	0	0	0	0	0	0	0	0	0	-	-
3060	FM	50	50	100	100	100	100	50	50	0	0	0	0	-	-
3161	FM	100	100	100	100	100	100	100	100	100	100	100	100	-	-
3185	FM	100	100	100	100	100	100	100	100	100	100	100	100	-	-

[1]Treatments: N = no treatment, FM = frequent milk-out four extra times per day for three days (began D1), amox = 3 IMM amoxicillin treatments at 12-hour intervals (only one streptococcal culture was resistant to amoxicillin *in vitro;* cow 3451), treatment began on D1 for the first five cows listed and then on D2 for the rest of the cows.

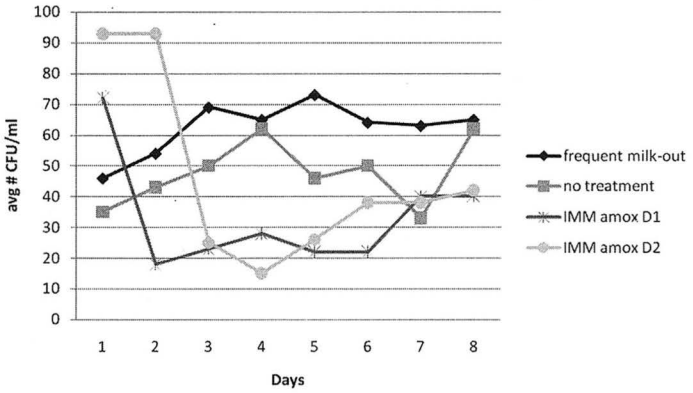

Figure 3. Average # cfu/50 µl by treatment and day of clinical *Streptococcus* spp mastitis.

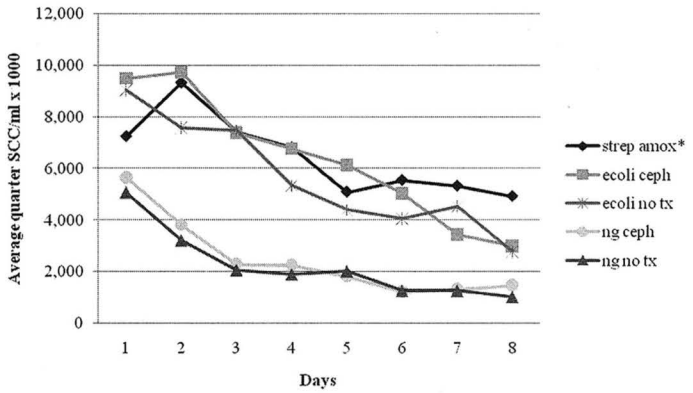

Figure 4. Average quarter SCC/ml x 1000 for the first 8 day of clinical mastitis by culture result and treatment. * strep = environmental streptococci; amox = IMM amoxicillin by label, ceph = IMM cephapirin by label, ng = no growth, no tx = no treatment.

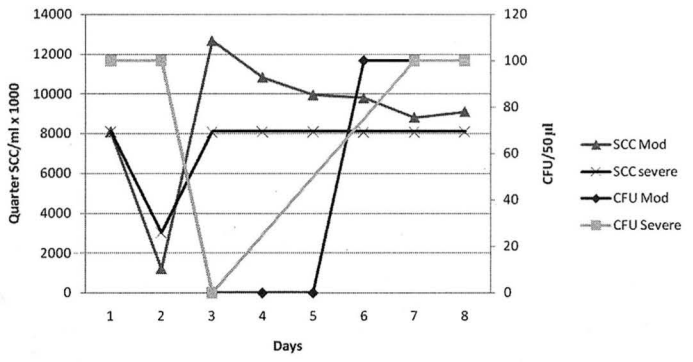

Figure 5. The first 8 days of cfu/ml and SCC for two cows with *Arcanobacterium pyogenes* clinical mastitis.

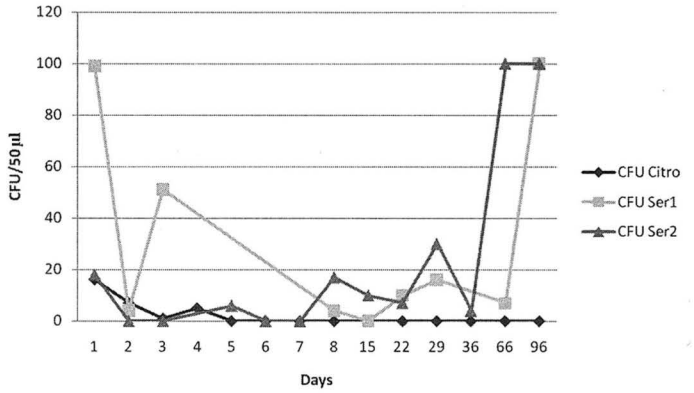

Figure 6. The first 8 days of cfu/ml and SCC for two cows with *Serratia marcesens* one cow with *Citrobacter* clinical mastitis.

known to create mild chronic mastitis and is typically resistant to most IMMA, similar to what was seen with these two cases.

Coagulase-negative Staphylococci

The CNS, as a group, are probably the most common IMI of dairy cattle. However, the CNS do not typically create high SCC or clinical mastitis. The cfu and SCC data of four cases of clinical CNS mastitis are presented in Figures 7 and 8. CNS 1 and 2 represent single quarters, whereas CNS 3 and 4 represent two quarters from a single cow. All cases were classified as mild clinical mastitis. CNS 1 was treated with IMM amoxicillin by label; the other cases received no treatment. CNS 1 was not typed but CNS 2 was *Staphylococcus hemolyticus* and CNS 3 and 4 were *Staphylococcus simulans*. All quarters obtained clinical cures by 12 days. Although the cow with *S. simulans*-affected quarters cured clinical on day 4, bacterial cures did not occur and this cow dried off at 96 days with quarter SCC more than 4 million cells/mL in both quarters. Although possibly atypical, some CNS can create chronic IMI with high SCC. Treatment seems justified for CNS clinical mastitis cases.

Pasteurella multocida

Data from three cows with clinical mastitis due to *Pasteurella multocida* are presented in Figure 9. All cases were classified as moderate clinical mastitis. Cow 3298 was treated with IMM ceftiofur, which appeared to be effective as there was no bacterial growth on days 3 through 6. After treatment ceased, *Pasteurella* growth reappeared until day 29 and 36, when the quarter appeared to become cured. The milk remained clinical and the quarter SCC was more than 6 million cells/mL through day 36, when the cow was dried off. Cow 3425

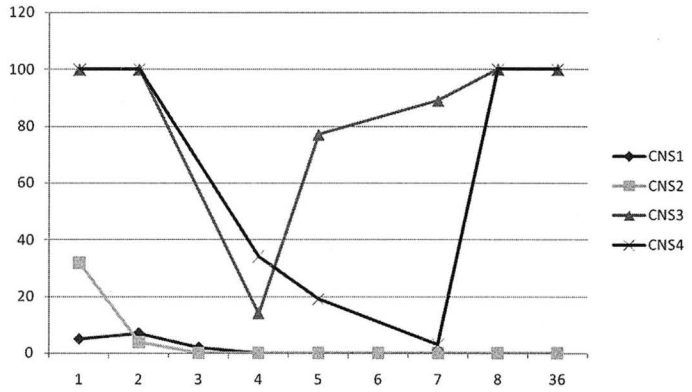

Figure 7. CFU/50µl for days 1-8 and 36 of cows with CNS clinical mastitis.

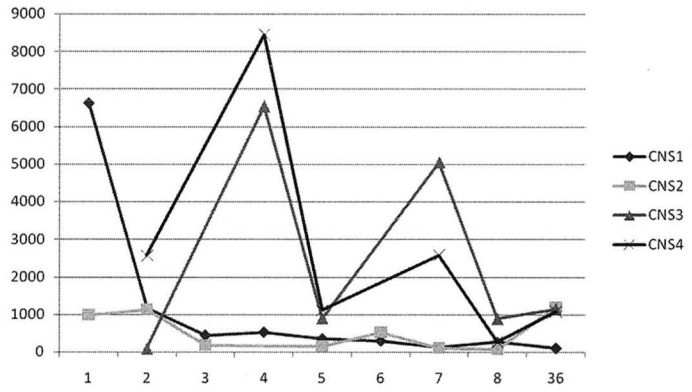

Figure 8. SCC/ml x 1000 for days 1-8 and 36 of cows with CNS clinical mastitis.

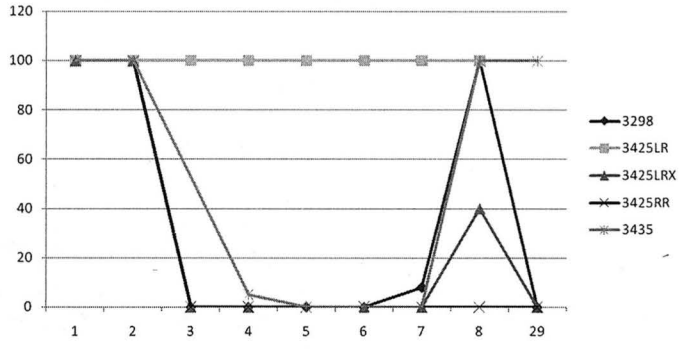

Figure 9. *Pasteurella multocida* clinical mastitis treated with IMM ceftiofur[g] (except 3425 LR): cfu/50µl by day and cow (quarter).

was assigned to the no-treatment group when initially diagnosed with clinical mastitis due to *P. multocida* in the left rear quarter (3425LR). This case was considered a failure after two weeks of absolutely no improvement and the appearance of another clinical quarter (right rear: RR) with *P. multocida*. Both quarters were then treated with IMM ceftiofur (3425LRX and 3425RR). The high levels of cfus present prior to IMM treatment were reduced to zero cfu by day 3, again indicating that ceftiofur is effective against *P. multocida*. The RR quarter became clinically cured on day 8, and the quarter SCC was less than 500,000 cells/mL by day 15. The LR quarter took considerably longer to become completely cured, as a clinical cure did not occur until day 33 and the SCC was not reduced to less than 500,000 cells/mL until day 66. Cow 3435 was treated with IMM ceftiofur using a different dosage (100 mg once daily for five days) than that of the cows above. Cow 3435 cured clinically at 28 days but, despite an early drop in cfu/mL (suggesting efficacy), the cow did not become bacteriologically cured and her quarter SCC was consistently over 2 million cells/mL through day 186.

Conclusion

The understanding of what is taking place during the first few days of the clinical mastitis case is essential in determining the efficacy of treatment, the justification for treatment and devising future clinical mastitis management protocols which may include...no treatment.

Footnotes

[a]Amoxi-mast, SmithKline-Beecham Animal Health, Exton, PA
[b]API 20E, bioMerieux Vitek, Inc., Hazelwood, MO
[c]Banamine®, Intervet/Schering-Plough Animal Health
[d]PRN High Potency Calcium Gel®, PRN Pharmacal, Pensacola, FL
[e]Naxcel®, Pfizer Animal Health, New York, NY
[f]Cefa-lak®, Fort Dodge Animal Health, Fort Dodge, IA
[g]Excenel, Pfizer Animal Health, New York, NY

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