Management Factors Affecting Antibiotic Residues and the Establishment of Antibiotic Resistance in Dairy Calves

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Summary

Management practices that may contribute to antibiotic residues in dairy calves were surveyed on 42 large-scale dairies in Tulare County, California. The survey covered antibiotic use in cows and calves, colostrum use, feeding of milk from cows treated with antibiotics, treatment personnel, and record keeping,

Results indicate a wide range of antibiotics were used by the dairy operators. Antibiotics were used by a substantial number of operators for treating calves on a continuous basis, and for conditions not always related to disease. Dosage rates were set by veterinarians on only 21% of the dairies, and antibiotic use was not discontinued per label or veterinary instructions on 72% of the dairies surveyed, 24% of operators discontinuing use with the passage of time. On 62% of the dairies surveyed dairy operators pooled colostrum with milk from treated cows, and on 59% of the dairies this milk constituted a majority of the feed for young calves. A majority of dairy operators kept treatment records (60%), but only 12% kept calf health records. Calf care and treatment is done by hired employees (62%) and the training of these personnel is accomplished through the owner on 61% of the dairies surveyed.

While a vast majority of large-scale operators appear to understand and act upon available data in some critical areas (such as not feeding milk from treated cows to calves within the first 24 hours following birth), there is an inadequate priority on quality assurance activities and on management of details of antibiotic treatment.

Antibiotic residues in milk continue to be an increasing concern faced by both producers and the dairy industry. Possible deleterious effects of antibiotic residues on public health, and production problems in the manufacturing of milk products are the main reasons for testing milk and rejecting that which contains antibiotic residues.[1,2,3] For instance, in dairy calves, residues have been found in muscle tissue,[4,5,6] endangering consumers of calves sold for veal. In an attempt to reduce losses from dumping antibiotic tainted milk, the producer may feed the "waste" milk to calves, exposing the calves to antibiotic resistant bacteria and future health problems.[7,8,9,10,11,12,13,14,15] Additionally, calf treatment and disease control practices may contribute to the buildup of antibiotic resistance in the replacement herd.

A survey of current antibiotic use practices is, first, an initial step in providing information concerning the potential for spread of antibiotic resistant bacteria in herds, second, a measure of how effective antibiotic management information has been transmitted to dairy operators and third, a basis for making practical recommendations regarding management practices that affect antibiotic resistance and residues.

Previous calf management surveys have focused on calf health and mortality[16] and on economic efficiency.[17] The present study was designed to focus on those management practices identified in the literature or by experts in the field as having a potential impact on antibiotic residues. The survey covered antibiotic use in cows and calves, colostrum use, feeding of milk from cows treated with antibiotics, treatment personnel factors, and record keeping on 42 dairies in Tulare County, California, a center of large-scale dairies averaging 837 milking cows.

Materials and Methods

Herds Surveyed

Dairies in this survey were located in Tulare County in California. Surveyed dairies were predominately large-scale (averaging 837 milking cows), intensively managed, with high density feedlot systems. Forty-two dairies were randomly selected for the survey using a random number generator from a Dairy Herd Improvement Association (DHIA) list provided by the University of California Cooperative Extension Advisor. These 42 dairies represented approximately 18% of the dairies in Tulare County.

Survey Methods

The survey was constructed on the basis of a review of current literature and discussions among veterinarians in the region. Questions were formulated to deter-

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mine current practices and to quantify the level of management action (frequency, duration, priority and consistency). The on-farm interviews lasted an average of 45 minutes during which the manager was asked specific questions which were confirmed by using overlapping questions and when possible, the direct observation.

To limit variability in question phrasing and response interpretation, a single surveyor was used, a veterinary student familiar with the literature and trained by a variety of experts during a 3-dairy trail survey. The interviews were conducted in either the dairy milking parlor or the calf barn. The surveyor asked questions and recorded responses and observational data on a prepared form. Data were entered into a Lotus 123 spreadsheet and responses expressed as percentages.

Results and Discussion

Antibiotics Used (cows and calves)

A wide range of antibiotics were used by the dairy operators surveyed (Table 1). Six antibiotics were used by more than 50% of the operators for treatment of cows, and four were used by more than 50% of the operators for treatment of calves; thus, a potential for multiple antibiotic residues in milk and veal is present if proper antibiotic management techniques are not followed.

Table 1. Survey responses of 42 diary operators concerning types of antibiotics used in dairy cows and calves.

Question	Response (cow %, calf %)		
Types of Antibiotics used	Penicillins:	100%	93%
	Tetracyclines:	88%	79%
	Aminoglycosides:	79%*	
	Sulfonamides:	79%	69%
	Novobiocin:	67%	2%
	Tylosin:	54%	74%
	Cephalosporins:	43%	14%
	Erythromycin:	5%	0%
	Polymyxin, spectinomycin		
	Trimethoprim:	3%	12%
	*same percentage		

Penicillin and tetracycline are the most commonly used antibiotics and the most commonly detected residues.[18] The risk for penicillin residues in milk to occur is increased as penicillins are contained in 76% of the intramammary products, two-thirds of which contain more than one antibiotic to provide a wide-spectrum effect for treatment of conditions of unspecified etiology.[18] Tetracyclines have been detected in various tissues in dairy calves and cows. Oxytetracycline in concentrations up to 40 ppm (the concentration in some feeds) has been detected in the cortex and medulla of the kidney and meat. Chlortetracycline in concentrations of up to 80 ppm has been detected in meat, cortex and medulla of kidney, and urine (100% of cases tested).[19] In another study, 30 of 61 cows treated with oxytetracycline had residues in postinjection milk for a mean period of 26.6 days with a std. deviation of 10.3.[20]

Antibiotic Management Practices

The wide range of antibiotics used may in part be explained by the management practices identified in the survey (Table 2). Antibiotics were used by a substantial number of operators when treating calves on a continuous basis (50%) and for conditions not necessarily related to disease (off feed, 45%; high temperature, 50%; other sick animals, 21%). This practice would increase the likelihood of residues and of antibiotic resistant bacterial strains developing, requiring different antibiotics for treatment.

Table 2. Survey responses of 42 dairy operators concerning antibiotic management practices in dairy cows and calves.

Question	Response (%)
Source of antibiotics	Drug Company/Dealer: 51% Veterinarian: 33% Dairy cooperative: 15% Fed store: 1%
Storage of antibiotics	Barn refrigerator: 81% Barn shelve: 26% Dairy owner's house: 3%
Who sets dosage rate?	Owner: 33% Insert: 21% Veterinarian: 21% Manager: 17% Employee: 7%
When is antibiotic use discontinued?	Symptoms disappear: 58% Passage of time: 24% Label instructions: 11% Veterinary instructions: 7%
When do you treat calves with antibiotics?	Respiratory problems: 100% Scours: 83% Continuously: 50% High temperature: 50% Off feed: 45% Other sick animals: 21%

Critical decisions, such as dosage rate and discontinuance of antibiotic use, appear to be made by operators without adequate understanding of antibiotic treatment. Drug companies, through dealers were the most common source of antibiotics, which provides a potential situation for drug misuse if a veterinarian is not directly involved in their management. Dosage rate was set by veterinarians on only 21% of the dairies surveyed, although the literature indicates that dosage rates set by hired employees are associated with the increased occurrence of residues.[21] Antibiotic use was not discontinued per label directions, 24% of operators discontinuing use with the passage of time, although using drugs in accordance with the label directions (only 11% of the responses in this survey) has been shown to reduce the occurrence of residues.[22] Veterinarians were consulted regarding antibiotic discontinuance by only 7% of the dairies (3 od 42 dairies surveyed). Antibiotic storage was also inconsistent with label directions on one-third of the dairies.

The antibiotic management practices identified are consistent with a management strategy of relying on a treatment solution rather than preventive management practices to solve calf disease problems. For example, few dairy operators (7-14%) reported vaccinating calves against major pathogens such as E. coli, Rota-Corona virus, Clostridia species; a practice which would reduce antibiotic use to some extent.

Antibiotic management practices on a majority of the dairies surveyed suggest that information concerning antibiotic use has been (1) ineffectively transmitted to dairy operators; (2) misunderstood by dairy operators; (3) given low priority by operators; or (4) not transmitted from operator to employees responsible for antibiotic management. The resulting management practices are inconsistent with recommended practice and may be self-defeating, with poor antibiotic management resulting in the need for increased antibiotic use.

Use of Colostrum

Calves are dependent on colostrum to establish a strong immunological status in the first 24 hours of life.[23] It should be fed as soon as possible after birth, with the literature often recommending force feeding of colostrum versus allowing suckling to ensure that the calf receives adequate volumes within the necessary time.[23] The quality of colostrum is an important variable as well. First milking colostrum from fresh cows has the highest concentration of immunoglobulins and should be used fresh or immediately placed in proper storage, frozen or refrigerated properly for only a short time.[24] Fermentation to reduce antibiotic residues is not recommended because it may expose the calf to micro-organisms which will be absorbed through the newborn gut.[25,26,27]

Management practices related to meeting these standards were somewhat inconsistent (Table 3). While 90% of operators used first milking colostrum from fresh cows, many of the same operators also used heifer colostrum (40%) and 62% pooled colostrum, which may dilute its immunologic concentration. Also, they are pooling colostrum with milk from treated cows which could expose the susceptible newborn calf to antibiotic resistant bacteria and antibiotic residues.

Table 3. Survey responses of 42 dairy operators concerning colostrum use in dairy calves.

Question	Response (%)
Do you use the first milking colostrum from fresh cows?	Yes (93%) No (7%)
Do you use colostrum from first calf heifers?	Yes (40%) No (60%)
Do you pool colostrum from cows of different ages with milk from treated cows?	Yes (62%) No (38%)
How is the colostrum preserved?	Frozen (14%) Refrigerated (49%) Fermented (0%) Fresh (37%)
How long between milking and storage of colostrum?	Average: 1.15 hrs.
How do you identify your stored colostrum?	Individual label and Date (9%) order on shelf (41%) memory (50%)
Do you use a colostrometer?	Yes (14%) No (86%)
Are sodium sulfite tests done your calves?	Yes (5%) No (95%)
Has your colostrum ever been cultured for bacteria?	Yes (0%) No (100%)

Most operators chose to use fresh or refrigerated colostrum, but handling and storage often were inadequate to ensure efficacy. An average of 1.15 hours elapsed between milking and storage of colostrum, and it was not adequately labeled to ensure that supplies were being rotated. Only 6 of 42 operators used a colostrometer to measure immunological status of sup-

plies and even fewer used the sodium sulfite test. In addition, studies have shown that calves may have high mortality rates when fed colostrum from mastitic cows.[14] Yet, no operator cultured colostrum to determine the presence of pathogenic bacteria, even among operators who pooled colostrum and were risking disease transmission from treated cows.

It would appear, then, that operators understand the benefits of colostrum, but may not recognize or be giving adequate priority to the need for quality control. As a result, calves may be challenged by antibiotic resistant bacteria from treated cows, therefore requiring additional antibiotic treatment, and may not receive colostrum of adequate efficacy early enough to ensure their immunological status. The net result may be a need to treat calves with antibiotics, and to treat them with a wider range of antibiotics in doses that would not be necessary if colostrum feeding recommendations were followed.

Feeding of Hospital Pen Milk

Although feeding of hospital pen milk does not appear to affect weigh gain[4,7,14,23,28] or the incidence of health disorders in calves[10,11,12,23,29] and the practice is widespread in both the U.K. and the United States,[14] calves may be exposed to antibiotic residues and resistant bacteria during the process. A few studies have shown calves fed mastitic milk have a higher incidence of scouring[8,14] and heifer calves may become infected through suckling each other's teats after being fed milk containing viable bacteria; these calves are likely to excrete these bacteria after parturition.[14,29,30] Nevertheless, hospital pen milk is probably the most economical feed for young calves.[28]

Dairy operators surveyed (Table 4) thus predictably used hospital pen milk (HPM) (98%), including HPM mixed with milk from cows recently freshened (78%). There is potential that milk pooled in this manner might contain antibiotic residues from dry cow therapy. HPM constituted a majority of the feed for calves on 59% of the dairies surveyed, indicating a potential for calves to receive contaminated feed. In fact, a majority fed HPM (52%) to all calves, although some of this milk might contain very high antibiotic residue levels.

A vast majority (95%) followed literature recommendations to avoid first day feeding of hospital pen milk to prevent bacteria from permeating the gut,[9] to prevent malabsorption of immunoglobulins,[31] and to prevent the transfer of antibiotic resistance to nonpathogenic anaerobic bacteria normally present in the gut.[14] A similarly large majority also did not ferment milk (98%); this is consistent with findings that fermentation increases microorganism populations[7] and the amount of enterotoxin product[14] and results in slower weight gain from birth to weaning.[8]

Table 4. Survey responses of 42 dairy operators concerning feeding of hospital pen milk to dairy calves.

Question	Responses (%)	
Is hospital pen milk fed to calves?	Yes (98%) No (2%)	
Do you feed fresh cow milk fresh cow fresh cow milk exclusively, sick cow milk sick cow milk exclusively, or sick and fresh and sick cow fresh cow milk mixed?	(2%) (10%) (78%)	
What % of the calves total All of liquid feed liquid feed is hospital pen milk?	(26%) 50-99% 25-49% <25%	 (33%) (29%) (12%)
Is hospital pen milk fed to all calves?	Yes (52%) No (48%)	
Is hospital pen milk fed on the calve's first day of life?	Yes (5%) No (95%)	
Is hospital pen milk fed to calves before colostrum feeding is finished?	Yes (12%) No (88%)	
Do you withhold mastitic milk from calves after cow antibiotic treatment?	Yes (12%) No (88%)	
Do you ferment your hospital pen milk?	Yes (2%) No (98%)	
Do you culture cows with mastitis?	Always (7%) Sometimes (33%) Never (60%)	
How much physical contact is allowed between calves being fed hospital pen milk?	full contact (12%) minimal contact (71%) no contact (17%)	

Quality control measures such as culturing cows with mastitis (40% always or sometimes; 60% never) and withholding mastitic milk from calves after cow antibiotic treatment (12% yes; 88% no) were not generally observed. In addition, calves were allowed contact (and thus allowed suckling) on most dairies, which has been shown to increase the incidence of mastitic *Streptococcus agalactiae*.[29] Penning and joint feeding has been correlated to chronic mastitis as well.[28,30]

Dairy operators thus appear to be avoiding some major risks associated with HPM feeding (feeding too early, using fermented HPM) but may not be taking adequate precautions to prevent calves from receiving antibiotic contaminated feed or feed containing resistant bacteria.

Record Keeping

Although poor record keeping (and not reading label directions) has been shown to contribute to drug residues in milk,[21] record keeping practices were inconsistent and not adequate to provide adequate animal disease histories. A majority kept hospital pens records (60%), only 60% of these (thus 36% of the total) recorded each diagnosis. And only a few operators kept calf health records (12%), many of these records being incomplete (no treatment and mortality data).

Record keeping is a quality control measure used by management to track performance; the efficacy of treatment may depend on having records which indicate prior record of antibiotic use (and therefore sensitivity). A lack of adequate records indicates that operators are not monitoring antibiotic use; this would predispose them to use a wide range of antibiotics and to overuse antibiotics. Without knowledge of prior antibiotic use, appropriate treatment may also be more difficult, and many operators in this study relied on casual observation and memory in monitoring calf treatment.

Calf Care and Treatment Personnel

Calf care and treatment are generally relegated to the owner and the owner's family on 38% and hired employees on 62% of the dairies surveyed. The treatment training of personnel is accomplished mainly through the owner/manager and his or her experience (61%), 28% through the veterinarian, 7% through a training course, and 3% from other employees. This finding that veterinarians are not directly involved with treatment training is consistent with other surveys,[16,18] and indicates a potential for communication problems and improper administration of antibiotics. This is confirmed by the finding above that antibiotic treatment is suspended when symptoms disappear (58%), contrary to recommended procedures.

Conclusions

The responses of the 42 dairy operators in this survey indicate only a limited understanding of management practices which influence antibiotic residues in the herd. While a vast majority of operators appear to understand and act upon available data in some critical areas (such as not feeding HPM to calves within the first 24 hours following birth), there is inadequate priority placed on quality assurance activities and on management of details of antibiotic treatment. This would suggest a simplified understanding of a complex management issue, a failure to understand the importance of monitoring and record keeping, of limiting exposure to resistant bacteria, and ensuring that label directions are followed. This may be a result of an unrealistic faith in the efficacy of antibiotics, the belief that they are so efficacious that they work even when misused; it may also be a result of insufficient instruction of operators by drug companies, cooperative extension agents, and veterinarians for reducing antibiotic residues in dairy calves and their products through improved management of practices related to the occurrence of these residues.

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Abstracts:

A neuropathological survey of brains submitted under the Bovine Spongiform Encephalopathy Orders in Scotland

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Bovine spongiform encephalopathy was not confirmed histo-logically in 225 of 829 bovine brains submitted for diagnosis. Several previously described disorders of the central nervous system were observed in these brains as well as disorders not previously recognized in Britain, including bilateral vacuolation of the substantia nigra, hippocampal sclerosis with brainstem neuronal chromatolysis and necrosis, focal symmetrical encephalomalacia and meningio-angiomatosis. Severe cerebellar dysplasia consistent with pre-natal bovine viral diarrhoea - mucosal disease virus infection or mineralisation of the blood vessels of the basal ganglia were interpreted respectively as congenital changes or changes due to ageing and were considered to be of no clinical significance.

Treatment of lead poisoning in cattle

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Groups of four Holstein cows which had received 2 mg lead/kg bodyweight for 28 days were treated either with 2 mg thiamine hydrochloride intramuscularly daily for 13 days, or with 62 mg disodium, calcium EDTA twice daily intravenously for four days or with the two treatments together. Thiamine alone was not effective in reducing blood lead concentration, but the other two treatments did reduce the concentration. However, the treatment with thiamine was more effective than the other two treatments in reducing the severity of the clinical signs of plumbism. Measurements of plasma progesterone concentration and an ovarian examination indicated that neither the exposure to lead nor the treatments had any effects on the cows' ovarian cycles.