Calf-related Drug Use on Holstein Dairy Farms in Southwestern Ontario

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ABSTRACT

Calf-related drug use was studied on 104 randomly selected Holstein dairy farms in southwestern Ontario between October 1980 and July 1983. About 20% of dairy farmers were observed to administer antimicrobials preventively to healthy newborn calves (primarily as commercial "cocktails" of various antimicrobials, vitamins and minerals given in an oral bolus form) at some time during the year. About 30% of the farmers were observed to use vitamins (primarily vitamins A,D and E) preventively. The pattern of types of antimicrobials used preventively appeared to be different from the pattern seen for therapeutic use. Chloramphenicol was the single most commonly used therapeutic antimicrobial in this population of calves, accounting for some 30% of overall therapeutic antimicrobial use. In this study population, the prophylactic use of antimicrobials was associated with a decreased risk of being treated for pneumonia, and of dying, but an increased risk of being treated for scours. Case fatality rates for calves treated therapeutically varied, depending on the antimicrobial used and the routine of treatment. Calves treated with penicillin consistently suffered the highest case fatality rates. Case fatality rates for calves treated with chloramphenicol were considerably higher for calves treated once per day than for calves treated twice per day. For instance, calves first treated for scours with chloramphenicol, if treated once per day, suffered a case fatality rate of 22%. For scouring calves treated twice per day the case fatality rate was just under five percent. Clinical field trials of specific antimicrobials used preventively and therapeutically are required to delineate the conditions under which they might be useful.

Key words: Dairy calf, drug use.

RÉSUMÉ

L'usage d'antibiotiques chez les veaux, dans des troupeaux laitiers Holstein du sud-ouest de l'Ontario

Cette étude s'étalait sur la période d'octobre 1980 à juillet 1983 et elle portait sur l'usage d'antibiotiques chez les veaux de 104 troupeaux laitiers Holstein du sud-ouest de l'Ontario. Elle révéla qu'environ 20% des éleveurs administraient une antibiothérapie préventive à des veaux nouveau-nés en santé, sous la forme de bols qui contenaient divers antibiotiques, des vitamines et des minéraux, à une période quelconque de l'année. Par ailleurs, environ 30% de ces éleveurs donnaient les vitamines A,D et E, à titre préventif. L'antibiothérapie préventive semblait différer de la thérapeutique. Le chloramphénicol correspondait à l'antibiotique utilisé le plus souvent comme agent thérapeutique et représentait environ 30% de toute l'antibiothérapie thérapeutique. Chez les veaux impliqués dans cette étude, l'antibiothérapie prophylactique s'accompagnait d'un risque moins grand de traitement pour la pneumonie et de mort, mais d'un risque plus élevé de traitement antidiarrhéique. Le taux de mortalité, chez les veaux soumis à une antibiothérapie thérapeutique, varia selon l'antibiotique utilisé et la façon de l'administrer. Les veaux traités à la pénicilline affichèrent constamment le taux de mortalité le plus élevé. Quant aux veaux traités au chloramphénicol, ils affichèrent un taux de mortalité beaucoup plus élevé quand ils n'en recevaient qu'une injection quotidienne au lieu de deux. C'est ainsi que les veaux traités contre la diarrhée, au moyen d'une seule injection quotidienne de chloramphénicol, affichèrent un taux de mortalité de 22%, comparativement à un peu moins de 5%, chez ceux qui en avaient reçu deux. Il faudra réaliser des expériences cliniques avec des antibiotiques spécifiques, à titre d'agents prophylactiques et thérapeutiques, pour déterminer les conditions optimales de leur utilité.

Mots clés : veaux laitiers, usage d'antibiotiques.

INTRODUCTION

The extent, nature and consequences of calf-related drug use by dairy farmers has not, to date, been measured in any scientific or systematic fashion. Three published reports from Great Britain and the United States have reported crude breakdowns, based on sales and/or prescription statistics, of antimicrobial use in food-producing animals (1,2) and in people (3). At the same time, it was reported that data on the use of antimicrobials in the dairy industry (in feeds or otherwise) were not available (2,4). Recently, a report on antibiotic use in agriculture, based specifically on the situation in Ontario, was released (5). Background material for this report included a brief from the Ontario Veterinary College (6). Neither of these documents provided quantitative data on the nature and extent of antimicrobial use in the dairy industry.

Quantitative, statistically sound data on calf-related therapeutic and

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prophylactic drug usage under field conditions would be of great benefit to dairy farmers and veterinarians in their attempt to develop rational calf management programs, as well as those who are concerned with the regulation of drugs in agriculture.

This paper describes the nature, extent and some of the consequences of calf-related drug use on Ontario Holstein dairy farms. The data on which this description is based were gathered from a random sample of southwestern Ontario Holstein dairy farms, which had been enrolled for at least five years on the supervised recording program of the Ontario Dairy Herd Improvement Corporation (ODHIC), or on the Record of Performance (ROP) program with milk samples centrally processed. The characteristics of these farms, and the manner in which they were selected, have been described elsewhere (7).

MATERIALS AND METHODS

Of the 104 farmers who participated in this study, a randomly selected subset of 35 kept individual calf records on all heifer calves from birth to weaning. These farms were denoted intensive farms. The 1968 heifer calves born on these farms between the fall of 1980 and the summer of 1983 provided the data base for the measurement of outcomes associated with different prophylactic and therapeutic treatments. On the remaining farms, denoted extensive farms, calves were not individually identified.

On all farms, the records kept included the date and reason for treatment, the particular drugs used, the frequency of treatment per day, and the number of days of treatment. Records were kept from the winter of 1980 through to the summer of 1983. In order to give all farmers some time to accustom themselves to the recording system, however, only the records kept between January 1, 1981 and May 15, 1983 were used for farm level analysis; for the last few months of the study, the number of farms participating was gradually reduced as the research project was phased out. Measurement of overall drug use, as well as the relative contribution of specific drugs, was based on 4977 heifer calves born on these 104 farms between January 1, 1981 and May 15, 1983. Overall drug use was measured by calf treatment days, calculated as the number of calves treated times the number of days each calf received treatment.

A questionnaire, administered by interview to all farms at the beginning of the survey, included several questions on the routine use of various drugs for prophylaxis. These questions, as well as information on preventive drug use in individual calves derived from intensive farm records, have been considered in other contexts,(7,8,9) but are included here as well to give a complete picture. Preventive treatments to dams were defined as those administered within six weeks before the expected date of parturition. Preventive treatments to calves were defined as those administered to calves, by injection or oral bolus, in the absence of recognizable disease. Most of these treatments were administred to calves at birth or very shortly thereafter. Specific information on drug formulations and rates of administration were not usually recorded by farmers, but could sometimes be inferred from the records.

Intensive farm records were used to assess differences in duration and outcome of treatment for different clinical diagnoses (scours, pneumonia, crude morbidity) for the main antimicrobials used. In this study, the terms "crude morbidity" and "all diagnoses" are used interchangeably to refer to a pooled morbidity category, which includes all calves treated therapeutically, for whatever reason. Calves treated for both scours and pneumonia were listed under both categories; hence the sum of the scours-treated and pneumonia-treated calves could exceed the number of calves treated for all diseases. The antimicrobial used for the first treatment of the disease was noted if antimicrobials were used. No account was taken of changes in the treatment regime once the disease was in progress. Multiple logistic regression was used to assess the differences in the odds of a calf dying according to the antimicrobial used for initial treatment, with one dummy term being created for each antimicrobial evaluated. Multiple linear regression was used to assess the differences in duration of treatment between calves, also according to antimicrobials used for the first treatment. Based on analysis of residuals, a logarithmic transformation of the dependent variable was deemed appropriate for the least-squares analysis. A dummy variable for farms was included in the models in order to control for differences in antimicrobial usage between farms.

RESULTS

Antimicrobials comprised 39% of all prophylactic calf treatment days, the remainder consisted of various vitamin preparations. Eighty-two percent of therapeutic calf treatment days were related to antimicrobial use, eight percent were vitamin-preparation related and various miscellaneous preparations such as astringents and fluids comprised ten percent.

The vitamins used therapeutically were primarily multivitamin mixtures (92.8% of vitamin-related calf treatment days), with vitamins A, D and E, with or without selenium, comprising the remainder. Prophylactic vitamins used were 75.8% vitamins A, D and E, 19.6% vitamin E and selenium and the remainder unidentified multivitamins.

Miscellaneous drugs consisted primarily of fluids and electrolyte mixtures, and a few other nonmedical therapeutic substances such as kaopectate.

The specific antimicrobials used therapeutically are detailed in Table I. The 4977 calves were treated, in total, for 10,331 days, for a crude average of two treatment days per calf. On average, each calf was given 2.7 doses of antimicrobial, over a 1.7 day period. Chloramphenicol was the most common antimicrobial used for therapeutic purposes in these calves, comprising 32% of all calf antimicrobial treatment days. Tetracycline, the second most commonly used antimicrobial, comprised 17% of treatment days. Commercial mixtures, consisting of "cocktails" of various antimicrobials, vitamins and minerals, usually in oral bolus form, comprised almost 14% of calf treatment days. This study did not differentiate between pure penicillin and penicillin-streptomycin mixtures. For convenience of presentation, the term penicillin is used to cover both preparations. These comprised 13% of antimicrobial treatment days in these calves. The classification of farms according to stated policies on the rou-

TABLE I
THERAPEUTIC ANTIMICROBIAL USE IN 4977 HEIFER CALVES ON SOUTHWESTERN ONTARIO HOLSTEIN DAIRY FARMS, 1981-83

Antimicrobial	Doses/Day	Percent of Treatment Days[a]
Chloramphenicol	1.7	32.0
Tetracycline	1.6	17.1
Commercial mixtures[b]	1.6	13.7
Penicillin	1.3	13.3
Trimethoprin-sulfa	1.5	8.1
Sulfonamides	1.7	4.9
Others	1.6	10.9

[a]Treatment days were calculated as the number of calves treated times the number of days each calf received treatment.
[b]These were primarily "cocktails" of various antimicrobials, vitamins and minerals, delivered in oral bolus form.

TABLE II
PROPHYLACTIC DRUG USE IN PREGNANT DAMS AND HEIFER CALVES ON 104 SOUTHWESTERN ONTARIO HOLSTEIN DAIRY FARMS, 1981-83[a]

Use of routine preventive treatments to dams within six weeks of expected calving date.			
	Vitamins	Vaccines	
None given	77.9	96.2	
Winter only	0.6	1.0	
Winter and summer	12.5	2.9	
Use of routine preventive treatments to calves during first three days of life.			
	Vitamins	Vaccines	Antimicrobials
None given	70.2	94.2	79.8
Winter only	7.7	3.8	3.8
Winter and summer	22.1	1.9	16.3
If antimicrobials are given to the newborn calf, which are used?			
Commercial mixtures[b]	33.3		
Furacin	28.6		
Penicillin	14.3		
Tetracycline	14.3		
Chloramphenicol	9.5		
Antimicrobials present in the milk replacer and/or calf starter.			
None	76.9		
Tetracycline	19.2		
Other	3.9		

[a]Numbers represent percent of farms in each category.
[b]These were primarily "cocktails" of various antimicrobials, vitamins and minerals, delivered in oral bolus form.

TABLE III
CASE FATALITY RATES (CFR) (%) FOR CALVES FIRST TREATED WITH SELECTED ANTIMICROBIALS IN DIFFERENT DISEASE CATEGORIES: DATA FROM 1968 HEIFER CALVES ON SOUTHWESTERN ONTARIO HOLSTEIN DAIRY FARMS, 1981-83

Antimicrobial	Pneumonia n = 302	Scours n = 403	All Diagnoses[a] n = 688
Chloramphenicol	6.3[b]	11.1[b]	7.8[b]
Penicillin	12.7[b]	12.1[b]	11.5[b]
Tetracycline	2.9	7.4	4.1
Sulfonamides	0.0	12.0[b]	10.3[b]
Trimethoprim-sulfa	0.0	4.1	3.8
Average	5.4	7.0	6.4

[a]This category includes pneumonia and scours as well as other illnesses.
[b]These drugs were significantly associated with mortality ($p \leq 0.05$) in a multiple logistic regression.

tine use of various biologicals and antimicrobials as part of a preventive program is displayed in Table II. Pre-weaning case fatality rates, duration of treatments, and time from first treatment to death are displayed in Tables III, IV and V, respectively. Case fatality rates for calves first treated with chloramphenicol are broken down by daily frequency of treatment in Table VI. Only one calf was started at three times per day, hence this category of frequency was not included in the analysis.

For all diseases, both penicillin and chloramphenicol usage were significantly associated with higher case fatality rates than other antimicrobials (Table III). Nevertheless, the rates for chloramphenicol varied considerably for different frequencies of treatment (Table VI). Case fatality rates for calves first treated with other antimicrobials did not differ significantly, nor consistently, for different frequencies of treatment. Sulfa drug usage in scouring calves was associated with an increased risk of mortality.

Calves first treated for pneumonia with chloramphenicol or trimethoprin sulfa tended to be treated for significantly longer periods of time than calves first treated with other drugs. For crude morbidity, calves first treated with tetracycline tended to be treated for a significantly longer period, and calves treated with penicillin for a significantly shorter period, than other calves (Table IV).

In those calves which died, time from first treatment to death was generally shorter for chloramphenicol-treated calves than for calves treated with other antimicrobials (Table V).

The effects on preweaning pneumonia and scours treatments, and on neontal mortality, of preventive antimicrobial administration to healthy newborn calves are displayed in Table VII. The fraction of disease or mortality in a population which can be attributed to a particular risk factor has been called the Population Attributable Fraction (PAF), Risk, or Proportion, or Etiologic Fraction (10,11). For both pneumonia treatment and neonatal mortality, the calves not given preventive antimicrobials were at greatest risk, and hence nonpreventive-treatment was considered to be the risk factor. For scours, preventive antimicrobial administration itself was the risk factor. The prevalence of preventive antimicrobial treatment to liveborn heifer calves was 13.6%. The PAF was calculated as $((p(F+)(OR-1))/((p(F+)(OR-1))+1)$, where p(F+)

TABLE IV

DURATION OF TREATMENT (DAYS) FOR CALVES FIRST TREATED WITH SELECTED ANTIMICROBIALS IN DIFFERENT DISEASE CATEGORIES: DATA FROM 1968 HEIFER CALVES ON SOUTHWESTERN ONTARIO HOLSTEIN DAIRY FARMS, 1981-83

Antimicrobial[a]	Pneumonia Mean (SE) n = 302	Scours Mean (SE) n = 403	All Diagnoses[b] Mean (SE) n = 688
Chloramphenicol	5.0 (0.5)[c]	3.2 (0.3)	4.7 (0.3)
Penicillin	2.6 (0.2)	2.5 (0.2)	2.7 (0.2)[d]
Tetracycline	4.9 (0.5)	2.6 (0.3)	4.7 (0.4)[c]
Sulfonamides	8.1 (1.4)	4.5 (0.8)	5.8 (0.9)
Trimethoprim-sulfa	6.9 (2.4)[c]	2.7 (0.3)	3.2 (0.3)
Overall average	4.8 (0.3)	3.3 (0.1)	4.6 (0.2)

[a]These are total days treatment from the time of first treatment until the calves were weaned. Categories are nonexclusive. Durations for exclusive categories, not shown, followed similar patterns.

[b]This category includes pneumonia and scours as well as other illnesses.

[c]These drugs were significantly associated with prolonged duration ($p \leq 0.05$) in a multiple linear regression.

[d]Penicillin was significantly associated with a shortened duration of treatment in the multiple linear regression.

TABLE V

TIME FROM FIRST TREATMENT TO DEATH FOR SELECTED ANTIMICROBIALS: DATA FROM 1968 HEIFER CALVES ON SOUTHWESTERN ONTARIO HOLSTEIN DAIRY FARMS, 1980-83

Disease	n[a]	Antimicrobial	Days to Death Mean (SE)	First Week Fatality (%)[b]
Scours	9	Chloramphenicol	5.3 (1.2)[c]	77.8
	7	Penicillin	21.6 (15.0)	57.1
	3	Sulfonamides	31.3 (17.1)	33.3
	27	Average	14.4 (4.5)	66.7
Pneumonia	10	Chloramphenicol	21.7 (9.3)	50.0
	7	Penicillin	41.3 (10.9)	0.0
	17	Average	29.5 (7.8)	35.3
All Diagnoses	18	Chloramphenicol	16.4 (5.5)	61.1
	10	Penicillin	22.4 (9.0)	60.0
	3	Sulfonamides	31.3 (17.1)	33.3
	44	Average	18.6 (3.7)	54.5

[a]Number of calves in each treatment category.

[b]Percent of calves which died within seven days of first being treated.

[c]These are times for nonexclusive categories; mean times based on exclusive categories, not shown, demonstrate similar patterns.

TABLE VI

CASE FATALITY RATES FOR HEIFER CALVES TREATED WITH CHLORAMPHENICOL, BY DAILY FREQUENCY OF DOSAGE, ON SOUTHWESTERN ONTARIO HOLSTEIN DAIRY FARMS, 1980-83

Disease	Daily Frequency of Treatment	Number of Calves Treated	Case Fatality Rate (%)
Scours	1	27	22.2[a]
	2	62	4.8
Pneumonia	1	70	10.0[b]
	2	87	2.3
All diagnoses[c]	1	105	11.4[b]
	2	137	4.4

[a]Differences between case fatality rates for once-a-day versus twice-a-day were significant at $p \leq 0.05$.

[b]Differences between case fatality rates for once-a-day versus twice-a-day were significant at $p \leq 0.10$.

[c]This category includes scours and pneumonia as well as other diseases.

was the prevalence of the risk factor, and OR was the odds ratio derived from multiple logistic regression models which controlled for farm effect and date of birth (8,9). Based on the estimated PAF, the increase in the number of cases of scours and decrease in cases of pneumonia and neonatal mortality which would have been observed if all calves had been given preventive antimicrobial doses, were calculated. The mean duration of treatment for pneumonia in this population of calves was five days and for scours it was three days (7). Using these figures, a net reduction of 397 therapeutic antimicrobial treatment days would have been expected if all calves in this population had been given the preventive antimicrobials. However, assuming preventive antimicrobial treatment would last one day per calf, this would have involved a minimum increase of 1701 days of preventive antimicrobial treatment. Overall, the practice of administering preventive antimicrobials to all 1968 newborn calves in this population would have meant increasing the total (preventive plus therapeutic) antimicrobial treatment days by one and one-half times, from 2986 to 4290 days. At the same time, one might have expected neonatal mortality to be reduced from 2.24 percent to 0.01 percent.

DISCUSSION

For those who are concerned with the possible excess use of drugs in dairy calves, the relatively low percentage of farms which use antimicrobials in a routine, preventive fashion should be a source of encouragement (Table II). Other data collected from these farms has indicated that even farmers who, for instance, said that they gave their calves antimicrobials at birth never treated all of their calves in this way (7). For instance, whereas about 20% of farmer stated that they routinely administered antimicrobials to newborn calves in a preventive fashion, fewer than 50% of live-born heifer calves on those farms were recorded as receiving such treatment. Similar figures were seen for routine administration of vitamins to newborn calves.

A question which must be raised in this context is whether or not the routine use of preventive drugs is of any benefit. Other analyses (9) indicate that the administration of vitamins A, D and E to the prepartum cow might be of some benefit in preventing subsequent calf mortality. As well, farms where calves were fed calf starter or milk

replacer which contained subtherapeutic levels of antimicrobials were more likely to experience below median rates of treatment for pneumonia than farms where these were not fed (8).

At the individual calf level, calves that were given prophylactic antimicrobials were less likely to be treated for pneumonia than other calves (Table VII). As well, there were tendencies ($p < 0.10$) for these preventively-treated calves to experience a decreased risk of neonatal mortality, but a higher risk of being treated for scours (Table VII). All of these effects are biologically plausible and are not inconsistent with previous research (1,2). A bolus of antimicrobial given to a calf at birth, for instance, might at one and the same time kill potential lung pathogens and disturb the gastrointestinal flora. However, only a well-designed field trial can clarify whether or not the antimicrobials *per se* or a particular calf-handling procedure related to this, such as increased observance of calves at or around the time of birth, are responsible for the effects seen in these calves.

If the effects seen in this study are real ones, that is, causally connected to the antimicrobial treatment itself, then the calculated net increase in prophylactic antimicrobial treatment days which could be expected to occur if all calves were given preventive antimicrobials at birth still needs to be set against the expected reduction in mortality (Table VII). These effects on the health and mortality of calves, of course, need to be set into the larger context of environmental and public health concerns.

Given the controversy surrounding the use of chloramphenicol in animals, particularly since the banning of its use in food producing animals, the results of this study are of considerable relevance. A detailed examination of the records indicates that the therapeutic use of chloramphenicol in these dairy calves was widespread (86 of 104 farms). Its apparent failure as an effective treatment, as measured by case fatality rate, is therefore of concern to the dairy industry.

The differences in case fatality rates with different antimicrobials may have been due to at least two different factors. In the first place, since no random assignment of calves to treatment took place, the more severely ill calves may have been treated with antimicrobials such as chloramphenicol. Among the calves which were treated and died, those first treated with chloramphenicol tended to have a relatively shorter course of disease than those treated with penicillin and sulfonamides (Table V). This may indicate that chloramphenicol was reserved for the more severe cases. However, no independent measure of disease severity was available in this data set, and only a well designed field trial can adequately test this hypothesis.

A second explanation for the apparent lack of effectiveness of chloramphenicol, in particular, relates to the frequency of daily treatment. The daily frequency of treatment for all antimicrobials ranged from 1.3 times per day to 1.7 times per day, with a mean of about 1.5. For most antimicrobials, this could provide adequate therapeutic levels. For others, in particular chloramphenicol, it would have been unlikely that therapeutic levels would have been maintained in the calves at that frequency of treatment (12). Indeed, a markedly higher case fatality rate was seen for all diseases if chloramphenicol was administered once per day rather than twice per day (Table VI). No significant or consistent differences at different daily treatment frequencies were seen for penicillin, tetracycline, sulfonamides, or trimethoprim-sulfa.

When evaluating specific antimicrobials for their apparent efficacy under field conditions, it is difficult to separate the efficacy of the antimicrobial from its manner of use. Certainly, data derived from observational studies such as this one are useful in generating and/or supporting hypotheses. However, observational study data on the efficacy of antimicrobials are subject to possible confounding by disease severity, which can be related both to the choice of antimicrobial as well as to the outcome(s) (e.g. case fatality rates). Nevertheless, laboratory and experimental challenge data, which are currently used to justify much of veterinary therapeutics, offer at best only corroborative evidence for field efficacy. We conclude that only a clinical field trial, designed to offer the maximum probability of refutation of the null hypotheses about drug efficacy in the field, should be considered to be sufficiently stringent to serve as a basis for recommendations about efficacy.

Radostits *et al* (13) reported the results of a trial in which fluid replacement, rather than antimicrobial treatment, was the critical therapeutic factor in the treatment of calf scours. Further clinical trials of various therapeutic agents alone, or in combination in different treatment regimes, using field cases of calf disease, should be undertaken as soon as possible.

Besides the need for specifically designed clinical trials of therapeutic antimicrobials in calves, these survey results indicate that the judicious administration of preventive antimicrobials to newborn calves, perhaps under strictly specified conditions, should be examined in a formal scientific study.

The results of this study suggest that calf survival rates could be increased if those administering antimicrobials

TABLE VII

THE EFFECTS OF PREVENTIVE ANTIMICROBIAL ADMINISTRATION TO HEALTHY NEWBORN CALVES: DATA FROM 1968 HEIFER CALVES ON SOUTHWESTERN ONTARIO HOLSTEIN DAIRY FARMS, 1981-83

Outcome	Odds Ratio[a]	PAF[b]	Current No. of Cases	Change in No. of Cases[c]
Pneumonia	0.46	0.503	302	-152
Scours	1.36	0.047	403	+121
Mortality[d]	0.20	0.776	44	-34

[a]The odds of calves being treated for scours or pneumonia, or dying if they were given preventive antimicrobials versus those not given preventive antimicrobials. An odds ratio of less than one indicates a sparing effect and vice versa. The odds ratio for pneumonia was significant at $p \leq 0.05$; those for scours and mortality were significant at $p \leq 0.10$.

[b]Population Attributable Fraction (See text for full explanation).

[c]Reduction (-) or increase (+) in number of cases if all calves had been given preventive antimicrobials.

[d]This applies specifically to mortality at ≤ 28 days of age.

therapeutically were more conscientious in adhering to recommended treatment regimes.

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ABSTRACT

ORSHER RJ, ROSIN E. Open peritoneal drainage in experimental peritonitis in dogs. *Veterinary Surgery* 1984; 13: 222-226. (Sch. Vet. Med., Univ., 3850 Spruce St, Philadelphia, Pennsylvania 19104, USA).

Peritonitis was induced in 12 dogs by creation of an avascular jejunal loop. After 24 h, the loop was removed, and purulent material was aspirated. The abdominal incision in six experimental dogs was left open under a bandage, and was closed in six control dogs. All six open-abdomen, and four control dogs survived the 8 days of the study. There were fewer bacteria in the peritoneal exudate in experimental animals than in control animals. At the end of the study, experimental animals were more active, had better appetites, and were less likely to have fever, vomition, diarrhoea and dehydration. Experimental animals weighed less than control animals. There were no differences in blood chemistry and haematology between groups. At PM examination the experimental animals had fewer adhesions and less peritoneal fluid accumulation than control animals. Complications of open peritoneal drainage included persistent fluid loss, weight loss, adhesions of abdominal viscera to the bandage, and contamination of the peritoneal cavity with cutaneous organisms.

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