Is Preoperative Antimicrobial Prophylaxis Needed in Canine Surgery? Analysis of Data from Forty Four Small Animal Practices in Europe

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ABSTRACT

Background

Surgical site infection (SSI) is a common surgical complication in small animal surgery. Wound infections cause suffering for the animal, increase morbidity and mortality rates, are an economical burden, and escalate and prolong the use of antibiotics. Veterinary surgical use of prophylactic antibiotics is directly extrapolated from human studies, because of the limited number of studies on animals.

The purpose of this pilot study was to analyse whether preoperative prophylactic antibiotics prevented superficial SSIs on dogs; in this study SSIs are measured as exuding wounds.

The study population for this prospective cohort study was collected from northern and central European veterinary practises belonging to a European veterinary care company, AniCura. Clean and clean-contaminated incisional surgeries on dogs were included.

Dogs were categorized to either a nonantibiotic group (group 1) or a preoperative antibiotic group (group 2). Antibiotic administration was documented, and wound follow-up was done 7 to 10 days postoperatively to observe signs of wound infection. The wound appearance was evaluated in an appointment or by telephone consultation with the owner.

Results

Twenty-six out of 400 dogs (6.5%) in group 1 developed superficial SSI compared with

18 out of 316 dogs (5.7%) in group 2. We found not enough evidence that the preoperative antibiotic treatment decreased superficial surgical site infection rate (p-value 0.656).

Conclusions

This pilot study suggests that preoperative prophylactic antibiotics should not be used preventively on dogs in clean and clean-contaminated surgeries.

INTRODUCTION

Surgical site infection (SSI) impairs the success of all surgical procedures. Moreover, our experience is that SSI is one of the most common complications in surgical procedures on small animals.[1] Wound infections increase patient morbidity and mortality, increase veterinary costs, prolong the hospitalization time, and demand several visits to the clinic.[2]

Avoiding surgical site infection is a demanding and complicated task. SSI can be prevented by several protective measures, but is more likely if existing risk factors are ignored. Several factors influence the risk of developing SSI:

- patient preparation
- preparation of the surgical team
- surgical techniques
- consideration of intraoperative measures, and
- the monitoring of physiological parameters of patients[3-7]

Use of antibiotics is seen as a preventative measure against surgical site infections. However, antibiotics have to be used cautiously because microbial resistance is an increasing problem in human as well as veterinary medicine.

Few veterinary medical studies evaluate the advantages and disadvantages of antibiotic prophylaxis because these studies have limits such as specific types of surgeries, small sample size, different use of antibiotics, different SSI definitions, or retrospective view.[8-10] Overall, the results are conflicting.[3,11-13]

The aim of this study was to determine whether pre-surgical or pre- and post-surgical antibiotics prevented superficial SSI in clean and clean-contaminated surgery. In this study, superficial SSI was defined as exuding wound. We compared a nonantibiotic group to an antibiotic group.

METHODS

Study Design and Participants

This study was designed as a prospective cohort study where 58 clinics within the European veterinary care company, AniCura, were invited to participate. Each clinic registered predetermined data according to protocol in Table 1, on 20 consecutive surgical cases on dogs.

The authors did not set the medical procedures for participating clinics to follow. It was assumed that the clinic would be performing the procedures according to their everyday routines. Nor did they specify which antibiotics/medications, dosages, and administrations would be used for this study. Further it was assumed that each clinic would be following recommendations for the chosen drug.

Study inclusion criterion for these 20 patients was a surgical incision of the skin under general anaesthesia.

From the collected data, we were able to exclude contaminated and dirty surgeries according to definitions in Table 2 from Centers for Diseases Control and Prevention (CDC). Also, dental and ocular approaches were excluded as well as cases without complete documentation, postoperative follow-up, and patients receiving antibiotics only post-surgery. Additionally, deep and organ/space surgical site infections were excluded (Table 3), i.e. only dogs with superficial SSI were included. Finally, we included clean, clean-contaminated surgeries without antibiotics or with antibiotics administered; pre-operatively or pre- and post-operatively.

The questionnaire was presented as part of AniCura´s medical quality program, and the data analysed in this study was limited and, therefore, did not include demographics

Table 1. Surgical protocol

Surgical data
Medical record identity
ASA[a] classification (I-V)
Surgical procedure
Use of prophylactic antibiotics (yes/no)
Duration of antibiotic peri-prophylaxis (hours)
Time point for prophylaxis in relationship to surgical incision and completed surgical procedure
Duration of anaesthesia (minutes)
Duration of surgery (minutes)
Rectal temperature before induction and after completed procedure (Celsius)
[a] American Society of Anesthesiologists (ASA) Physical Status Classification System

Table 2. Wound classification system from Centers for Diseases Control and Prevention (CDC)[15]

Class	Wound appearance
1. Clean	Uninfected operative wound without inflammation and NOT entering to respiratory, alimentary, genital or urinary tract
2. Clean-Contaminated	Operative wounds in which the respiratory, genital or urinary tracts are entered under controlled conditions and without unusual contamination
3. Contaminated	Open, fresh accidental wounds. Operations with major breaks in sterile technique or gross spillage from gastrointestinal tract and incisions in which acute purulent inflammation is encountered
4. Dirty	Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera.

data like sex, breed and weight. This was to encourage more clinics to participate.

The sample size was not predetermined. To ensure an appropriate case load all, AniCura clinics were asked to participate under study period. The study groups were made up of patients filling inclusion and exclusion criteria.

Variables

Two different protocols were used; one for surgery and one for patient and wound check-ups (Tables 1 and 4). All cases were documented and followed up by local clinic personnel. Each surgical team was responsible for filling in the following surgical variables:

- medical record identity
- surgical procedure
- American Society of Anesthesiologists status (ASA-group)[14]
- possible use of antibiotic prophylaxis and substance
- time point for pre-prophylaxis administration
- duration of post-surgery antibiotic prophylaxis
- time point for anaesthesia induction, for incision, for closure of the wound, and completed surgical procedure
- rectal temperature before induction
- completed surgery and finally the time point for total recovery (extubation) from anaesthesia.

Table 3. *Criteria for defining surgical site infection (SSI) according Centers for Diseases Control and Prevention (CDS)*[15]

Superficial Incisional SSI
Within 30 days
AND involves only skin and or subcutaneous tissue of the incision
AND at least one of the following:
1. Purulent drainage, with or without laboratory confirmation
2. Organisms isolated from an aseptically obtained culture of fluid or tissue
3. At least one of following signs or symptoms for infection: pain, redness or heat and superficial incision is deliberately opened by surgeon, unless incision culture is negative
4. Diagnosis of superficial incisional SSI by surgeon or attending physician
Deep Incisional SSI
Within 30 days or within 1 year if implant left in place
AND involves deep soft tissues (e.g. fascial and muscle layers)
AND at least ONE of the following:
1. Purulent drainage, but not from the organ/space component
2. Spontaneous wound dehisces or opened by surgeon if at least one of the following signs or symptoms: fever, local pain, unless incision culture is negative
3. At least one of following signs or symptoms for infection: pain, redness or heat
4. Diagnosis deep incisional SSI by surgeon or attending physician
Organ/Space SSI
Within 30 days or within 1 year if implant left in place
AND involves any part of body (e.g. organs or spaces), which was manipulated or opened during surgery
AND at least ONE of the following:
1. Purulent drainage from a drain placed through a stab wound in to the organ/space
2. Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space
3. An abscess or other evidence of infection involving organ/space
4. Diagnosis of an organ/space SSI by surgeon or attending physician

Table 4. *Postoperative check-up protocol by telephone or on an appointment*

Follow up data
Check up by telephone call or on an appointment
General condition (good/not good)
Wound appearance: red (yes/no), swollen (yes/no), exudation (yes/no)
Problems/issues between surgery and consultation (use of collar, licking, scratching, other)

This protocol is presented in Table 1.

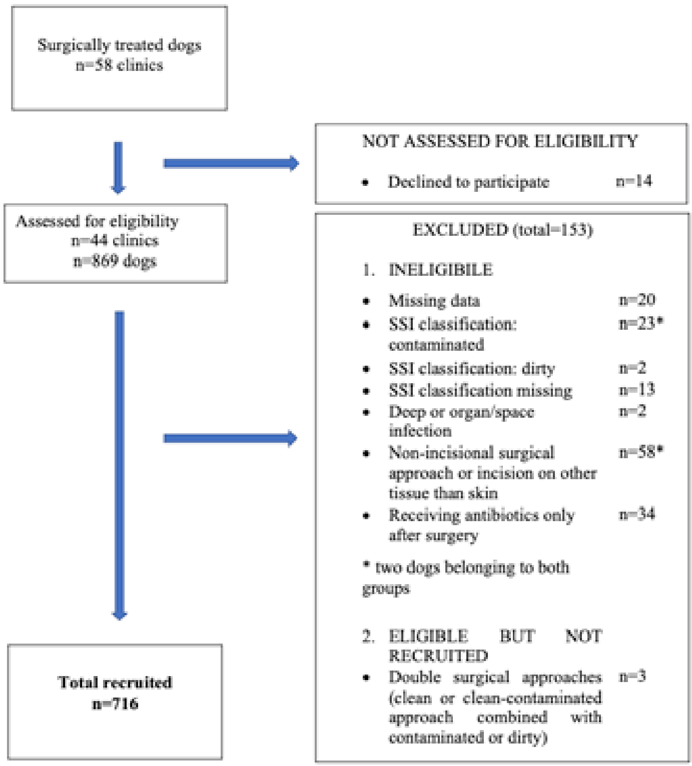
Dogs included in the study were examined at the appointment or owners were contacted by telephone both at 7-10 and 30 days after surgery. The same questionnaire was used on both occasions, and is presented in Table 4. The veterinarian or the nurse had access to the actual patient's medical records and consultations were performed in the local language. General condition of the dog was evaluated, and wound appearance was described by using terms "red, swollen and exudative." Other issues like use of collar and licking or scratching the wound were recorded. All dogs with signs of abnormal wound healing were assigned for veterinary control and sampling of the surgical site for bacterial analysis.

The standardized SSI definitions from CDC (Table 3)[15] were used as a base for determining SSI. However, in this study, wound exudation was assumed to be the most reliable parameter to determine superficial surgical site infection; for further details refer to SSI.[15]

Statistical Analysis

Dogs were divided into two groups: those not receiving any antibiotics (Group 1) and those receiving pre-surgical antibiotics (followed, or not, by post-surgical antibiotics) (Group 2).

Figure 1. *Study eligibility flow chart*



Data were initially explored by means of descriptive statistics, to check the consistency of the variables, and the extent of missing values. Then, univariable logistic regressions were done to assess the potential association between the occurrence of surgical site infections and the following variables:

- type of surgery (clean/clean-contaminated)
- ASA classification, (I, II, III+)14
- emergency surgery (yes/no)
- prophylactic surgery (yes/no)
- prophylactic neutering (yes/no)
- rectal temperature (≤ 37 °C/> 37 °C)
- duration of surgery (min)
- duration of anaesthesia (min)
- type of check-up (telephone/visit)
- prophylactic antibiotic treatment (yes/no).

Variables that were associated with the occurrence of superficial SSI at a significance level of 0.10 were considered for inclusion in the final model. Prior to that, they were pair-wise checked by means of Chi-square or Fisher's exact test to assess their possible mutual associations. Crude and adjusted odds ratios (OR) for associated variables were finally compared by means of Cochran-Mantel-Haenszel test to assess any possible confounding or effect modification which needed to be considered in the final analysis.

From the univariable analysis, we found type of postoperative check-up and prophylactic castration to be possibly significantly related to the outcome and, therefore, considered for inclusion in the final model. The final model included the following variables: superficial SSI 7-10 days post-surgery as outcome: type of check-up, prophylactic castration and antibiotic treatment before surgery as explanatory variables (i.e. fixed effects), and clinic as random effect to account for potential data clustering. Surgeries within the same clinic share the same practicalities and routines and are therefore more alike than surgeries in different clinics.

All the analyses were done with the statistical software R (R core team, 2017).

RESULTS

In total, 44 veterinary practices located in Sweden, Norway, Germany, Denmark, Austria, and the Netherlands, participated in our study. Data collection started February 16th, 2016 and ended August 16th, 2016 with the last follow up. Of the 869 surgical cases on dogs documented, 716 were included in the statistical analyses. Cases excluded are presented in Figure 1

Of 869 dogs assessed for eligibility, 716 met the inclusion criteria. 400 were enrolled in Group 1 and 316 in Group 2.

In Group 1, 48% of the surgeries were classified as clean and 52% as clean-contaminated. The median anaesthesia time was 75 minutes (range, 25-250 minutes) and the surgical time 30 minutes (range, 5-150 minutes). The most common procedures 92% were soft tissues, 8% were orthopaedics (3% without implants and 5% with implants), and <1% neurology. Fifty nine percent of the cases were evaluated per telephone and 41% during an appointment. Group comparison on collected data is shown in Table 5.

In Group 2, 62% of the surgeries were classified as clean and 38% as clean-contaminated, the median anaesthesia time was 120 minutes (range, 25-455 minutes), and surgical time 51 minutes (range, 3-310 minutes). The most common procedures, 59%, were soft tissues, 38% were orthopaedics (31% with implants and 7% without implants), and 3% neurology (Table 5). Forty seven percentof the cases were evaluated per telephone and 53% on an appointment (Table 5).

Different types of surgeries were represented like; prophylactic surgeries, i.e., neutering (both males and females), eye lid corrections, and approaches for brachycephalic airway syndrome, emergency surgeries, i.e., abdominal, thoracic, neurological, and fracture surgery and planned soft tissue and orthopaedic procedures (Table 5). Superficial SSI rate for different surgeries is presented in

The gender of the dogs was known only in neutering cases due to surgical nomenclature on all used local languages.

Summary statistics of collected variables and results of univariable logistic regression for their association with superficial SSI are presented in Table 7, and results of multivariable logistic regression with random effect is also included in Table 8. Only data from 7-10 days check-up was used because 30-day follow-up responses were insufficient.

For clean procedures (n=385) superficial SSI rate was 5.7%, and clean-contaminated procedures (n=331) 6.6%. Superficial SSI rate for the non-antibiotic group (n=400) was 6.5% and for the antibiotic group (n=316) 5.7% (Table 7).

Duration of the anaesthesia and surgery in the two groups are presented as a median and range in Table 5. Despite Group 2 had longer duration of both surgery and anaesthesia, there was no evidence that duration of surgery and anaesthesia were significantly associated to SSI (p-value = 0.11 and 0.43, respectively), as shown in Table 7.

Superficial SSI rate for dogs followed up by telephone was 3.6%, but 9.1% for check-up appointments. Patients that were checked only by telephone interview were 75% less likely to have superficial SSI (p-value .001 and OR = 0.25 [0.11-0.58]) (Table 8.). In other words, it was more likely that superficial SSI was detected at check-up appointment compared to telephone interview. We therefore hypothesized detection bias and included this effect in the statistical model to ensure unbiased estimates for other parameters.

Three hundred sixteen (44%) dogs were given antibiotics. In 251 (79%) cases beta lactam antibiotics were used. In 43 (14%) cases other short duration substances were chosen. The antibiotic substance was unknown in 22 (7%) cases. The time point of preoperative parenteral antibiotic administration is summarised in Table 9.

DISCUSSION

To our knowledge, this is the first veterinary study about surgical site infections which covers various types of veterinary practices in several countries. Our study showed that preoperative use of prophylactic antibiotics on clean and clean-contaminated surgeries did not lower the incidence of superficial surgical site infections in canine surgery. In other words, non-antibiotic and antibiotic groups did not differ. Encouragingly, two independent studies, by Turk *et al.* and by Nicholson *et al.*, showed similar results; they found no difference between non-antibiotic or antibiotic groups.[9,16] The study of Eugster *et al.* suggested the possible benefit of administering prophylactic antibiotics but provided no statistical significance in a small number of cases of non-antibiotic dogs.[10]

In our study, the overall SSI rate for clean and clean-contaminated surgeries was 6.1%, which is at a similar level as other investigations in small animal surgery. For all types of surgical procedures, we found five studies that have reported SSI rates ranging between 3.0 and 6.1%.[9,10,17-19] For clean surgical wounds, the SSI rate was between 0.8-4.8% in four studies.[6,20-22] Nicholson *et al.* reported SSI rate 5.9% for clean-contaminated cases16 and Travis *et al.* 6.1% for uncomplicated midline celiotomy.18 A higher risk of SSI is observed in orthopaedic implant surgery.[3,9] In clean orthopaedic surgery, such as total tibial plateau levelling osteotomy (TPLO), the SSI rate was found to be between 2.9% and 21.3%.[6,11,12,23,24] In our study, the implant surgery was not associated with increased risk of superficial SSI.

Our data indicated that combined surgeries, like neutering, along with other soft tissue procedure, might increase the risk for superficial SSI. Longer surgery/anaesthesia duration is observed as a higher risk for SSI to develop.[10,16,17,22] From our study, we can only speculate whether duration of anaesthesia or surgery or other possibilities like asepsis may be responsible.

The correct critical timing and proper antibiotic choice is vital in preventing the effects of SSI according to Verwilghen and Singh.3 In our study, antibiotics were administered within 60 minutes preoperatively in 73% of cases, which is in line with existing guidelines. We cannot conclude if the antibiotic choice was proper because we had only information on antibiotic class. Beta lactam antibiotics were used most frequently.

With regard to follow up of surgical patients to determine the presence or not of superficial SSI, each clinic followed its own routine. In our study, superficial SSI was diagnosed more often at a check-up appointment than by telephone consultation. The reason for this could be that dog owners either might or might not be able to recognize self-limiting surgical infection. Furthermore, it could be that they are more motivated to attend a check-up appointment if they identify an infected wound. Telephone consultation has been satisfactorily used as a research method in medical and veterinary studies, but medical studies with a large number of patients have mostly used only medical record references.[9,13,25] Garcia Stickney and Thieman Mankin[17] reported recently regarding the usefulness of active surveillance (follow up contact) in veterinary medicine, since it is more reliable in detecting SSI. Additionally, in our study we also concluded that the type of follow-up had an impact on the number of infections found after surgery.

Preoperative antibiotic prophylaxis has long been common practice in human medicine as well in veterinary medicine. The National Institute for Health and Care Excellence (NICE) in United Kingdom indicates that prophylaxis within clean non-prosthetic type of surgeries is not routinely needed.[26]

According to CDC (updated 2017), antimicrobial prophylaxis should be administered only in accordance with specific clinical guidelines.[5] Some local clinical guidelines for specific procedures are available for human use.[27,28] In veterinary medical literature of today, there are several antibiotic guidelines but with few evidence-based recommendations for specific clinical practice. Most veterinary practices perform many different types of surgical procedures, and it is challenging to obtain sufficient data for a specific type of surgery in a given clinic, which in turn affects the validity of findings. We isolated some specific surgical categories to determine SSI rate in a specific category. Our study found an SSI rate of 3.3% for prophylactic neutering and of 6.9% for all other procedures. Here, our study gave support to the recommendation that antibiotics not be given in case of prophylactic castrations.

Furthermore, whether human wound classification, i.e., clean, clean-contaminated, or contaminated and dirty, can be used for animal surgery, e.g., dogs, is unclear. For example, ovariohysterectomy is a common procedure in dogs without uterus pathology, but in humans, it is only done when gynaecological problems exist. According to the CDC, for humans the procedure is classified as clean-contaminated. Determining whether the human wound classification system is directly applicable in animals with different surgical indications would be worth further research. Possible differences could influence general antibiotic recommendations for specific procedures on dogs.

To diagnose SSI is challenging in animal as well as in human studies. Surprisingly, this difficulty has been discussed in few studies. Wound appearances such as, redness, oedema, and exudation are all subjective parameters. These signs are difficult to identify not only for medical personnel but also for people without medical knowledge, such as dog owners. We observed and accepted some bias in our study, in determining SSI; other studies have done similarly. In our study, wound exudation was chosen as most reliable parameter. Exudate can be presented in different forms and different exudation types are clinically difficult to separate.

Wound exudation, which may be seropurulent, purulent or haemopurulent, is a sign of abnormal healing process within our follow-up time, 7-10 days postoperatively, and a sign of infection.[29,30] In our study, we may have overestimated SSI rates by including non-infectious discharge such as seroma or bleeding. We suggest that in future studies of SSI the most accurate diagnosis of SSI could be done by cytology or biopsy although we recognise this may be practically demanding, or even impractical particularly with a large number of patients. The usefulness of bacterial culture to diagnose SSI was predicted to be low because of normal dermal bacterial flora in the area. As far as we know, this topic of research has not yet been studied.

This study involves data from many centres involved in various types of veterinary practice in several countries, which is both a strength and a limitation. One limitation is that clinics differed considerably, which was a variation we were not able to control. Not only do facilities, personnel, approaches, and local procedures differ, but national recommendations and regulations also differ. Our study probably involves bias to some extent because data came from so many different centres, compared to studies at one site, e.g., a university. On the other hand, bias can be limited by asking a broad number of facilities and regions to participate, by treating the clinic as a random effect in the statistical analysis.

To avoid case selection bias, the clinics were asked not to choose their cases but to include them on the basis of patients' arrival at the clinic, in other words, consecutively. Moreover, surgical personnel were not informed about the aims of the study. The authors were not involved in case collection or evaluation of outcomes. Postoperative interviewers were not aware of the study hypothesis, and we believe that collected data was not biased consciously or subconsciously. Cases in the both study groups were chosen and examined in a similar way, so that we could avoid selection and information bias. We attempted to minimize variability of surgical and postoperative parameters, and multiple observers were used. Variability of the surgical and postoperative study variables was kept to a minimum while multiple observers were used.

CONCLUSION

Our study found that the use of preoperative prophylactic antibiotics in clean and clean-contaminated surgery in dogs did not prevent superficial SSI. We contend that our findings support the introduction of additional guidelines on some specific clinical practices. We also believe that there is a need for further studies on the use of prophylactic antibiotics in small animal surgery. We conclude that antibiotic medication should be used carefully.

DECLARATIONS

Authors' Contributions

UG organized the collection of the study material and designed the study with OT and AC. OT summarized the data and drafted the manuscript. AC did the statistical analysis. All authors collaborated in discussing the results with interpretation of the results and finishing the final draft of the manuscript. All authors have read and approved the final version of the manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

Ethics approval

This study did not require official or institutional ethical approval.

Prior publication

All collected data are not used for submitted publication and some parts, not published here, are used for publication in Dansk Veterinaertidskrift "Antibiotikaprofylaxe inden for små dyrskirurgien" 2017(2) 22-24, for evaluation of timing of antibiotic prophylaxis.

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