Two thousand sixty-three surgical procedures were performed on 1992 patients (1715 dogs and 277 cats). In a retrospective analysis, the procedures were categorized according to the expected degree of wound contamination, and corresponding wound infection rates were determined. The number of procedures in each category and the percent that became infected were as follows: clean (1100, 2.5%), clean-contaminated (554, 4.5%), contaminated (172, 5.8%), and dirty (237, 18.1%). The administration of antibiotics significantly reduced the frequency of wound infection in clean surgical procedures performed by senior veterinary students (p < 0.05), but not in clean elective procedures performed by faculty or resident surgeons that required 90 minutes or less to complete. There was a significant correlation between elevation of rectal temperature postoperatively and increased duration of the surgical procedure. However, the rectal temperature measured the day after surgery was not an accurate predictor of wound infection.

In studies of human patients with surgical wound infections, the classification of operative procedures into categories based on the expected degree of bacterial contamination has been useful because of its accuracy in predicting the likelihood of wound infection. Knowledge of the relative risk of infection permits more selective use of preventive measures such as prophylactic antibiotics or rooms with ultraclean air for patients in high risk categories. The classification of procedures and determination of associated infection rates also permits comparison between individual surgeons or institutions, thereby providing an assessment of aseptic methods and operating technique. The system has been challenged, however, because surgical procedures within the same broad category may vary widely in their associated postoperative infection rates, and debilitated or immunosuppressed patients are not categorized as a separate group, despite their higher risk for infection.

Information in the veterinary literature regarding the frequency of wound infection in surgical patients is limited. Infection rates in dogs and cats undergoing surgery in a private referral hospital have been reported. None of the animals in that study received antibiotics unless bacteria were observed in a Gram stain from wound exudate or a positive culture was obtained. The overall rate of wound infection in 406 cases was 7.6%. In two prospective, controlled studies, the administration of ampicillin or penicillin did not significantly change the infection rate in dogs and cats undergoing clean, surgical procedures. The number of animals and the percent of wounds becoming infected in the latter two studies were 128 (0.8%) and 60 (3.3%), respectively. Another study examined the role of the scalpel blade in causing subsequent wound infection; 40 dogs underwent clean, orthopedic or neurosurgical procedures and one wound became infected for an infection rate of 2.5%.

The purpose of this study is to use the large patient population of a teaching hospital to determine surgical wound infection rates within established categories, thereby providing a baseline for comparison with other institutions and surgical specialists. We also divided the large group of clean, elective procedures into subcategories, to study the effect of antibiotic administration and the duration of surgery on the frequency of wound infection.

Materials and Methods
Pertinent data were collected from the hospital surgery log and the medical records of dogs and cats that under-
TABLE 1. Wound Classification System

<table>
<thead>
<tr>
<th>Wound Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>Nontraumatic, uninfected operative wounds in which the respiratory, gastrointestinal, or genitourinary tracts were not entered</td>
</tr>
<tr>
<td>Clean-contaminated</td>
<td>Operative wounds in which the bronchi, genitourinary tract, intestinal tract, or oropharyngeal cavity was entered, but without unusual contamination; acute, simple lacerations were also included in this category</td>
</tr>
<tr>
<td>Contaminated</td>
<td>Severe or chronic traumatic wounds, operations with a major break in sterile technique, and incisions encountering acute, nonpurulent inflammation</td>
</tr>
<tr>
<td>Dirty</td>
<td>Traumatic wounds involving abscessation, perforated viscera, fecal contamination, etc.</td>
</tr>
</tbody>
</table>

went surgery from March 1, 1984, to June 1, 1986. During this period, surgical patient preparation methods consistently included clipping the hair from around the surgical site with a #40 clipper blade, a 5 to 10 minute scrub with povidone iodine detergent, a tap water rinse, and a final spray with a povidone iodine solution. Conventional draping techniques were employed using cotton muslin drapes. Preparation of the surgeon included a 5 to 10 minute hand scrub with povidone iodine detergent, followed by donning a cotton muslin gown and gloves. Disposable paper caps and masks were worn at all times by operating room personnel. Information recorded for each case included: case number, client name, species, age, breed, sex, date of surgery, type of surgical procedure, duration of the procedure, primary surgeon, use of antibiotics including type, dose, initiation, and duration of administration, whether or not a febrile response (>102.5°F) occurred in the 24 hour period after surgery, whether or not a wound infection developed, and the type of organism(s) cultured when that information was available. A wound was defined as infected if, during the 14 days after surgery, there was discharge of purulent material from the wound or there was spontaneous dehiscence of one or more wound layers accompanied by serous drainage and signs typical of infection (redness, pain, swelling). Cases in which the record was incomplete or the owner could not be contacted, if necessary, were not used for the study. Cases in which routine, elective procedures were performed were carefully reviewed to ensure that, if antibiotics were administered prophylactically, they were used in accordance with established guidelines for perioperative initiation and duration, and those which did not conform to the guidelines were not used for the study. A total of 1992 cases (1715 dogs and 277 cats) met the prescribed conditions and were included in the study. When animals were not returned for suture removal 7 to 14 days after surgery, the client was telephoned and asked to describe any wound-related complications that might have occurred after release from the hospital.

The surgical procedures were categorized as clean, clean-contaminated, contaminated, and dirty, using the criteria established by the National Research Council (Table 1). The data were entered into a microcomputer to facilitate subsequent retrieval and analysis. Stepwise logistic regression and 2 × 2 contingency tables were used to determine which factors were significant predictors of wound infection. For the contingency tables, both two- and one-tailed versions of Fischer’s exact test were used to assess significance; p < 0.05 was considered significant.

Results

A total of 2063 surgical procedures was performed on 1992 animals (1715 dogs and 277 cats). Examples of multiple procedures performed on the same animal included cancellous graft collection in association with fracture stabilization or arthrodesis and excision of several masses. All of the multiple procedures were classified as clean wounds and were considered independently.

The number of procedures in each category and the percent that became infected are listed in Table 2. Eleven hundred procedures were classified as clean; 27 (2.5%) of these became infected. Senior veterinary students under faculty or resident supervision performed 504 of the clean procedures; 350 were ovariohysterectomies, 128 were castrations, and the remainder were simple mass excisions. Faculty or resident surgeons performed 596 of the clean operations; they consisted of a wide variety of soft tissue, orthopedic, oncologic, and neurosurgical procedures.

Five hundred fifty-four procedures were classified as clean-contaminated; 25 (4.5%) of these became infected. The only cases in this category in which students were the primary surgeon involved the suturing of simple lacerations (n = 15). The remainder were performed by fac-

<table>
<thead>
<tr>
<th>Wound Category</th>
<th>No. of Wounds</th>
<th>% Infected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>1100</td>
<td>2.5</td>
</tr>
<tr>
<td>Clean-contaminated</td>
<td>554</td>
<td>4.5</td>
</tr>
<tr>
<td>Contaminated</td>
<td>172</td>
<td>5.8</td>
</tr>
<tr>
<td>Dirty</td>
<td>273</td>
<td>18.1</td>
</tr>
</tbody>
</table>

TABLE 2. Infection Rates in 2063 Surgical Wounds in Dogs and Cats
Surgical Wound Infection Rates in Dogs and Cats

ulty or resident surgeons and included uncomplicated small bowel resections, pulmonary lobectomies, cystotomies, and portocaval shunts. Ophthalmic procedures accounted for 38% of the cases within the clean-contaminated category. They were placed in this category because of inability to prepare the cornea, lids, and periocular tissues aseptically.

One hundred seventy-two procedures were classified as contaminated; 10 (5.8%) of these became infected. All of these procedures were performed by either faculty or residents. They included oral surgery, complicated bowel resections, gastric torsion cases in which the stomach or outflow tract was opened, pyometra, perianal mass excision, and chronic, traumatic wounds without abscessation.

Two hundred thirty-seven procedures were classified as dirty; 43 (18.1%) of these became infected. All of the operations were performed by faculty or resident surgeons. Most of them involved chronic disease processes with preexisting inflammation or frank abscessation, or both. Included in this group were ear ablations for chronic otitis, infected nonunion fractures, amputations for severe trauma associated with infection, celiotomies for ruptured hollow viscera, and perianal fistulectomy.

Overall, infections occurred in 105 of the 2063 wounds (5.1%). There were no instances of multiple wound infections in one animal. Of the 105 animals with wound infections, 33 (31.4%) had a febrile episode (rectal temperature > 102.5°F) in the 24 hour period after surgery. The rectal temperature was not significantly associated with the occurrence of wound infection (Fischer's two-tail exact test). There was, however, a significant correlation between elevation of rectal temperature postoperatively and increased duration of the surgical procedure.

Most of the wound infections in the clean and clean-contaminated categories were considered to be localized problems that responded to antibiotic therapy or wound care, or both. Five positive cultures were obtained from the 28 wound infections in the clean category and 13 positive cultures from the 25 wound infections in the clean-contaminated group. In the contaminated and dirty categories, positive cultures were obtained from 7 of 10 and from 26 of 43 infected wounds, respectively. Coagulase-positive staphylococci were the most frequently cultured organisms from all wound categories.

Cases within the clean category were divided into subgroups to analyze the effect of antibiotics and the duration of surgery on the frequency of wound infection (Table 3). Within the clean category, 303 animals did not receive antibiotics prophylactically (subgroup B); of the 797 that did (subgroup A), 693 (87%) received ampicillin, 88 (11%) received oxacillin, and 16 (2%) received cephazolin sodium. Whenever antibiotics were administered prophylactically, appropriate guidelines were followed with regard to perioperative initiation and duration of treatment. There was a significantly lower infection rate in the animals receiving antibiotics. The beneficial effect of antibiotics was not observed, however, when procedures took less than 90 minutes to complete and were performed by faculty or resident surgeons (Table 3, subgroups C and D). In Table 3, subgroups E and F consisted of procedures that required more than 90 minutes to complete and were performed by faculty or resident surgeons. The small number of animals in subgroup F precluded a statistically valid comparison, although a numerically lower infection rate (2.3 vs. 8.0%) was noted in those animals given antibiotics.

The relationship of antibiotics and skill level was further examined by calculating infection rates on spays and castrations which had been performed by senior veterinary students (subgroups G and H). In these subgroups, the overall infection rate was significantly higher in those animals that did not receive antibiotics (4.4 vs. 1.5%). The increased rate of infection was not due to an increased duration of surgery, because the number of infections occurring after spays and castrations which took less than 90 minutes to complete (subgroups I and J) was also significantly greater in animals that did not receive antibiotics (5.7 vs. 1.6%).

Discussion

In this study, the frequency of wound infections in companion animal surgical patients generally increased in accordance with the degree of bacterial contamination, in accordance with human studies and the limited...
data relating to veterinary surgery. This conclusion assumes that the classification scheme provided an accurate separation of cases based on wound contamination. Although it is clear that a perianal fistulectomy is associated with more contamination than a routine ovariohysterectomy, many other procedures do not fall neatly into the categories defined by the National Research Council. For example, is a gastric volvulus procedure that includes a tube gastrostomy clean-contaminated or contaminated? Is a chronic wound with extensive devitalized tissue contaminated or dirty? Certainly the effect of vigorous debridement and lavage is significant and can convert such wounds into an almost clean condition. Standard procedures such as feline onychectomy and most ophthalmic operations cannot be considered purely clean procedures because of the contaminated operative field, but they should probably not be categorized along with bowel resections as clean-contaminated procedures. We agree with other authors who have stated that there is too much variation within these broad categories to make them of much value. For instance, infection rates in “clean” vascular surgery in humans varied from less than 1% for carotid artery procedures to 12% for abdominal aortic resections. In “clean” neurosurgical procedures in humans, the risk of deep wound infection varied more than tenfold depending on the type of operation. Within the clean category, it is clear that many procedures either vary significantly in the degree of bacterial contamination, or other factors such as the duration of the operation, characteristics of the patients, or the degree of technical difficulty result in differing susceptibilities to wound infection. An index combining patient susceptibility and wound contamination variables was developed and tested during the Center for Disease Control Study on the Efficacy of Nosocomial Infection Control. This more detailed scheme, which included four risk factors, predicted the surgical wound infection risk about twice as well as the traditional wound classification system. Although such a detailed method is probably not practical in veterinary medicine, the improved accuracy of the system illustrates the complexity of wound infection biology and accentuates the need for a more detailed analysis of the various risk factors.

Although of marginal usefulness for predicting the frequency of wound infection in particular types of operations, the wound categories used in this study do provide a rough guideline for determining the effect of hospital-wide changes such as conversion from muslin to disposable barrier materials, or new antiseptic protocols, on the frequency of wound infections in the overall surgical patient population. They also provide essential information if a wound infection surveillance program is being used to monitor changes in the “clean infection rate.”

We attempted to minimize the uncontrolled variables associated with a retrospective analysis by dividing the clean procedure category into subgroups in which the number of variables was minimal. Nonetheless, conclusions from this study regarding the efficacy of antibiotics in surgical wounds can only be tentative, because the patient population in each subgroup was not randomly determined. There may have been a selection process whereby the surgeon elected to use or not to use antibiotics for reasons not apparent in the medical record. The results of this study do correspond to those of prospective, randomized studies in veterinary surgical patients which indicated that administration of prophylactic antibiotics did not significantly modify the infection rate in routine, elective surgical procedures requiring less than 90 minutes to complete and performed by experienced surgeons. In the current study, the importance of surgical skill level is emphasized by the fact that routine procedures (spays and castrations) performed by students had a significantly higher rate of postoperative infection when antibiotics were not administered. It is likely that more traumatic tissue handling by inexperienced surgeons resulted in greater susceptibility to infection.

The duration of surgery has been shown to be an important risk factor for predicting surgical wound infections in humans. Although the numbers were too small to permit statistical verification, the results of the current study suggest that in more complex, clean procedures that require more than 90 minutes to complete, the rate of wound infection is greater in those animals that do not receive antibiotics. It is reasonable to assume that procedures requiring more than 90 minutes to complete are more difficult or that a complication has delayed an otherwise routine operation. Prolonged operating time results in increased bacterial contamination, and the excessive retraction and tissue dehydration which occurs has a markedly deleterious effect on tissues, compromising their ability to resist infection.

References


