Bacterial Culturing for Prediction of Postoperative Complications Following Open Fracture Repair in Small Animals

SHARON STEVENSON, DVM, MS, PhD, Diplomate ACVS, MARVIN L. OLMSTEAD, DVM, MS, Diplomate ACVS, and JOSEPH KOWALSKI, DVM, PhD

Swab specimens for bacterial culturing were obtained from 82 consecutive dogs and 13 cats undergoing open reduction and internal fixation of 110 fractures. Bacteria were isolated from 51 wounds. When the data were analyzed by stepwise logistic regression, it was found that bacterial contamination of wounds was associated most often with open fractures and with tibia or radius/ulna fractures. Contaminated wounds were five times more likely to develop complications than those without bacterial contamination. Regardless of results of bacterial culturing, postoperative complications developed significantly more often in animals that were febrile (≥39.4°C [103°F]). Postoperative complications did not develop in animals that did not have bacterial contamination of wounds and were not febrile.

Postoperative wound complications and infections result from the interaction of several factors, including the condition of the patient, wound contamination, trauma, and the skill of the surgeon. Although the relative importance ascribed to various factors has been largely speculative, some information is available from retrospective and prospective studies of human patients undergoing various surgical procedures. Results of these studies suggest that factors that increase the incidence of postoperative wound infection are age of the patient, duration of the operation, gross contamination of the wound, presence of a concurrent remote infection, and the presence of bacteria in the wound at the end of the procedure. A study of human orthopedic procedures has confirmed that bacterial contamination of wounds is associated with a higher rate of postoperative wound infection. Although several investigators have concluded that most cases of osteomyelitis in the dog result from open reduction and internal fixation of fractures, prospective studies to evaluate the importance of similar factors in postoperative wound complications and osteomyelitis in dogs and cats have not been reported. The purpose of this study is to document the incidence of bacterial contamination in a series of orthopedic cases, to identify the factors associated with bacterial contamination of wounds, and to ascertain the significance of bacterial contamination in predicting postoperative complications.

Materials and Methods

From March 1980 to July 1980, 110 fractures in 13 cats and 82 dogs were treated by open reduction and internal fixation by 11 surgeons at The Ohio State University Veterinary Teaching Hospital. Operative wounds were swabbed at the time of fracture exposure (19 wounds) and immediately before wound closure (110 wounds). Two swab specimens were collected at the time of each surgical procedure. One swab was immediately immersed in cooked meat broth modified by the addition of 5 μg of hemin/ml and 0.5 μg of

* Hemin (Bovine), Sigma Chemical Co., St. Louis, MO 63178.

From the Department of Pathology, School of Veterinary Medicine, University of California, Davis, Davis, California (Stevenson), and the Department of Clinical Sciences (Olmstead and Kowalski), College of Veterinary Medicine, The Ohio State University, Columbus, Ohio.

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Reprint requests: Dr. S. Stevenson, Case Western Reserve University, School of Medicine, Department of Orthopaedics, 2074 Abington Rd., Cleveland, OH 44105.
menadione/ml. The second swab was used to inoculate 5% bovine blood agar and MacConkey agar plates. The plates and the swab in cooked meat broth were incubated at 37°C under atmospheric conditions. Colonies growing on the agar plates were identified by standard laboratory procedures. Susceptibility tests were performed on these organisms using a modified disc susceptibility procedure. If examination of Gram-stained smears from the cooked meat broth revealed bacteria with morphologic characteristics of anaerobes, or if growth occurred only in cooked meat broth, subcultures were made onto anaerobically incubated blood agar plates. Anaerobic isolates were identified by use of gas chromatography and prerduced biochemical media.

A questionnaire was completed by the operating room nurse with the aid of the surgeon. Information recorded included signalment of the patient; bone(s) fractured; whether the fracture was open or closed; the extent of soft tissue injury; name(s) of surgeon(s); number of people participating in the surgery; duration of the procedure; number of procedures performed; whether this procedure was the initial attempt at repair or a reoperation; whether the wound was lavaged, and if so, with 0.9% saline solution alone or a saline-antibiotic solution (80 μg of neomycin/ml and 400 units of polymixin B/ml); whether plastic self-adhering drapes were used; and the method(s) of fixation. The clinical records were reviewed 3 months after surgery, and notations of administration of antibiotics (pre- and postoperatively), development of fever (>39.4°C [103°F] at 24 hours after surgery) and any clinical signs of postoperative complications (seroma, drainage, dehiscence) within the first 10 days after fracture fixation were recorded. Osteomyelitis was diagnosed when diffuse, excessive periosteal proliferation or premature and biomechanically unexplainable implant loosening were noted radiographically and when clinical signs such as drainage and/or wound dehiscence indicated infection. Data were analyzed by stepwise logistic regression using the BMDF- LR package$ (1983 version) and by chi-square analysis using the Yates correction; p < 0.05 was considered to be significant. Each surgical wound was considered separately; i.e., the initial fracture repair was one wound, and if the fracture was reoperated, the resulting wound was considered a second, separate wound. Likewise, for animals undergoing several surgical procedures in the same anesthetic period, each wound was considered a separate event.

Results

There were 30 mixed breed dogs in the study. The most prevalent breeds were Poodles (10), German shepherd dogs (9), Great danes (7), and Labrador retrievers (6). The breeds of cats were not recorded. The median age of the study group was 12 months (range, 2–156), and the median weight was 12 kg (range, 2–45). Fifty-one animals were male and 44 were female. The bone repaired most frequently was the femur (42), followed by the pelvis (24), humerus (14), tibia (12), and the radius and/or ulna (12). Eighty-eight of the fractures were closed on presentation. Of the 22 open fractures, two were type I, 14 were type II, and four were type III as described by Gustilo and Anderson.

Soft tissue damage around the fracture site (contusion and necrosis of muscle, hematoma) was judged by the surgeon to be minimal in 53 of the fractures, moderate in 27, and extensive in 30. Metal plates and screws were applied to 57 of the fractured limbs, pins and wires to 44, and screws alone or in combination with pins and wires to nine. The median duration of the surgical procedure was 95 minutes (range, 15–240). Twenty-two wounds were lavaged with saline and 86 with antibiotic solution. Twelve of the limbs were prepared for surgery with a plastic adherent drape, but only six of the drapes adhered to the skin throughout the surgical procedure. Two people were scrubbed in for 19 of the procedures, three for 51, four for 35, and five for five procedures. During one anesthetic period, one bone was repaired in each of 85 animals, two bones were repaired in each of 17 animals, three bones were repaired in each of five animals, and four bones were repaired in each of three animals. In 104 of the animals, the surgery was the first attempt at repair. In five dogs, the procedure was the second repair attempt, and in one dog, it was the third attempt.

Fifty-two animals were given preoperative antibiotics (7, ampicillin 20 mg/kg orally BID; 19, chloramphenicol 50 mg/kg orally TID; 26, cephalaxin 10 mg/kg orally TID). Sixty-four animals received postoperative antibiotics (6, ampicillin; 21, chloramphenicol; 37, cephalaxin). Thirty-one animals developed postoperative fever. A total of 13 wounds from 11 animals had complications (one wound from each of nine animals and two wounds each in two animals). Nine bones developed clinical and radiographic signs of osteomyelitis (two bones in each of two animals, one bone in each of five animals). The diagnosis of osteomyelitis
was confirmed by culture of wound swabs in five bones; swabs were not taken from the other four. Of the five osteomyelitic bones that were swabbed, four were contaminated with bacteria of the same genus as was present at the time of surgery.

Bacteria were cultured from 10 of 19 swabs taken upon initial fracture exposure. Forty-seven of 110 swabs taken at closing were contaminated. Bacteria were cultured from a total of 51 wounds (at opening, closing, or both). The following bacteria were isolated: *Staphylococcus aureus* in 14 wounds, *S. epidermidis* in 15, *Beta streptococcus* in four, enterococci in nine, *Klebsiella* sp in four, *Pseudomonas* sp in three, *Enterobacter* sp in four, *Proteus* sp in two, *Bacillus* sp in seven, *Diphteroids* sp five, *Clostridium* in three, *Pasteurella* sp in one, and *Salmonella* sp in one. The three *Clostridium* isolates were obligate anaerobes; all other isolates were aerobes.

By preliminary analysis of the data using chi-square tables, it was found that the signalment of the patient, name of the surgeon, number of people participating in the surgery, duration of the procedure, number of procedures performed, wound lavage, use of plastic self-adherent drapes, and method of fixation did not have a significant effect on incidence of bacterial wound contamination. The preliminary analysis indicated that the bone fractured (p = 0.003) whether the fracture was open (p = 0.001), whether this procedure was an initial attempt at repair or a reoperation (p = 0.007), and the extent of tissue damage (p = 0.009), all significantly affected the incidence of wound contamination. Consequently, these factors were entered into the logistic stepwise regression model together with administration of preoperative and postoperative antibiotics, and the presence or absence of fever, wound complications, or osteomyelitis. When the data were analyzed to determine which factors had the most impact on the probability of a positive culture, the most important factor was whether a fracture was open prior to surgery (p = 0.005): open fractures were four times more likely to have positive cultures than closed fractures. However, even after the statistical analysis considered open vs. closed fractures, there was a significant impact due to specific bones (p = 0.02). For instance, distal radius/ulna fractures were 10.5 times more likely to harbor organisms than femoral fractures, and tibial fractures 7.5 times more likely (Table 1). Once the impact of these two factors was analyzed, no other factor proved to be significant in predicting wound contamination. Bacteria were grown from the swabs of all reoperated wounds, but the extremely small number (n = 6) of these wounds made statistical analysis impossible.

Preoperative systemic antibiotics were administered 11 times more often to animals with extensive soft tissue damage than to those with minimal soft tissue damage, and postoperative antibiotics were administered 14.6 times more often, regardless of whether the fractures were open. No association was found between antibiotic administration and wound contamination. Neither bacterial contamination nor an open fracture was predictive of postoperative fever; however, animals with fevers or positive cultures were 14.5 or 4.8 times, respectively, more likely to develop postoperative complications than unaffected animals. Conversely, animals with a normal postoperative temperature and a clean surgical wound did not develop postoperative complications (Table 2).

**Table 1. Rates of Contaminated Wounds Related to Bones and Open/Closed Fractures**

<table>
<thead>
<tr>
<th>Bone</th>
<th>Open Fractures</th>
<th>Closed Fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis</td>
<td>0/1*</td>
<td>9/23*</td>
</tr>
<tr>
<td>Femur</td>
<td>3/5</td>
<td>10/37</td>
</tr>
<tr>
<td>Humerus</td>
<td>3/4</td>
<td>4/10</td>
</tr>
<tr>
<td>Tibia</td>
<td>1/1</td>
<td>8/11</td>
</tr>
<tr>
<td>Distal radius/ulna</td>
<td>3/3</td>
<td>3/4</td>
</tr>
<tr>
<td>Proximal ulna</td>
<td>2/4</td>
<td>0/1</td>
</tr>
<tr>
<td>Other</td>
<td>4/4</td>
<td>1/2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>15/22</td>
<td>35/66</td>
</tr>
</tbody>
</table>

*Number of contaminated wounds/total number of wounds of that type.

**Discussion**

The many variables that may predispose a surgical wound to postoperative complications and infections are complex, interrelated, and resistant to simple analysis. For these reasons, we chose stepwise logistic regression to analyze the data. This program scans the data and identifies factors that have the most impact on a chosen result (i.e., positive culture). The effect of that factor is analyzed, and the model is reassembled. If variability still exists, the next most important factor is identified and analyzed. With this method, the relationship between multiple and interrelated factors can be defined and clarified.

The 110 wounds that were studied included some small groups (for example six reoperated wounds), so the results must be interpreted with caution. Factors that did not appear to have an impact on the incidence of bacterial contamination of surgical wounds in our study may require a larger study group to show significance. Additionally, a small number (n = 13) of cats was included compared to the number of dogs. Cats may respond differently from the dogs, and this would not be evident from our data. However, certain observations resulting from this study are of interest. It was not surprising that open fractures were more likely to have bacterial contamination than closed fractures.
but the additional impact of certain bones had not been described previously. Both the tibia and the distal radius/ulna were more likely to be contaminated than the femur and humerus, even when the data were adjusted for the presence of open and closed fractures. Additionally, although the small sample precluded statistical analysis, it is noteworthy that organisms were cultured from all six reopened wounds. It has been reported that 50% of clean surgical wounds in humans harbor bacteria after 1 hour of surgery. The rate of bacterial clearance by the host is unknown, and this previous contamination may account for the high incidence of bacterial contamination at reoperation.

The usefulness of bacterial culturing of wound surgical swabs in predicting postoperative complications also was assessed. We found that contaminated wounds were more likely to suffer complications than those free of pathogens, a fact reported previously in the human literature. Also, although not statistically significant, wounds contaminated with both gram-positive and gram-negative bacteria suffered relatively more complications than wounds harboring only gram-positive or gram-negative pathogens. Although the choice of 39.4°C was entirely arbitrary, we found that a postoperative fever of 39.4°C [103°F] 24 hours after surgery was associated with an increased incidence of postoperative complications. Animals with both a contaminated wound and a postoperative fever were significantly more likely to develop wound complications than animals with normal to slightly elevated temperatures and uncontaminated wounds. In fact, none of the 46 animals with normal temperatures and negative cultures developed postoperative complications or osteomyelitis.

The administration of systemic antibiotics was not controlled in this study. Because of this potential bias, we examined the data for those factors associated with antibiotic administration. It was found that antibiotic use varied with tissue damage but not with other factors. Neither tissue damage nor antibiotic administration affected the incidence of wound contamination in our study. It would be inappropriate, however, to draw any conclusion about the role of systemic prophylactic antibiotics in veterinary orthopaedic surgery from our data because of the small number of wounds analyzed.

### References