

Posttraumatic Bacterial Infections in Extremities before and after Osteosynthesis in Small Animals

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Abstract

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Posttraumatic osteomyelitis is one of the most serious complications after fracture treatment. Even though first-generation cephalosporins are always recommended as the first choice of antibiotic prophylaxis in orthopaedic surgery, they cannot eradicate all bacteria, which can enter into the fractured bone during orthopaedic procedures.

The purpose of this study was to identify bacteria cultured from surgical wounds during osteosynthesis in order to select properly suitable antibiotic prophylaxis in our clinical practice. Our study was performed on 60 patients with long bone fractures operated at the Department of Surgery and Orthopaedics, Small Animal Clinic, University of Veterinary and Pharmaceutical Sciences, Brno. The patients without an antibiotic treatment 24 hours prior to surgery were included in the study. Samples for bacterial culture were collected before and after internal fixation of the fracture. Several factors possibly influencing the risk of infection were evaluated. Patients with severe degree of soft tissue damage and with open fractures were at higher risk of infection before osteosynthesis, whereas the patients younger than one year, with positive cultures before surgery, with plate and screw fixations, with primary bone healing, with abnormal radiographic findings and intramuscularly anesthetized patients were at a significantly higher risk of bacterial infection after the fracture fixation. A high percentage of the bacterial isolates was *Pseudomonas aeruginosa* resistant to cephalosporins. Although we use cephalosporins prophylactically in all patients undergoing orthopaedic surgery in our clinic, the incidence of postoperative infections was very low. Therefore, it is obvious that the use of cephalosporins as preoperative prophylaxis is sufficient in most cases. In the patients at high risk of osteomyelitis development (polytraumatized or immunosuppressed patients, patients receiving prosthetic joint or large metallic implants), or in the patients where the infection is already present, it is important to know hospital-specific pathogens to select adequate complementary antibiotics (in our case we use cephalosporines together with quinolones such as enrofloxacin). This emphasizes the need of epidemiologic studies, specific for each clinic.

Osteomyelitis, bone, dog, cat, surgical attire, nosocomial infection

Posttraumatic osteomyelitis or osteitis is described as resulting from trauma or nosocomial infection during the treatment of trauma that allows pathogens to enter bone, proliferate in traumatized tissue and cause subsequent bone infection (Parker 1987; Stein et al. 1998). Predisposing factors to osteomyelitis include bacterial contamination in combination with severe trauma, surgical intervention, the presence of dead bone, or metallic implants, especially if bone or implants are unstable (Gristina and Costerton 1989). Posttraumatic osteomyelitis is nearly always infectious in etiology, caused by various pathogens. The typical causative agents of this infection are aerobic bacteria especially staphylococcal species (Johnson 1994; Love and Johnson 1992; Stevenson et al. 1986). Even though staphylococci cause about 50-60% of bone infections in dogs (Johnson 1994), many organisms such as pyogenic streptococci (Calza et al. 2001), gram-negative

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aerobic bacteria (eg. *Escherichia coli*, *Pseudomonas* spp., *Proteus* spp. and *Klebsiella* spp.) (Hirsch and Smith 1978), and coagulase-negative staphylococci (Allignet et al. 1999; Stein et al. 1998; Shuttleworth et al. 1997) are commonly found. Although aerobic bacteria are commonly responsible for these causative posttraumatic infections, some uncommon microorganisms such as *Brucella canis* (Smeak et al. 1987), *Mycobacterium avium* (Caywood et al. 1978) can be found. Furthermore, anaerobic bacteria such as *Peptostreptococcus anaerobius*, *Propionibacterium* spp., *Actinomyces viscosus*, *Fusobacterium nucleatum*, *Bacteroides* spp., *Clostridium villosum* were isolated. It is also reported that *Wolinella recta*, *Leishmania donovani* (Johnson 1994), *Blastomyces dermatitidis* (Marcellin-Little et al. 1996), *Scedosporium prolificans* (Swerczek et al. 2001) can cause osteomyelitis in humans and domestic animals (Muir and Johnson 1992; Hodgins et al. 1992) but their incidences are rare.

According to the previous study (Dvořák et al. 2000), it was found that about 30% of 40% of the patients who had complications after osteosynthesis had abnormal radiological bone healing without any abnormal clinical signs. It was suspected that it might be caused by posttraumatic osteomyelitis or cryptic infection.

The purpose of this present study is to find out the type of aerobic bacteria, which plays an important role in the posttraumatic infection before and after fracture osteosynthesis. If the type of bacteria can be identified, the suitable antibiotic prophylaxis can be properly selected to achieve an effective prevention of posttraumatic osteomyelitis after osteosynthesis (Love and Johnson 1992). Since poor aseptic and surgical techniques have been the primary cause of posttraumatic infection (Walldvogel and Vasey 1983), the aseptic techniques in orthopaedic surgery are also theoretically evaluated.

Materials and Methods

Our study was performed on 60 patients who had undergone osteosynthesis in extremities at the Department of Surgery and Orthopaedics, Small Animal Clinic, University of Veterinary and Pharmaceutical Sciences Brno from October 2001 till October 2002. All the patients were treated according to the principles of AO/ASIF with open reduction and internal fixation. The patients without antibiotic treatment 24 hours before surgery were included in our study. The methods of fracture repair were selected according to the fracture-patient assessment score (Piermattei and Flo 1997). The osteosynthesis procedures were performed by two experienced orthopaedists. Patients were hospitalized from 2-6 days in our clinic to receive standard postoperative care. They were returned to our clinic at 4-8 weeks after operation for follow-up orthopaedic and radiographic examinations. The next follow-ups were carried out at 4-6-week intervals, if needed. The implants for internal fracture were removed after clinical and radiological bone healing. Long bone diaphyseal fractures were classified using an Unger's system (Miller et al. 1998). In cases of physeal injury, the Salter-Harris (1963) classification was used. Fracture classifications were used for communications among surgeons and radiologists.

All data of the patients, including breed, age, sex, type of fracture (based on the classification system adopted by AO vet (Unger 1990)), methods of internal fixation, interval between the time of injury and surgery, type of bone healing, type of anaesthesia, radiographic finding, and type of surgical attire used in operation were recorded and evaluated.

Routine preoperative patient preparation and disinfectants used (Nečas et al. 2000b) were theoretically evaluated. Preoperative surgical site preparations were performed starting with hair clipping with an electric clipper, and then 3-5 min povidone-iodine scrubbing, and chlorhexidine spraying were applied to the preoperative operation site. All surgical instruments were sterilized with autoclave (132-135 °C; 10-25 min). Povidone-iodine and alcohol were used for hand-scrubs of surgical team.

Two types of surgical attire were used in our present study (96 operations). There were: Foliodrape® (Hartmann) including disposable non-woven surgical gowns with incision drape which was performed in 28 operations.

Reusable woven (cotton) surgical gowns with disposable non-woven polypropylene drape (Polydrape®) which were performed in 68 operations.

Foliodrape® were mainly selected in osteosynthetic procedures (21 operations) whereas reusable gowns with Polydrape® were always used when the implants were removed (58 operations). Types of surgical attire were also statistically analyzed for their influences on the risk of infection among several factors of patients.

Our study was divided into two parts; bacterial culture was performed before osteosynthesis and when the internal fixations were removed.

In the first part, 1 gram of tissue and/or bone fragment at the fracture site was collected. Furthermore, another sample was taken by means of sterile cotton sponge, which was saturated with blood. Both types of sample were collected from 55 patients when the fractured bone was approached to perform internal fixation. Samples were

collected in Amies transport medium (CM 425, Oxoid) and or in modified Cary-Blair medium (CM 519, Oxoid). To perform bacterial cultivation, samples were inoculated onto Blood agar base (CM 854, Oxoid) and MacConkey's agar (CM 7b, Oxoid) and also into TH broth in order to enrich bacterial cells. The inoculated media were incubated at 37 °C for 1-3 days. The bacteria found in each sample were identified and tested for antibiotic sensitivity by means of discs diffusion method according NCCLS. Six factors (Table 1) including species, patient's age, type of fracture, degree of soft tissue damage, presence of small bone fragments and the interval from the time of injury to the time of surgery were examined for the incidence of bone infection before internal fixation was performed.

Table 1
Criteria to evaluate the incidence of bacterial bone infection

Data	Classification of criteria		
Age of patients	< 1 year		> 1 year
Type of surgical attire	Foliodrape®		Cotton gown and Polydrape®
Type of fracture	Close		Open (Table 4.3) Type I Type II Type III
Soft tissue damage	Mild	Moderate	Severe
Fracture with bone fragment	Yes		No
Interval from the time of injury to the time of surgery	1-2 days	3-4 days	More than 5 days
Radiographic abnormalities	Yes	No	Unknown
Type of internal fixation	Plates and screws	Kirchner pin	Screws combination with pins
Type of bone healing	Primary		Secondary
Duration of anaesthesia	Less than 100 minutes		More than 100 minutes
Method of anaesthesia	With propofol		Without propofol
Bacterial culture	Negative	Indirect culture	Direct culture

In the latter part, one gram of tissue and internal fixations were obtained from each of 41 patients when the internal fixations were removed. One gram of tissue at the fracture site was transferred into Amies transport medium (CM 425, Oxoid) and internal fixation devices were put into Cary-Blair medium (CM 519, Oxoid) as the transport medium. The bacterial cultivation was performed in the same procedure as in the first part. Eleven factors, including the age of patients, type of fracture, degree of soft tissue damage, presence of small bone fragments, interval from trauma to surgery, positive bacterial culture results before implantation, abnormal radiographic findings, type of internal fixations, type of bone healing, type of anaesthesia, and duration of anaesthesia when the osteosynthesis was performed were evaluated (Table 1).

Since *P. aeruginosa* strains were frequently isolated, we separately evaluated the incidence of *P. aeruginosa* infection in each group of patients in order to properly determine the incidence of bacterial bone infection. Cefazolin (20 mg/kg) was intravenously administered to all patients as soon as the sample was collected.

Statistical analysis

All criteria were analyzed by using χ^2 test and Fischer's exact test with $p < 0.05$ and $p < 0.01$ to evaluate the incidence bone infection in each group of patients.

Results

Aseptic techniques evaluations

Surgical site preparation methods were theoretically supposed to be effective and appropriate to reduce a number of bacteria at the surgical site. Due to the efficacy of antiseptics used and methods of preoperative preparation of patients we assumed that it was sufficient to prevent the bacterial contamination of the surgical site.

Incidence of fracture and infection

The most frequently fractured bones were the tibia (43.33% of long bone fractures), followed by the femur (26.67%), the radius and ulna (18.33%) and the humerus (11.67%).

Once each fracture was categorized by localization and type of fracture line, the diaphyseal complex (25.4%), diaphyseal transverse (24.2%), metaphyseal and/or physeal and/or epiphyseal extraarticular (16.7%), intraarticular (16.8%), and diaphyseal oblique or spiral (16.9%) fractures were found. The positive bacterial findings were frequently detected in the patients with tibial (69.23%) and radial (63.63%) fractures.

Type of surgical attire

Two types of surgical attire were used in this study (96 operations) including non-woven disposable surgical gowns, drape, incise drape (Foliodrape®) and reusable woven cotton surgical gowns with disposable non-woven polypropylene drape (Polydrape®). The incidence of bacterial findings found between these types of surgical attire was significantly different ($p < 0.05$). The positive bacterial results were frequently found in 48 operations (70.58%) performed with reusable surgical gown and non-woven disposable drape (Polydrape®) whereas only a few bacterial findings were detected in the operations performed with Foliodrape® (3/28, 10.7%). Once the types of surgical attire were statistically analyzed for their influences on the positive results among each group of patients categorized by several factors, which may influence the risk of infection, there was no statistical difference in the positive results between types of surgical attire and each factor.

Bacterial culture before implantation

The negative and positive results of bacterial culture were found in 21 patients (38.18%) and in 34 patients (61.81%), respectively. Among the patients with the isolation of bacteria, there was mixed bacterial infection in 6 patients (17.64%) and single pure bacterial cultures in 28 patients (82.35%). In all patients bacteria can be isolated via enrichment in broth media. Bacterial species found in the patients before were *Pseudomonas aeruginosa* (50.0%), *Staphylococcus epidermidis* (20.6%), *Staphylococcus aureus* (8.82%), *Staphylococcus intermedius* (5.88%), *Bacillus* spp. (5.88%), *Corynebacterium* (5.88%), *Proteus mirabilis* (5.88%), *Escherichia coli* (5.88%), *Staphylococcus* spp. (2.94%) and *Enterococci* (2.94%). The differences in detection of bacteria among species, patient's age, patient with or without small bone fragments, and patient with different durations from trauma to surgery were not statistically significant. On the other hand, statistical differences were found in the patients with different fracture types and those with different degrees of soft tissue damage. We found that patients with open fractures and those with severe degree of soft tissue damage had significantly higher positivity of bacterial culture ($p < 0.01$).

Bacterial culture after metallic implantation

The negative results of bacterial culture were found only in 8 patients (19.51%) whereas the positive results were found in 33 patients (80.48%) after implantation. The incidence of bacterial infection after implantation was significantly higher than that before implantation ($p < 0.05$). Among the patients with culture of bacteria, there was mixed bacterial infection in 5 patients (15.15%) and single bacterial species in 28 patients (84.84%). The incidences of mixed and single bacterial infection before and after implantation were not different. The bacteria could be isolated via primary cultivation on agar plate media in 4 patients (9.76%). As a whole, bacteria found in the patients before and after implantations were almost in the same species or genus and incidences including *Pseudomonas aeruginosa* (51.51%), *Staphylococcus epidermidis* (21.21%), *Staphylococcus intermedius* (12.12%), *Staphylococcus haemolyticus* (12.12%), *Staphylococcus aureus* (3.03%), *Staphylococcus* spp. (15.15%), *Bacillus* spp. (6.06%), *Escherichia coli* (3.03%), and enterococci (3.03%). The incidences of bacterial findings were not significantly different among each group of patients categorized by type of fracture, degree of soft tissue damage, presence of small bone

fragments, the interval from trauma to surgery, and duration of anaesthesia. On the other hand, the patients of younger age (less than 1 year), those with plate and screws internal fixation, those with positive bacterial results before implantation, those with primary bone healing, those with abnormal radiographic findings, and those administered intramuscular anaesthesia had significantly higher positive bacterial culture results after implantation ($p < 0.05$).

In our investigation, we found that only 2 patients (3.33%) had clinical problems after osteosynthesis. Both of them had positive bacterial results before and after implantation and also had radiographic abnormalities (bone lysis around implants, periosteal reaction, and loose implants).

Discussion

In our study, incidence rate of type and localization of long bone fractures were the same as in the previous report (Dvořák et al. 2000). We found the tibia and fibula (43.33%) and the femur (26.67%) to be the most frequently fractured bones whereas the previous report (Dvořák et al. 2000) showed that the radius and ulna were the most commonly fractured. However, our number of patients is lower than that reported in the previous study. In addition, our study excluded the patients with previous antibiotic treatment. Furthermore, we also found similar to the previous reports that the incidence of bone infection is high in tibia and radius fractures. Due to less dense muscle covering the bone at these sites, it was found that infection always occurred in the tibia and the radius (Braden 1991; Braden et al. 1989; Carek et al. 2001; Caywood 1983; Fitzgerald et al. 1992; Johnson 1994).

Because the surgical site infection etiology is multi-factorial, the sterilization, preoperative patient preparation and operating theatre environments must be considered as the main sources of this bacterial contamination. Antiseptics used in our practice were theoretically supposed to be effective. Since povidone-iodine and chlorhexidine have a broad spectrum of antimicrobial activity against vegetative bacteria, fungi, viruses, protozoa, and yeasts, they are suitable for removing bacteria from the skin surface at preoperative surgical site (Lemarie and Hosgood 1995). Additionally, povidone-iodine surgical scrub is also used extensively in veterinary practice for the pre-operative preparation of patients and surgeons (Amber et al. 1983).

Surgical attire used in the operation also plays an important role in the sterilization in the operation theatre and postoperative wound infection. We found that Foliodrape® was mainly selected in the osteosynthetic procedures (when internal fixations were performed) whereas reusable gown and non-woven drape were always used when the implants were removed. Due to the high cost of Foliodrape®, it is always selected when osteosynthesis is performed or when the risk of infection is high. According to our results, the positive bacterial results from the osteosynthetic procedures (before implantation) seem to be lower than those when the implants are removed. These types of surgical attire may interfere with the positive bacterial results before and after implantation. However, we did not find any statistical differences of positive culture results between each factor and surgical attire. Our results showed that the disposable non-woven surgical gowns, drape, and incision drape (Foliodrape®) could effectively reduce the bacterial contamination of the surgical wound. We suggested that Foliodrape® should be used in the operations which have high risk of infection, such as joint prosthesis, and when large metallic internal fixations are performed. The woven surgical gown and Polydrape® can be used in soft tissue surgery, or in routine orthopaedic procedures which have lower risk of infection.

The microbiological cultivation methods used in our present study were supposed to be effective in identifying aerobic bacteria (Abia gom and van Horn 2002). Amies and Carry Blair transport mediums were used as transport mediums in our study. Both are acceptable

as effective transport mediums that can prolong the survival of both aerobic and anaerobic bacteria such as *Staphylococcus*, *Pseudomonas*, *E. coli*, *Enterococcus*, *Peptostreptococcus*, *Prevotella*, *Streptococcus*, *Haemophilus*, *Neisseria*, *Fusobacterium* etc. (Abiagom and van Horn 2002; Colasante et al. 2002; Ferrington and Brown 2002; Robinson and Gruver 2002; Sarina and Knoll 2002). Bacterial cultivation was performed by inoculation samples onto the blood agar medium and MacConkey's agar (solid media). The enrichment in broth media was used to detect only few bacterial cells in the sample. The types of bacterial species found in our study were in agreement with the other previous reports (Braden 1991; Braden et al. 1989; Calza et al. 2001; Carenti-Etesse et al. 1999; Caywood 1983; Caywood et al. 1978; Costerton and Marrie 1985; Fitzgerald 1983; Fitzgerald et al. 1992; Griffiths and Bellenger 1979; Harrari 1984; Johnson 1994; Lew and Waldvogel 1997; Smith et al. 1978). Since *P. aeruginosa* was frequently found in our study, we assumed that it was the main nosocomial pathogen in our operating theatre. Furthermore, this species was also classified as the main nosocomial pathogen in humans (Stein et al. 1998; Lobati et al. 2001; Valenziano et al. 2002). The mixed bacteria identified from the samples before and after implantation were in the same incidence. However, in the present study, multimicrobial bone infections were commonly found in the patients with open fractures and always contained mixtures of staphylococci as well as gram-negative aerobic rods such as *Escherichia coli*, *Pseudomonas* spp., *Proteus* spp. and *Klebsiella* spp. (Hirsch and Smith 1978). Bacteria commonly found in primary wound cultures in open fractures in extremities were *Staphylococcus* species (Popovitch and Nannos 2000; Shuttleworth et al. 1997) such as *S. epidermis*, *S. aureus* (Calza et al. 2001) and also *Pseudomonas aeruginosa* (Carsenti-Etesse et al. 1999; Greenberg et al. 2000; Calza et al. 2001; Shirliff et al. 2002).

Since the collecting, transporting, and cultivation methods for anaerobic bacterial evaluation are difficult and complicated, our present study was not performed for anaerobic bacterial identification. Furthermore, osteomyelitis caused by anaerobic bacteria always shows typical signs, such as a foul odor and the presence of sequestra (Johnson et al. 1984; Walker et al. 1983) and it is rarely identified in the osteosynthetic procedures. Thus, it was excluded from our study, which focused only on aerobic bacteria, which tend to play more important role in orthopaedic procedures. However, there seems to have been more interest in recent decades in anaerobic bacteria, which can cause osteomyelitis including *Peptostreptococcus anaerobius*, *Propionibacterium* spp., *Actinomyces viscosus*, *Fusobacterium nucleatum*, and *Bacteroides* spp. (Muir and Johnson 1992; Hodgkin et al. 1992; Walker et al. 1983). Therefore, further studies should be performed to identify the type and incidence of anaerobic bacteria when osteomyelitis, whose cause is unknown, occurs in clinical practice.

According to our results, it was shown that the young patients (less than 1 year of age) were at higher risk of bacterial infection after osteosynthesis. Due to immature host defense, they are susceptible to bacterial infection especially when the large metallic implants such as bone plates and screws are in place. These may cause a severe degree soft tissue damage. To our knowledge, there is no veterinary report available concerning the incidence of posttraumatic bone infection in young and old patients. It was mentioned that posttraumatic osteomyelitis is not an age-specific disease (Braden 1991; Caywood 1983). However, for posttraumatic osteomyelitis there appears to be a slight predilection in young male animals due to the increased incidence of trauma in this subset (Braden 1991; Caywood et al. 1978; Radasch 1993; Nečas et al. 2002a; Baranyiová et al. 2002, 2003). Furthermore, the patients with intramuscular anaesthesia also had high risk of bacterial infection. Due to our anaesthetic protocols in young patients, intramuscular anaesthesia (medetomidine in combination with ketamine) was mainly performed in the patients of young age. Thus the

positive results in this group of patients were also high, even though the intramuscular anaesthesia might not influence the incidence of infection.

As a whole, the patients with open fractures tended to have a higher risk of bone infection than those with closed fractures. Incidence of osteomyelitis following open fractures is reported to be 2-16% depending significantly on the grade of trauma and the type of treatment administered (Kaim et al. 2001). In open fractures, bacteria can easily enter into the bone even by open wound or by the surgical approach when performing osteosynthesis. Additionally, an association with severe soft tissue damage in these patients puts them at a higher risk of infection (Carenti-Etesse et al. 1999; Lew and Waldvogel 1997; Petty et al. 1985). In accordance with these data, we also found that these patients had a higher risk of infection. Bacteria found in patients with open fracture include *P. aeruginosa*, *Staphylococcus aureus*, and *Staphylococcus epidermidis*. Furthermore, according to our investigation, *P. aeruginosa* was frequently found in the sample of the patients with closed fractures before and after implantation whereas the other bacteria (staphylococci, enterococci, *E. coli*) were mainly found in patients with open fractures. Thus, it was concluded that *P. aeruginosa* might be the main nosocomial pathogen in our operating theatre.

Other factors, which can promote cryptic infection of the bone, are the degree of soft tissue damage, type of internal fixation, and interval from the time of injury to the time of treatment, avascular bone fragment, and duration of surgery (Petty et al. 1985). Soft tissue trauma and fracture fixation using metallic implants may produce structural and functional damage to the local host tissue causing devascularization, malperfusion, disturbance of endothelial permeability, hypoxia, acidosis, haematoma, edema, and increased intracompartmental pressure (Gristina et al. 1991; Wichmann et al. 1996). This may result in an impaired humoral and cellular immune competence (Hock et al. 1993). On a local level it may decrease resistance to the pathogenic microbiological load with subsequent manifestation of infection in the traumatized tissue (Balto et al. 2001; Hoch et al. 1993; Nair et al. 1996; Petty et al. 1985). Nevertheless, numerous clinical investigations have shown that operative treatment of closed fractures with severe soft tissue injury is associated with a higher risk of infection than that without severe soft tissue injury (Kalicke et al. 2003; Siebert et al. 1995). These investigations indicate that even without major bacterial contamination, soft tissue damage and its pathophysiological consequences act as a catalyst for infection since they reduce resistance to infection.

Fracture stabilization with metallic implants, such as plates and screws, require tissue trauma and devitalization during implantation, provide a relatively large surface area for bacteria with adherent properties, and provide a mechanical barrier to the immune system. Alteration of cellular activity associated with prolonged fracture healing and a small amount of bacteria in a cryptic infection may cause osteomyelitis. Although cryptic infection itself may not cause any clinical problems, whenever the host defense mechanisms are suppressed (i.e. systemic diseases, hypersensitivity to metallic implants), the bacteria may be recalcitrant and cause the infection leading to implant failure (Lobati et al. 2001). In our study, we found that the patients with internal fixations with plates and screws were at a higher risk of infection. Due to more severe tissue damage, longer surgery, and large metallic implants, cryptic infection easily occurred when the plate and screws fixation were performed. However, we did not find any statistical difference of bacterial culture results among patients that underwent different durations of operation. Thus the invasive surgical techniques, intensive sterile techniques, and antimicrobial prophylaxis selection for the orthopaedic procedure play important roles in prevention of bone infection as well (Parker 1987).

The interval from the time of injury to the time of treatment also plays an important role

especially in patients with open fracture. Bacteria entering into the fractured bone can multiply in the necrotic tissues and haematoma (Hoch et al. 1993; Petty et al. 1985). However, we did not find any statistical differences among patients with different intervals. The bacterial culture results in the patients with long interval may be influenced by antibiotic administered to stabilize the systemic condition before surgery. Moreover, we also found that the patients with primary bone healing had higher positive bacterial culture results than those with secondary bone healing. Due to compression force between bone fragments performed to achieve the primary bone healing, this force may create the necrosis of bone. Thus the patients in this group seem to have a higher risk of infection. It can explain that the high risk of infection due to plate and screw fixation may contribute to infection (Cordero et al. 1994). Additionally, the compression dynamic plate (DCP) will increase the stress at the fracture site and it may produce bone necrosis. Because of lack of blood vessel supply at the fracture site, the cryptic infection may easily become manifest (Arens et al. 1996).

We also found that the positive bacterial culture results before implantation and abnormal radiographic findings were related to the positive bacterial culture results after implantation. The patients who had the positive results before implantation also had a higher risk of infection after implantation. The same groups or species of bacteria found before and after implantation were found in more than 70% of patients with positive results. Radiographic abnormalities such as bone lysis and/or periosteal reaction were found in 11 patients who had positive results both before and after implantation. Two of them also had clinical problems including delayed bone healing, loose implants, and osteomyelitis. Thus we concluded that positive bacterial culture results before implantation and radiographic abnormalities can predict the risk of bone infection when osteosynthetic procedures are performed.

Given that the overall infection rate for clean, elective surgical procedures in the present study was in line with values reported for human patients (Stevenson et al. 1986), it is unlikely that an abnormally high bacterial burden was a problem in our hospital. Operating room protocols and surgical sterility appeared to be adequate. However, compared with previous reports, the high percentage of *Pseudomonas aeruginosa* isolates was an unusual finding. Therefore, a change may be warranted in the choice of antimicrobials used in our hospital in patients in which infections are suspected but results of bacterial culture and susceptibility testing are not yet known. Knowledge of the commonly isolated organisms and their antimicrobial susceptibility patterns within a given hospital assists in the selection of appropriate antimicrobial treatment. In most patients with cephalosporins given prophylactically, the antimicrobial was not effective against *Pseudomonas* spp. as reported by (Edin et al. 1996). Therefore, we cannot comment on what value appropriate prophylactic antimicrobial treatment might have provided. Our findings do, however, give weight to the efforts to reduce the prophylactic use of antimicrobials in our hospital and emphasize the importance of hospital-specific epidemiologic studies of infection rates (Shirtliff et al. 2002; Stein et al. 1998). According to our results, it is recommended to administer the first generation of cephalosporins during preoperative operation in every patient (Edin et al. 1996; Love and Johnson 1992; Patel et al. 2000; Whitttem et al. 1999). In patients with a high risk of infection, such as polytraumatized or immunosuppressed individuals, the patients who have undergone prosthetic joint or large metallic implants, the quinolone group such as enrofloxacin should be added and postoperative care should be performed intensively to prevent posttraumatic osteomyelitis (Greenberg et al. 2000).

Posttraumatická bakteriální infekce kostí končetin malých zvířat před a po osteosyntéze

Posttraumatická infekce kostí (osteomyelitis) je jednou z nejzávažnějších komplikací osteosyntézy. Při ortopedických operacích je proto indikováno profylaktické podání antibiotik (chráněné koagulum v průběhu operace), přičemž antibiotiky první volby jsou v těchto případech cefalosporiny první generace. Tyto preparáty však nezaručují eradikaci všech bakterií, které pak v průběhu chirurgického zákroku mohou proniknout do místa lomu.

Cílem této studie bylo určit nejčastější bakteriální agens vykultivovaná ze stěrů získaných během osteosyntézy, aby mohla být zvolena nevhodnější antibiotická profylaxe pro naši klinickou praxi. Do studie bylo zařazeno 60 pacientů s frakturami dlouhých kostí končetin ošetřenými osteosyntézou na Oddělení chirurgie a ortopedie Kliniky chorob malých zvířat Veterinární a farmaceutické univerzity Brno. U pacientů zařazených do studie nebyla v období minimálně 24 hodin před operací podána žádná antibiotika. Stěry pro mikrobiální kultivaci byly odebrány před a po přiložení implantátů k vnitřní fixaci zlomeniny. Byly hodnoceny některé rizikové faktory rozvoje infekce. Vyšší riziko vzniku infekce před operací bylo zjištěno u pacientů s rozsáhlým poškozením měkkých tkání a v případech otevřených zlomenin. Naopak vyšší riziko rozvoje infekce po provedené osteosyntéze bylo zjištěno u pacientů mladších jednoho roku, u pacientů s pozitivní bakteriální kultivací před operací, u pacientů, u nichž byla použita ploténka se šrouby, u pacientů s primárním hojením kostí, s rentgenologickými abnormalitami hojení zlomeniny a u pacientů v intramuskulární anestezii. Vysoké procento bakteriálních izolátů v naší studii představovala *Pseudomonas aeruginosa* rezistentní na cefalosporiny. Ačkoli na naší klinice jsou u všech pacientů před operací používány právě cefalosporiny, incidence pooperačních infekcí byla velmi nízká. Z našich výsledků je tedy patrné, že za normálních okolností je dostačující běžná předoperační profylaktická aplikace antibiotik. V případech zvýšeného rizika rozvoje infekce (polytraumatický nebo imunosuprimovaný pacient, použití endoprotézy nebo velkých kovových implantátů), nebo tam, kde se již infekce rozvinula, je důležitá znalost specifické epidemiologické situace na daném pracovišti a následně použití antibiotik účinných proti aktuálním patogenům. V našich podmínkách u těchto případů doplňujeme cefalosporiny první generace použitím chinolonů (enrofloxacin) a zvýšenou pooperační péčí, abychom předcházeli rozvoji posttraumatické osteomyelitidy.

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