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Seventy-three cases of individualized treatment strategies of different types of chronic osteomyelitis.

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Abstract

Objective: To explore whether individual choice treatment is a feasible choice in the treatment of different types of chronic osteomyelitis with different causes and history as well as the differences in local soft tissue conditions.
Methods: Seventy-three cases of different types of chronic osteomyelitis were included in the study. According to the classification of causes: 21 cases were blood-borne, 34 cases were traumatic, 6 cases were iatrogenic, 7 cases were sclerosing osteomyelitis, and 5 cases were caused by special causes.
Results: Individualized choice treatment was performed followed by a follow-up of 12 to 36 months with an average of 15.5 months. Osteomyelitis recurred in 1 case, while the rest were recovered.
Conclusion: In the treatment of different types of chronic osteomyelitis, individualized treatment plan is a feasible choice.

Keywords: Osteomyelitis, Individualization, Antibiotic bead chain, Soft tissue defect, Infectious bone non-union, Muscle flap.

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Introduction

Due to different pathogeny and medical history as well as individual differences in local soft tissues, there is few standardized treatment regimen for chronic osteomyelitis in clinical practice. There is no consensus on classification systems of osteomyelitis. Generally, osteomyelitis is characterized as acute or chronic. Chronic osteomyelitis typically presents six or more weeks after bone infection and is characterized by the presence of bone destruction and formation of sequestra. The treatment to the chronic osteomyelitis mainly includes antibiotics and surgery. Based on medical histories and soft tissue conditions, we chose individualized treatment options for patients diagnosed with chronic blood-borne osteomyelitis, traumatic chronic osteomyelitis, iatrogenic chronic osteomyelitis, chronic sclerosing osteomyelitis, chronic osteomyelitis caused by special factors, and brodie abscess. This study is designed to establish a comprehensive view on the classification of chronic osteomyelitis as well as to probe individual treatment on the patients with this disease.

Materials and methods

Design

A total of 73 patients who were diagnosed with chronic osteomyelitis caused by different types of factors from March 2007 to April 2014 were included in the study. Among them, there were 51 male patients and 22 female patients, aging between 19 and 76 years old. The average age was 43.1 years old. The site of infection was on femur in 28 cases, on tibias in 41 cases, on calcaneus in 2 cases, on humeri in 1 case, and on ulnae in 1 case. Duration of infection was between 2 months and 40 years, with an average of 16 months. Among all the patients, 37 cases showed sinus formation accompanied with varying degrees of exudate or pus at diagnosis, 9 cases were diagnosed with chronic osteomyelitis caused by infection after internal fixation, and 3 cases had internal fixators. Patients were classified by pathogeny as follows: 21 cases were blood-borne, 34 cases were traumatic, 34 cases were iatrogenic, 7 cases were sclerosing, and 5 cases were caused by special factors. Among those cases, 21 cases were diagnosed with chronic osteomyelitis caused by persistent blood-borne osteomyelitis (8 cases were atypical); 34 cases were traumatic chronic osteomyelitis (5 cases were atypical); 6 cases were diagnosed with osteomyelitis caused by iatrogenic infection; 7 cases were sclerosing osteomyelitis; 5 cases were diagnosed with osteomyelitis caused by other factors (3 cases were

caused by metaphyseal localized bone abscess, 1 case caused by rejection of bone fixation plate, and 1 case were caused by secondary infection of bone following venous thrombosis skin ulcers). Individualized treatment options were used, followed by a follow-up of 3-36 months. The average follow-up was 15.5 months. During the follow-up, osteomyelitis recurred in two cases while the rest recovered.

Treatment method

Preoperative preparation: The routine preoperative examination was performed. Erythrocyte Sedimentation Rates (ESR) and C-Reactive Proteins (CRP) were tested. X-rays of infection sites in all the patients were taken. In addition, 18 patients underwent CT examination and 28 patients underwent MRI for the differential diagnosis. After hospitalization, antibiotics were not used before bacterial culture. Antibiotics were not used in patients whose infection sites were in stable condition before surgery. Preoperative sinus secretion culture showed that 18 cases were positive. The positive rate was 48.65%. There were 5 cases of *Staphylococcus aureus* (3 cases of methicillin-resistant *Staphylococcus aureus*), 7 cases of Staphylococcus epidermidis, 3 cases of negative bacilli, and 3 cases of opportunistic pathogen.

Formulation of surgical scheme: In the treatment of all chronic osteomyelitis, thorough debridement and focal cleaning are fundamental. However, due to relatively large individual differences in local soft tissue conditions, we designed surgical scheme according to individual conditions. After thorough debridement, other treatment methods were used. We designed 8 combination methods for 73 patients: a. focal cleaning+stealth enlargement of the medullary cavity +antibiotic beads technique (32 cases); b. focal cleaning +antibiotic beads technique+muscle flap technique (12 cases); c. focal cleaning+antibiotic-loaded bone cement (4 cases); d. focal cleaning+antibiotic-loaded bone cement+muscle flap technique (9 cases); e. focal cleaning+biodegradable antibiotic delivery systems+closed negative pressure drainage technique (5 cases); f. focal cleaning+antibiotic-loaded bone cement +closed negative pressure drainage technique (5 cases); g. focal cleaning+stealth enlargement of the medullary cavity +closed negative pressure drainage (4 cases); h. focal cleaning +antibiotic beads technique+fixation (internal and external) (2 cases).

Inclusion and exclusion criteria

Operation points in various surgical schemes: (1) Focal cleaning+stealth enlargement of the medullary cavity +antibiotic beads technique: it is mainly used for patients with blood-borne and some traumatic osteomyelitis in the chronic stage. Soft tissue covering in patients was good, and patients have a wide range of inflammation. Debridement was expanded to remove all inflammatory and devitalized tissues around periosteum and the inflammatory thickening of the periosteum. Ischemic sclerotic bones with surface thickness were polished using an electro-saw or bone knife until normal bone tissues with needle-like bleeding on surface could be seen. After cortical bone was notched, dead bones or sclerotic tissues in the medullary cavity were removed. The medullary cavity was opened up. After thoroughly rinse of sites of infection using normal saline, hydrogen peroxide and iodine, self-made vancomycin-release bead chains were implanted, and the wound was closed. (2) Focal cleaning+antibiotic beads technique+muscle flap technique: it is mainly used traumatic osteomyelitis and blood-borne osteomyelitis with a medical history of a few decades, commonly accompanied with soft tissue defects, bone scars or sinuses. Patients have a wide range of inflammation. After debridement, canal blood circulation was improved by muscle flap packing, and the exposed bone was covered. Medial gastrocnemius muscle flaps were used for Tibias, and vastus lateralis muscle flaps were used for femurs. Finally, vancomycin-release bead chains were implanted, and the wound was closed. (3) Focal cleaning+antibiotic-loaded bone cement: it is mainly used for local infection in cancellous bone and metaphyseal bone abscess with a small range of infection. Soft tissue condition in patients is normal. The debridement range is relatively small. After the removal of the lesion, sclerotic bones were polished using surgical drills until normal bone tissues with normal blood oozing could be seen. Bone cement added with vancomycin was filled bone defects. (4) Focal cleaning+antibiotic-loaded bone cement+muscle flap technique: it is mainly used for traumatic osteomyelitis whose bone infection range is limited as compared with blood-borne osteomyelitis, mostly accompanied with bone scars or sinuses. There are local bone defects of less than 3 cm^3 (or defects after removal of dead bones) in patients. Debridement is relatively small. Sclerotic bones were polished using an electro-saw until normal bone tissues with needle-like bleeding on surface could be seen. Usually there was no obvious purulent discharge. Inflammatory granulation tissues or scar tissues could be seen. After debridement, based on Masquelet technique, bone cement added with vancomycin was implanted to fill bone defects [1]. Meanwhile, bone cement delayed the release of antibiotics, controlling local infection. Exposed bones needed to be covered by muscle flap. (5) Focal cleaning +biodegradable antibiotic delivery systems+closed negative pressure drainage technique: it is mainly used in traumatic and iatrogenic bone infection with low toxicity, and a limited infection range, accompanied with sinuses with a small amount of sinus secretions. However, the fracture end still can be recovered. After debridement, calcium sulfateshaped particles with vancomycin was added to play a dual role of bone grafting and delaying the release of antibiotics to control infection [2]. After soft tissues loosely closed, closed negative pressure suction drainage apparatus was posted outside. (6) Focal cleaning+antibiotic-loaded bone cement+closed negative pressure drainage technique: it is mainly used in traumatic osteomyelitis with relatively large bone infection range which is limited as compared with that of blood-borne osteomyelitis. Scarring or small sinuses usually accompany traumatic osteomyelitis, but the covering is basically intact. After debridement, bead chains were not able to be placed, and local muscle flap or flap surgery could not be performed because of lack of appropriate conditions. Based on Masquelet technology, bone cement with vancomycin was implanted,

playing the same role as antibiotic bead chains [1]. After soft tissues loosely closed, closed negative pressure suction drainage apparatus was posted outside, prompting the growth and coverage of granulation tissues. (7) Focal cleaning+stealth enlargement of the medullary cavity+closed negative pressure drainage: it is mainly used for sclerosing osteomyelitis. The causes of sclerosing osteomyelitis are mainly obstruction in the medullary cavity. The sclerosing scope of the medullary cavity was determined by preoperative MRI examination. The surgery did not need surgical debridement and expanding. Fenestration operation needed to be performed in the backbone. The operation scope was slightly larger than the sclerosing scope indicated by the images. Thickened cortical bones were removed. Stealth enlargement of narrowed medullary cavities was completed by bone knifes. Closed negative pressure suction drainage apparatus was used. (8) Focal cleaning +antibiotic beads technique+fixation: it is mainly used in iatrogenic infection. In one case, after intramedullary nailing in the close fracture of femoral shaft, infection of the medullary cavity accompanied by the non-union of bone occurred. Infection occurred in the other case after intramedullary nailing. After debridement, normal saline, hydrogen peroxide and iodine washed the infection sites and medullary cavity completely. External fracture fixators were used to fix fractures. Vancomycin-release bead chains were implanted sectionally. Then the wound was closed.

Postoperative managements: Based on culture results, patients received intravenous antibiotics for 2-3 weeks after surgery. If there was no evidence of bacterial culture, according to orthopaedic principles of infection prevention, antibiotics were selected and used. Usually first-generation or second-generation cephalosporins were used. Quinolones and Clindamycin were alternatives. The use of antibiotics could be adjusted according to inflammatory tissues in the surgery or postoperative bacterial culture of drains and drug sensitivity test results. If CRP did not returned to normal levels 2 weeks after the body temperature was normal, the patients needed to continue with oral antibiotics. Beads began to be removed 3 days after surgery. One bead was removed one time. Conventionally all beads were removed about 2 weeks later. ESR and CRP were regularly checked, and X-rays were taken.

Results

Cure criteria

Pain symptoms disappeared, sinuses closed, the capacity to act was restored, the canal was smooth in the X-ray, and no new periosteal reaction or dead bone occurred. ESR and CRP which increased in the preoperative examination were back to normal, and maintain the normal level for more than 1 year.

Table 1. *Types of osteomyelitis and case numbers.*

Types	Blood-borne	Traumatic	Iatrogenic	Sclerosing	Others	In total
Cases	21	34	6	7	5	73
Percentage (%)	28.8	46.6	8.2	9.6	6.8	100

Results

In the follow-up of 12-36 months with an average of 15.5 months, a secondary infection occurred in 1 patient who underwent the hip arthroplasty due to necrosis of the femoral head 6 months after infection following the proximal femoral internal fixation was controlled. The rest were recovered.

Complications

Bone fracture of slotted parts occurred in 2 patients with osteomyelitis of the distal femur when they fell. The patients did not walk carefully as the doctors said after getting home. After fixation by plaster, the two patients recovered.

Table 2. *Surgical schemes of patients with osteomyelitis, cases and surgical indications.*

Surgical scheme	Cases	In total	Surgical indications
A	Blood-borne 18, Traumatic 10, Sclerosing 3, the other 1	32	Intact soft tissues; stenosis/atresia/inflammatory tissues in the medullary cavity.
B	Blood-borne 2, Traumatic 9	11	Unstable bone scars; issue inflammation in the medullary cavity.
C	Traumatic 2, the other 3	5	Small infection range/local infection cancellous bone; metaphyseal bone abscess/ normal soft tissue conditions
D	Blood-borne 1, Traumatic 7, Iatrogenic 1	9	Exposed bone or unstable bone scars; local bone defects accompanied with nonunion of bones
E	Traumatic 2, Iatrogenic 2, the other 1	5	metaphyseal bone infection not associated with bone defects; bone infection after incomplete healing of fracture
F	Traumatic 4, Iatrogenic 1	5	Large infection range; poor condition of the soft tissue conditions with intact coverings
G	Sclerosing 4	4	Stenosis / sclerosis in the medullary cavity; no secretion and inflammatory tissues in the cavity
H	Iatrogenic 2	2	Purulent discharge in the medullary cavity accompanied with nonunion of bones

Discussion

Because of the different causes and the medical history of chronic osteomyelitis and individual differences in local soft tissue conditions, standardized treatment plan is difficult to make in the clinical practice. The features of chronic osteomyelitis were as follows: the course is relatively long, the blood supply is poor, it is difficult to eradicate the disease, antibiotics are difficult to achieve internal lesions, and resistant infections are relatively frequent [3-6]. In both traditional literature and recent clinical studies, researchers in China and abroad have found that is still the most important pathogens causing osteomyelitis [3-6]. Objectives of the treatment for chronic osteomyelitis are as follows: 1. to establish an environment of good blood circulation 2. To eliminate dead space 3. Effective use of sensitive antibiotics [3-5]. Since secondary osteomyelitis caused by trauma is not only accompanied with bone tissue infections, but also with fracture, bone exposure, bone defects, scars, sinus and soft tissue defects and other symptoms, the treatment difficulty is relatively high [7]. In current study, we raised the individual treatment for different types of osteomyelitis, which fully fulfil the objective for the osteomyelitis treatment, and take all the different situation of various patients into consideration. Debridement, antibiotic bead pouch technique, and muscle flap technique are the common treatment methods and techniques of chronic osteomyelitis [5]. In recent years, more techniques have appeared. Degradable calcium sulphate and calcium phosphate loaded with antibiotics, closed negative pressure drainage technique and Masquelet technique, a treatment strategy to manage a posttraumatic bone defect widen choices of doctors when osteogenesis is treated [5-7]. At the same time, we found that chronic osteomyelitis is associated with intramedullary sclerosis and hyperplasia so that dead space exists. Stealth enlargement of the medullary cavity is necessary for the treatment of osteomyelitis. Since the 1970's, delayed-release antibiotic beads using polymethyl acrylic acid as loads has become an important treatment method of post-traumatic osteomyelitis [5]. According to epidemiological statistics, is still the most important bacterium causing osteomyelitis. Therefore, the majority of antibiotic beads are made from norvoncomycin hydrochloride and polymethyl methacrylate [3-6]. However, antibiotic beads should not be used for the treatment of osteomyelitis which is insensitive to vancomycin in the bacterial culture. For the individual performance and conditions of patients with chronic osteomyelitis, individualized treatment strategies combined with the above technology can achieve satisfactory therapeutic effects [8-10].

Conflict of Interests

None

Author's Contributions

Ning Duan and Hongxing Zhang for bioinformatics analysis and writing of the manuscript. Ke Xing for discussion and comments on an earlier version of the manuscript. All authors read and approved the final manuscript.

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