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Osteomyelitis and Nursing Management

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1. Introduction

Osteomyelitis can be described as the inflammation of bone and bone marrow and it usually indicates the presence of an infection. Although the term of osteomyelitis among children usually expresses acute hematogenous osteomyelitis, it may occur as sub-acute and rarely as chronic. Although bacteria are the main cause for it, fungi, parasites and other microorganisms can also be responsible [1-3].

2. General facts

2.1. Epidemiology

The incidence of osteomyelitis in the first two decades is the highest. 50% of the cases occur among children under the age of 5. The rate of occurrence among patients with sickle cell anemia and people whose immune system is suppressed is high [4]. Except for the first year of life, the male female incidence rate is 2:1. Prior to the infection among 1/3 of the patients, a minor trauma history is found. Genetic and socio-economic factors are also influential in the process of formation of the disease [2,3].

2.2. Pathogenesis and pathology

Osteomyelitis cases among children may occur hematogenously, and more likely the metaphysis of the long bones are involved (especially the distal femur, proximal tibia) [5,6].

Microorganisms may infect bones in three ways:

- a. Direct inoculation (trauma, during surgical operation).

- b. From an infection in a nearby area (like cellulitis), local invasion [7,8].
- c. Hematogenously spreading out (bacterial) is the most common case.

The reason for this is that the capillaries in the metaphysis area show a sinus-like expansion, besides that the endothelial cells that are located around the ven area in the arterioles of the metaphysis lack the ability of phagocytosis. The capillaries in the metaphysis pose a suitable area for the location of microorganisms because the blood current here is low and it is a suitable nourishing place, on the other hand the state that around the capillary veins there are no phagocytic cells may result in a vulnerable environment [4, 9]. As a result, bacteria that come through the blood stream may easily multiply in the metaphysis sinusoids and the sinusoids will become filled with pus and form an abscess. Because of the ischemia caused by the abscess in the medullary bone necrosis will start. As the volume of the abscess increases, so does the intramedullary pressure, and cortical ischemia develops in this area. Later the abscess will reach to the sub-periosteal gap via the Haversian system and cause sub-periosteal abscess. "Sequestra" is the name for bone parts whose blood supply are impaired and are separated from living bone parts, and "involucrum" is called for healthy bone parts surrounding the dead bone parts. Meanwhile, new bone formation continues from the endosteal and periosteal. As a result, in the bones 1) inflammation and formation of abscess (with the influence of bacteria and enzymes) 2) necrosis (vascular obstruction) 3) pathological changes due to new bone formation processes will be observed [7].

Among children the effects of osteomyelitis may show difference according to age. Under the age of two, the nutrition of the epiphysis is obtained by the metaphysis veins that intercross the physis. Through these veins, the infection in the metaphysis may pass to the epiphysis. It may even spread to the joint and be the cause to the septic arthritis. Damage to the physis may be cause to separation of the epiphysis, deformities and extremity shortness. Diaphyseal involvement is rare except very heavy cases. Above two years of age, by taking role as a barrier, the physis borders the metaphysis from the infection, and prevents it from spreading to the epiphysis and the joint cavity. After the closing of the physis, the infection may spread from the metaphysis to the epiphysis, and it may form septic arthritis [2,7,10].

If the infection is not treated in the acute period, chronic osteomyelitis is unavoidable. Then, the surrounding of the infection-focus filled with pus and granulation tissue will be surrounded by a fibrous capsule and sclerosing bone-tissue and the "Brodie" abscess will be formed [9].

2.3. Etiology

The main cause among children at all ages is the *Staphylococcus aureus*. In a lower rate *Group A, streptococci* and *Streptococcus pneumoniae* may be observed. *Haemophilus influenza* and *Gram negative enteric bacteria* are becoming increasingly important in the etiology of osteomyelitis in areas where routine vaccination isn't practiced in the first year of life. In the newborn period (0-4 weeks) *Group B streptococci*, *Escherichia coli* (*E. coli*) and gram-negative bacteria are the major microorganisms that cause osteomyelitis. In penetrating injuries and IV drug addicts *Pseudomonas aeruginosa*, in sickle cell anemia *Salmonella strain*, in chronic hemodialysis patients

coagulase-negative staphylococci and *S. aureus*, and in chronic granulomatous disease *Serratia* and *Spergillus strains* are the expected pathogens. Fungal osteomyelitis especially occurs among newborns, immune-suppressed patients and intravenous drug users [3]. Tuberculosis osteomyelitis in less developed countries still constitutes the main cause of musculoskeletal infections. *Mycobacterium tuberculosis* most frequently grips the vertebral body and the synovial. In recent years, without primary lung focus osteomyelitis patients with single focused tuberculosis osteomyelitis have been reported. Although rare, tuberculosis osteomyelitis may develop due to tuberculosis vaccine (Bacillus-Calmette-Guerin; BCG vaccine). Among approximately half of the children with acute osteomyelitis, a bacterial etiology cannot be detected. *Staphylococcus aureus* and *gram-negative enterics* are the most common causes of chronic osteomyelitis. From pathogenic microorganisms, usually furuncles, impetigo, deep or superficial abscess, carious teeth and infected tonsils like primary focuses come to the bone via the blood. Any types of trauma that cause to bacteremia are important risk factors in the formation of the disease [9].

2.4. Clinical table

In osteomyelitis, clinical findings vary according to age. Because babies possess a weaker anatomic barrier to limit the spreading of infections among them, they show a tendency for the disease; and together with it, the septic arthritis, soft tissue infection and pseudo-paralysis of the affected extremity are widespread. Among older children, the infection is more focal. Most frequently, there is fever and ache at the infection location. More rarely, there may be loss of appetite, malaise and vomiting. The patient will be reluctant to use the extremity. Depending on the osteomyelitis, deep venous thrombosis may develop and it may be the first consultancy reason [7,10].

2.4.1. Age factor

Newborn Form: Among newborns, findings are very weak, when the affected extremity is touched or moved, the baby becomes disturbed. Around the pseudo-paralysis, there may develop a swelling. The newborn osteomyelitis consists of residual deformities, frequent infections of the multiple bones, and the involvement of the joints, facial bones and the proximal humerus. The onset is often hidden, following umbilical artery catheterization or the taking heel blood swelling or decreased activity may occur. There may be no fever or leukocytosis. Although there is an inclusion of a large number of bacteria species *Staphylococcus aureus*, *Candida albicans* and the group B *Streptococci* are observed as the most common pathogens [10].

Bone scans can detect clinically undefined points. Any joint affected is drained immediately. In newborns, usually in the bone cortex, a window-like drilling surgery is not necessary [10].

Baby form: it occurs among patients younger than the age of 1, and it often spreads from the epiphysis to the metaphysis and joints while the veins of the diaphysis enter into the epiphysis. The periosteum often becomes rapidly perforated and it becomes rapidly pierced. The cover

(new bone development belonging to one periosteum) formation may be large but due to absorption and reformation, it is temporary. If it inhibits a long bone, with the shortening of the organ, the epiphyseal growth centers may become damaged [10].

Childhood Form: This type generally occurs among patients from 1 year of age until puberty. It is usually settled in the metaphysis and doesn't spread to the epiphysis, as the veins do not enter the epiphyseal plaque. It rarely damages the growth cartilage or the joint [10].

Adult Form: This type reveals after the age of 16. The growth cartilage dissolves and the metaphyseal infection may spread to the epiphysis and the joint. Chronic infection is more common among adults in comparison to children [10].

2.4.2. Specific findings in the bones

Long bones: For long bones, acute hematogenous osteomyelitis is typical. In around 70% of the cases, the femur or tibia are affected. When there is no osteomyelitis area, it is more difficult to diagnose, usually it is in the metaphysis but it occurs in the diaphysis rather more (in the center) or epiphysis (in the center) of the long bone. To diagnose osteomyelitis of the femoral neck is difficult since negative findings in the joint resemble hip arthritis. Besides interruption of blood supply to the femoral head or as a result of the insertion penetration the osteomyelitis in the femoral neck area may be the cause to heavy hip-joint complications [7,10].

Feet: Puncture wounds of the foot, especially those in the metatarsal area may result in soft tissue, bone and particularly of the cartilage *Pseudo aeruginosa* infection. Typically, the patient may possess a wound through shoes and a developing swelling will heal in the first day or afterwards. Often, local pain is an important clue, but fever and leukocytosis in generally is mild or absent. When there is redness or swelling at the toes, a couple of days later, an exploratory surgery with the debridement of the area is nearly always necessary to the foot sole wound. Radiologic evidence of bone destruction generally may not be observed for several weeks. Scanning sometimes helps. The recovery of *Pseudomonas* on aspirated substance culture will yield to the determination of more demand for debridement [10].

Clavicle: Particularly among drug addicts, clavicle or a sternoclavicular joint is sometimes an area where sub-acute infection is built up. Osteomyelitis of the clavicle occurs also among children [10].

Patella: Patella osteomyelitis may be confused with suprapatellar bursitis for it is very seldom [10].

Fingers: Pyogenic osteomyelitis arises in many fingertip abscesses as a complication. Without a neighbor that is infected, the osteomyelitis of a finger bone may lead to a secondary tuberculosis case [10].

Rib: Rib excision will dry the osteomyelitis and secrete the agent to prevent the Ewing's sarcoma or other tumors. Generally, it will be accompanied by chest pain and fever [10].

Pelvis: Pelvic osteomyelitis will include pubis, ilium and ischium. Often, there will be fever, abnormal gait and severe sensitivity in the affected bone area. Roentgenographic changes

may last from 10 days to 10 weeks. *Staphylococcus aureus* is the common cause. Bone scans are useful but may be negative in the early stages. Ultrasound may show the displacement of the bladder [10].

Vertebra: Vertebral body infection is rare in children. But, intervertebral disc infection, i.e. discitis is common. Generally, the source can't be found [10].

Other Bones: Cranial osteomyelitis typically is an extension of otitis externa, mastoiditis, or sinusitis. It occurs after multiple antibiotics use and usually causes *Pseudomonas aeruginosa* [10].

2.5. Diagnosis

Several microbiological, haematological, serological and radiological tests are useful in the clinical diagnosing and the determination of the causative factors of the disease [6]. In an age in which the prevalence of antibiotic-resistant microorganisms is increasing, extreme effort is required to determine the specific etiology of the disease. For directing the anti-microbial treatment, it is imperative to obtain pathogen sensitivity tests. The diagnostic methods described below can be applied to all forms of osteomyelitis [7,9].

2.5.1. Laboratory findings

In osteomyelitis laboratory findings are nonspecific. The erythrocyte sedimentation rate (ESR) is usually measured in the range of 40-60 mm/hr; it reaches the highest rate within 3-5 days of the treatment, and it returns to normal within 3 weeks. As ESR gradually decreases with successful treatment, elevated ESR is a perfect parameter for monitoring the response to the treatment. The rise of the C-reactive protein (CRP) level is the highest on 2nd day of the treatment (mean 83 mg/L) and it drops to normal in 1 week. This, together with the ESR, is used for monitoring response to the treatment [3].

The etiologic diagnosis of osteomyelitis is performed by isolating the microorganism from the bone, sub-periosteal exudate and joint fluid [3].

Blood cultures should be obtained from all patients with possible osteomyelitis. The blood cultures of approximately 50% of the patients with acute hematogenous osteomyelitis are positive. Newborn osteomyelitis is often characterized with bacteremia. As in other osteomyelitis forms, the probability of the blood cultures to be positive is lower in osteomyelitis that is developing from the neighboring focus, like the osteomyelitis that is accompanying chronic osteomyelitis and peripheral vascular disease. In this context, blood culture is a limited guide. A separate set of two or four cultures should be taken [9].

There may be leukocytosis but cases in which the leukocyte number is normal or slightly higher occur often, and therefore it cannot be used to rule out the osteomyelitis diagnosis [9].

2.5.2. Radiologic findings

Conventional radiography for diagnosis of pediatric patients is necessary. In osteomyelitis, the usual development sequence of radiographic changes is as follows:

1. In the early stages of the disease, the direct radiographs are normal. At this stage, bone scintigraphy can detect abnormal findings. However, if there is bone destruction, further imaging is not necessary.
2. Stage: 3 days after the onset of symptoms in the metaphyseal area, a localized deep soft tissue swelling is observed. Soft tissue swelling and an increase in the subperiosteal space are the earliest detected abnormalities.
3. After 3 to 7 days of the onset, swelling in the muscles and a deletion in the translucent oil lines is observed.
4. Stage: 10-21 days after the start of the findings of bone destruction, lytic lesions, periosteal removal due to the accumulation of purulent subcortical and periosteal new bone formation becomes apparent. Lytic changes may not be visible in direct graphics until the 30% to 50% of the bone disappears and are not detectable until after 2-6 weeks of the onset of the disease. Sclerotic changes may occur weeks after the onset of the disease after the formation of the new matrix due to a delay in mineralization. Sclerotic changes associated with periosteal new bone formation (involucrum) indicate the presence of a more chronic process [9].

Magnetic Resonance imaging is a suitable method for the examination of the bone, and in comparison to computed tomography, it will better reveal the pus accumulation in subperiosteal and soft tissues. This is the preferred method for the diagnosis of vertebral osteomyelitis. In the diagnosis of acute osteomyelitis, its sensitivity is close to 100% and, in addition to this, it is useful in the differentiation of acute and chronic osteomyelitis. Radionuclide studies are helpful in early stage diagnosis even when there are no findings with plain radiography. However, its use is limited among newborns [7].

In comparison to radiologic examinations, bone scintigraphy is more valuable for osteomyelitis [2,7,9,10]. Among technetium radio-phosphate, scintigraphic methods especially the three-phase are the most used ones. Radiation exposure is approximately the same as the standard radiography and children patients are not contraindicated. Because of referred pain or the probability of a multifocal infection, the whole-body scintigraphy of patients who are suspected to have osteomyelitis should be done. Afterwards, a more thorough detailed radiologic investigation of the suspected areas can be made. Scintigraphy done with indium-labeled leukocytes is an excellent sensitivity and specificity method in the determination of early osteomyelitis. This method is technically a little more difficult, and has more radiation levels when compared with the bone scintigraphies with technetium [9].

Needle aspiration must be practiced to every patient whose absolute diagnosis has not been performed via blood cultures to obtain sample cultures from lesions inside bones, from the

collection of soft tissues, from the abscesses under the periosteum. Preferably, needle aspiration should be practiced prior to giving antibiotics. If there is joint effusion together with it, synovial fluid tests should be performed. The aspired effusion should be investigated regarding the cells it contains, and in terms of biochemistry, Gram staining and culture [9].

Patients among whom the exact etiology cannot be determined despite the blood cultures or needle aspiration, especially when tuberculosis, fungal or a malignant disease is suspected, open biopsy may be considered. The biopsy samples should be reserved for histopathological analysis and for cultures that are regarded necessary [7,9].

2.5.3. Differential diagnosis

In cases with possible high fever, pain and sensitivity in the extremities, the differential diagnosis should be performed. Rheumatic fever, septicemia, septic arthritis, cellulitis, Ewing's sarcoma, metastatic neuroblastoma, leukemia, reflex neurovascular dystrophy, to thrombophlebitis hemoglobinopathies connected bone infarcts and toxic synovitis can be counted to be in these cases [2,3].

2.6. Treatment

The initial treatment can be intense. Inadequate treatment of acute osteomyelitis can result in relapse and the development of chronic disease [3,11]. The treatment should be adjusted to the patient's characteristics (Table 1 and 2).

2.6.1. Antibiotics using principles

The basic choice of antibiotics and although the number of comparative studies for the determination of the duration of the treatment is few, antibiotics are the mainstay of the treatment [9].

2.6.1.1. Parenteral antibiotic treatment

Usually in the beginning of the treatment, to be sure of the harmony and to reach the necessary bone levels, parenteral agents are recommended. Because the passage of antibiotics to the bone is low, these agents are generally given in high doses [6]. The passage of antibiotics is linked to the vascularization of the bone (e.g., the surfaces in spongiform bone tissue are higher than in cortical bone). The levels of antibiotics in diseased bone are even higher. Penicillin, cephalosporins, gentamicin, vancomycin, clindamycin and ciprofloxacin reach to a level that exceeds the Minimal Inhibitory Concentration (MIC) of many of the susceptible microorganisms that lead to osteomyelitis [12]. When the obtained serum levels are considered, especially clindamycin and ciprofloxacin pass well into the bone. Indeed, whether you give these agents intravenously or orally, the treatment of them has been proven for all forms of osteomyelitis [2,9].

Patient Characteristics	Possible Pathogen	Antibiotics Selection
Empirical treatment	Staphylococcus aureus Haemophilus influenzae type b	nafcillin/clindamycin/ vancomycin (MRSA*) cefuroxime/cefotaxime/ ceftriaxone/ chloramphenicol
Newborn	S. Aureus Group B streptococcus Gram negative enteric bacteria	nafcillin* cefotaxime/gentamicin
<5 years	S. Aureus Streptococci H. influenza type	nafcillin + Cefotaxime/Ceftriaxone OR Cefuroxime OR Ampicillin-sulbactam
>5 years	Gram positive cocci	Nafcillin OR Clindamycin OR Cefazolin
Sickle cell anemia	S. Aureus Coliform bacteria	Nafcillin/Clindamycin+ Cefotaxime/ Ceftriaxone
Puncture injuries Partially broken	S. Aureus Anaerobe bacteria	Clindamycin
Immunosuppressed patients	MRSA Pseudomonas aeruginasa	Vancomycin + ceftazidime ticarcillin- clavulanate
Puncture foot injury	P. Aeruginasa	Ceftazidime/mezlosilin+ Aminoglycosides AND Surgical Debridement
Remained in the hospital for a long time preterm	Resistant gram negative bacteria Antifungal agents	Vancomycin Carbapenems Fungus

MRSA* : methicillin-resistant Staphylococcus aureus

Table 1. Treatment approach in acute osteomyelitis [3].

Medicine	Dose (mg/kg/day)	Daily dose
Nafcillin	150	4
Clindamycin	30	3-4
Cephazolin	100	3
Cefotaxime	150	4
Ceftriaxone	100	2
Cefuroxime	150	3
Ampicillin-Sulbactam	300	4
Gentamicin	5-7.5	3

Table 2. Antibiotics doses in acute osteomyelitis [3]

2.6.1.2. Oral antibiotics treatment

Patients will be treated with intravenous antibiotics for 5-10 days. After a good clinical response, the treatment of the patient is changed into a high-dose oral treatment and this continues for at least 3 weeks. One should especially focus on some aspects of the oral treatment.

- a. For susceptibility tests, one should obtain an active organism and it should be sensitive to the selected agent. In vitro sensitivity tests help to select the appropriate treatment. As a long-term treatment is necessary in this disease, it is vital that sensitivity tests are performed carefully. Because, combinations of antibiotics may lead to additional toxicity, if sensitivity combinations are not well known, the best way is to stay away from such combinations.
- b. Surgical debridement and drainage should be performed in a suitable manner.
- c. One should be certain about the harmony. If there is a doubt about the patient's adhering to the treatment, then treating the patient outside the hospital should be avoided.
- d. Some professionals defend that the serum bactericidal levels should be used in order to observe the effectiveness of the treatment. In this method, blood is taken from the patient just before and right after giving the antibiotics. Later on, serial dilutions of the serum are analyzed for the bactericidal activity to the active microorganism. But, as there is no standard protocol and there are no large studies to support this test, its real value is not known.
- e. The extension of the treatment is very important and the use of the antibiotics should be continued for at least 4-6 weeks. The rate of healing is expected to be more than 90% [9].

Medicine	Dose(mg/kg/day)	Daily dose
Amoxicillin	100	4
Cefaclor	150	4
Cephalexin	100-150	4
Chloramphenicol	75	3
Clindamycin	30-40	3
Cloxacillin	125	4
Dicloxacillin	75-100	4
Penicillin V	125	6

Table 3. Oral antibiotics doses in acute osteomyelitis [3]

2.6.2. Surgical drainage

Nearly all of the hematogenous osteomyelitis will heal without surgery when treated with suitable doses of antibiotics. In the treatment after 3 to 5 days from the beginning of the disease, the results are even better. Yet, these patients should be monitored by an orthopedic surgeon in the future to evaluate a surgical necessity [9].

The surgical indications include the following:

- a. **Diagnosis:** When pathogens are not determined in blood cultures for sure, diagnostic aspiration should be performed routinely.
- b. **Hip joint involvement (osteomyelitis of femoral metaphysis):** In these cases, it is imperative to drain early because of the tearing risk of the cortex and the possibility of the infection to spread into the hip joint.
- c. **The neurological complications of vertebral or cranial osteomyelitis.**
- d. **Poor response or non-response to the treatment:** If patients do not respond well clinically after 48-72 hours of the treatment, drainage operation is necessary. Among patients whose disease has occurred with gram-negative enteric bacilli, drainage is more often a requisite. A collection of pus under the periosteum that does not respond has to be drained too. A culture should be taken from all the surgical samples.
- e. **Sequestrum:** They need to be removed surgically [9].

Even in the case of a suitable antibiotics treatment among children and adolescents with CA-MRSA (Community-associated methicillin-resistant *S. Aureus*), incision and drainage were found to be necessary in osteomyelitis. Besides, when the child doesn't respond to the antibiotics treatment, surgical drainage should be considered. In such a case, surgical initiative can enhance the healing. In addition to this, surgical initiative will allow microbiological evaluation of the tissue collection to confirm the diagnosis of histological analysis of unusual causes of osteomyelitis [13].

2.7. Prognosis

The treatment results of children with acute hematogenous osteomyelitis who do not have complications are fine. Together with this, the prognosis is in relation with different factors. These factors include the active organism, the duration of the symptoms before the treatment, age and the duration of the antibiotics treatment [2].

Sufficient antibiotics treatment is essential. Among 10% to 20% of the patients who are treated for acute hematogenous osteomyelitis, recurrence is observed [2].

Among patients who have osteomyelitis due to gram-negative organisms, the recurrence rate is higher [2].

For completely healing, the best opportunity is the initial treatment. Only 50% of recurrent infection patients with full debridement and intravenous antibiotics for 4-6 weeks can heal. To prevent acute osteomyelitis chronic infections, one should be treated in an effective way and in adequate time interval [2,9].

Before the start of antibiotics, acute hematogenous osteomyelitis was a disease with a high morbidity and mortality rate. With the discovery of ways of diagnosis and cure and in a changing world, the mortality rate of the disease have become unimportant. Despite this, for various reasons, the clinical course of children with acute hematogenous osteomyelitis makes it difficult to apply standard treatment recommendations. The treatment should be always individualized with a team approach that include pediatric infection professionals and orthopedists [13].

Without regarding the attainability of all new microbial agents, the major therapeutic concern in all forms of osteomyelitis is to start with the most appropriate treatment as soon as possible. In this context two concepts are important; the first one, the difficulty in certifying the existence at the appropriate time, and the second one is the determination of the alleged pathogen and the opportunity to assess the antibiotics resistance [13].

3. Special forms of osteomyelitis

3.1. Chronic osteomyelitis

The patient was previously treated for osteomyelitis at the same location. The prognosis is worse than acute osteomyelitis. Treatment failure rate is higher than with the acute form and the way of treatment is different [9].

The patient rarely shows acute symptoms. Systemic symptoms like fever are not common. Except for drainage from the sinus or the wound, regional signs and findings are less common [2].

Among the causes, *Staphylococcus aureus* is the most common pathogen. *Staphylococcal* infections can recur after many years the initial episode. Gram-negative bacteria may mingle

as well. The treatment should be started according to the result of the cultures from the biopsies [2].

The full treatment of chronic osteomyelitis is difficult to define, because relapses are frequent and after a very aggressive treatment, it may occur after months or years. After intensive attempts for a full treatment, sometimes the extremity-threatening surgical operation, occasionally a long-term treatment with toxic and expensive antibiotics is required.

Surgical intervention may be necessary to obtain culture material, and for the subtraction of sequestra, for removal of necrotic tissue and dead matter [10].

In 1995, Dr. Charles Lautenbach performed the **Lautenbach operation** for the first time. Dr. Lautenbach had been using this method in the treatment of chronic osteomyelitis for 30 years. From November 1995 until the end of 1998, the Sheffield Limb Reconstruction Service healed 17 patients by using the Lautenbach method. With all of the patients being male, the infection durations were 12.5 years. The method consists of the debridement of the dead bone, piercing the medullary canal, soft tissue debridement and the insertion of irrigation tubing. The main difference between the irrigation method and this method, is caused by the dispersion of the antibiotics in it. In traditional methods, the antibiotics are constantly dispersed; unfortunately, this means that the medullary canal is directly washed. Whereas in the Lautenbach method the antibiotics become injected once in every 4 hours, until a new instillation is needed, it remains in the cavity, it washes the tissues, are then are discharged.

Other advantages of the system:

- To provide the most appropriate concentration of the antibiotics in the area of the infection, 2 or more couples of lumen tube are used.
- For the control of the organisms, samples are taken from fluid of the washed medullary canals; and according to their susceptibility, the antibiotics are adjusted.
- Without a systematic side effect, a high dose of antibiotics can be dispensed through tubes. The antibiotics are dispensed only if the patient shows the systematic effects of the disease.
- For the evaluation of the course of the healing and the treatment, sinus dimensions can be taken.

The irrigation should be continued for at least 3 and at most 6 weeks. Before the tubes are removed, the criteria that are expected to be achieved are the following:

- Clean washing water
- Zero cavity dimensions
- In the washing water samples taken in sequence, no breeding of organisms should be observed
- Stable blood parameters [14].

3.2. Tuberculosis osteomyelitis

Primarily it is seen among adults, and the occurrence among children is rare. While in almost all of the cases *Mycobacterium tuberculosis* is the agent, in rare cases atypical mycobacteria are reported to be the cause. There may be fever or not. However, patients with fever whose cause is unknown and with asymptomatic bone lesion should always be kept in mind. Although any bone can be involved, 50% of the cases are in the spine (50% thoracic, 25% cervical, 25% lumbar), 12% in the pelvis, 10% in the hip and femur, 10% in the knee and tibia, 7% in the ribs, and 2% in the ankle, shoulder, elbow or wrist, and in 3% more than one region is involved. In the diagnosis, chest radiography, tuberculin skin test and needle biopsy are used. As given in the treatment of lung disease, the regime is one composed of 9 to 12 months of isoniazid, rifampin, pyrazinamide, and ethambutol. Except for a very advanced disease, surgical treatment is rarely needed [10].

3.3. Newborn osteomyelitis

Newborn osteomyelitis is rare. Prematurity, low birth weight, another accompanying infection, blood transfusion, the presence of umbilical catheter may be considered as risk factors. Usually it is observed together in multiple bone and arthritis [3,10]. Because of nonspecific symptoms, the diagnosis may be delayed. As the most common *S. aureus* (> 90%), group B streptococci (especially in the postnatal 2-4 weeks) and enteric gram-negative bacilli may be the cause. There is no leukocytosis; ESR and CRP will have been increased. Mostly lytic bone lesions are seen in plain graphy. It may cause permanent disorders in joints and disturbance in the skeletal growth [3].

3.4. Osteomyelitis in sickle cell anemia

The susceptibility in the sickle cell hemoglobinopathies to bacterial infections has increased. During the sickling, due to microscopic infarcts, the blood invasion of intestinal microorganisms is facilitated. Besides, there is also splenic dysfunction. Of all the agents salmonella and gram-negative enteric bacilli factors (<70%), *S. aureus* are responsible. The diaphysis of the long bones, flat bones, the small bones of the hands and feet are often held. Acute vaso-occlusive crisis of the table is difficult to differentiate. It is difficult to distinguish the picture from an acute vaso-occlusive crisis. In both cases, there is fever, bone ache and leukocytosis. With MRI, one cannot distinguish an infection from an infarct. In a crisis attack, no response is obtained, needle aspiration and culture should be performed. A long-term (6-8 weeks) antibiotics treatment may be necessary for healing [3,9].

3.5. Traumatic osteomyelitis

Traumatic osteomyelitis develops as secondary in animal bites (especially due to *Pasteurella multocida*), and when blood is taken from newborns heel with needle sticking, during bone marrow aspiration, puncture injuries (especially when standing by *Pseudomonas* or by *Pseudomonas* through any injury somewhere) and due to open fractures including osteomye-

litis. As *Aeromonas* is an unusual type of bacteria causing osteomyelitis with contaminated water [10].

3.6. Postoperative osteomyelitis

Postoperative osteomyelitis may develop in the process that follows the reduction of closed fractures, craniotomies, median sternotomies and other bone surgeries [10].

3.7. Multifocal osteomyelitis

Postoperative is mainly multifocal. Drug addiction may cause multifocal osteomyelitis. The scanning of multifocal hot spots on the bone may reveal multiple tumors, too [10].

3.8. Chronic recurrent multifocal osteomyelitis

This is observed in childhood and among young adults. Girls are more frequently affected. There are attacks that show similarity to osteomyelitis, recurrent high fever, swelling in bones, ache and radiologic visions. Palmoplantar pustulosis, psoriasis, arthritis, sacroiliitis, and inflammatory intestinal disease may occur together with the Sweet's syndrome. The SAPHO syndrome observed among adults (synovitis, acne, pustulosis, hyperostosis, and osteitis/osteomyelitis) is believed to be equivalent to the ones of childhood. Most frequently, the clavicle and the calcaneus are affected.

Bone cultures are sterile. Clear benefits of antibiotics cannot be shown, steroids and anti-inflammatory treatment is recommended. Although the etiology is unknown, the prognosis is positive [10].

3.9. Osteomyelitis in immunosuppressive hosts

Any organism (a rare one or superficial fungi) can cause osteomyelitis in these patients [10].

4. Possible nursing diagnoses

4.1. Collaborative problems in osteomyelitis

Infective emboli

Side effects of the antibiotics treatment (hematological, renal, hepatic) [15].

4.2. Nursing diagnoses

- Hyperthermia related to infections [16,17].
- Fluid Volume Deficiency Risk with regard to excessive fluid loss [16,17].
- Change in comfort depending on the infection, swelling, and hyperthermia process in the bone [15].

- Pain and discomfort, Physical Restriction of Movement associated with musculoskeletal disorders [16,17].
- Less Nutrition than the Body Requirements related to loss of appetite [15].
- Risk of Deterioration in Skin Integrity in relation to physical immobilization [15].
- Change in health condition, Anxiety in relation to hospitalization [16,17].
- Ache in relation to Inflammation/Infection [16,17].
- Risk of Injury in relation to immobilization because of spread of infections [16,17].
- Limited physical activity, Social Isolation in relation to therapeutic isolation [16, 17].
- Risk of Colonic Constipation due to immobility [15].
- Deficit in Entertainment Activities due to long-term hospitalization and insufficient mobility [15].
- Poor Nutrition: Change in Nutrition due to anorexia that is secondary to the infection process [15].
- Risk of Deficiency in Skin Integrity due to the mechanical irritation of the plaster/splint [15].
- Risk of Trauma depending on the Process of the Disease: Pathologic Fractures [15].

The situation is Risk of Ineffective Management of Therapeutical Regime due to the lack of knowledge on wound care, activity limitations, symptoms and findings of complications, follow-up of pharmacological treatment and care (check-up) [15].

5. Nursing management

The nursing of children who suffer from heavy musculoskeletal infections; for a wide range of evaluation it requires a multidisciplinary team approach that consists of as well as the hospital staff and services, pediatricians, orthopedists and infectious diseases specialists [18].

The main objectives of nursing care; to avoid possible complications, reduce pain, to inform the children and their families about the process of the disease and the treatment management. In the acute stage of the disease, restriction of movement may be observed in the affected joints. However, by supporting the affected joint, the child will be in a comfortable position. Cautiously and gently moving the patient will reduce the pain. Pain treatment will relieve the patient. Vital findings are taken and recorded. If important changes may occur in the measurements, then this is shared with the team members [19].

In the antibiotic treatment, careful observation should be performed; the vascular pathway area and the intravenous sets should be observed. Generally, several antibiotics are used together. One should consider that the used drugs are compatible with each other. The use of drugs that are not compatible should be avoided. For long-term antibiotics treatment, inter-

mittent infusion devices or a central catheter (PICC) with peripheral input is used. The antibiotics therapy is often continued at home [19].

Isolation should be applied to children with an open wound. In wound care, the prescribed medicines are used. In addition, the insertion of antibiotic solutions into the wound care is very effective [19].

The received-removed fluid amount is continuously measured and recorded. Moreover, the wound drainage is also recorded. The state of healing of the wound tissue is evaluated and recorded [19].

To provide immobility, plaster is used and in such cases, routine plaster maintenance is performed [19].

The following are among nursing initiatives: Teaching the child to walk with crutches when necessary, ensuring that the child is kept away from slippery floors, preventing the child from moving in an uncontrolled manner during risk of insufficient mobility due to the plaster, and during the *Risk of Trauma* due to the dangers of walking with crutches [15,19]. Again, when necessary, supporting and observing the child during his/her walk and ensuring that the parents carry their children in or to safe environments. The family must be informed about the weight of the plaster and advised to adjust the body mechanics carefully while carrying the child or while giving position to him/her. The family must be warned not to take support from the plaster while lifting the child. Protecting the extremity in plaster from impacts is also among important nursing initiatives [19].

Risk of Deficiency in the Integrity of the Skin [15,19] as a result of the plaster applying a pressure on the skin surface and its being among important nursing initiatives, the nurses have to prevent the use of heating or cooling devices to dry the plaster because there is the risk of burning the skin under the plaster. Other nursing initiatives are as follows: observing the skin on the side of the plaster every day to see whether there is redness or not. Applying massage to these areas to prevent skin deficiencies. Placing cotton in these areas to prevent skin irritations. Explaining to the small children why they should not put pencils or other objects to the plaster. Elevating the extremity with plaster in order to prevent edema due to the pressure of the plaster. Following the extremity with plaster to see whether there are coldness, color change, edema, pain or numbness or not being able to check the pulse in the distal of the extremity and making neurovascular assessments [19].

Supporting the child to use his/her extremity without plaster in case of a *Lack of Self-Care* [15,19] as a result of the limitations in movement due to the plaster is also among nursing initiatives. It may be necessary to explain to the parents and to the child that the plaster will not prevent the daily care activities such as toilet need in the morning and general body cleaning [19].

Nursing Initiatives in *Lack of Entertainment Activities* [15,19] as a result of the limitations in movement due to the plaster are: Determining the entertainment activities of the child, ensuring that s/he plays chess or computer games, reads books, listens to music, draws pictures with the nurse or his/her parents or friends coming to visit if the child is bedbound [19].

In *Management of the Therapeutical Regime without Effects* [15,19], the important factors are, the maintenance of the plaster, the symptoms and findings of the complications, information on the use of helping-supporting devices. The relevant Nursing Initiatives are: If the plaster gets wet, its function will be disabled, therefore ensuring that the cleaning of the child with a piece of cloth is provided; keeping the plaster dry and clean; preventing the spill of food or drinks on the child by making him/her wear a pinafore; cleaning the pinafore if any food or drink is spilt. In case an area under the plaster itches, ensuring that cold air is blown is another nursing initiative. In case bad smell comes from below the plaster or the drainage area, its possibility of being a clue for an infection must be explained to the parents of the child. The knowledge that if the neurological and circulatory functions are broken, this might cause to permanent paralysis in extremities, to ischemia or damage in the nerves must be given to the parents. The information that, in case the plaster is near the perineum area, the plaster must not get dirty with the feces or the urine must be given to the parents as well. In addition, the parents must be informed about the situation when the plaster is removed, there might be dryness and peeling on the skin [19].

The affected area, whether in plaster or not is evaluated for color, edema, heat and sensitivity [19].

In the first stage of the treatment the child has no appetite. For a healthy diet, until the patient feels better, one is encouraged to consume high calorie liquids, fruit juice, ice cream and jelly. In order to have bone growth and healing, an adequate nutrition has to be provided [19].

After the treatment in the acute stage, the child will feel better. As a result of this, the appetite of the child will increase, and s/he will communicate socially. For this reason, the nurse may start entertaining and curative activities for the children in this period. However, these activities should be mostly in bed. Because resting of the child usually after the acute period is imperative. However, when isolation and bed-rest may not be required for a long term, moving in a wheelchair may be allowed [19].

The role of nurses is to provide information to patients and caregivers about the treatment, to support and to help for the treatment plan [14].

For providing the patient to go through the hospitalization period as comfortable as possible they are encouraged to share their fears and concerns [14].

Psychosocial evaluation leads to the possibility of self-recognition, coping mechanisms and to reveal the sources of motivation of the patient. This is for the creation of an appropriate and effective care-plan by the whole team. The patient should be informed about the contents of the processes, that the infection could not be eliminated successfully, risk factors like the development of a new infection, problems related to prolonged bed-rest and regarding a secondary reconstructive surgery. Patients that have become aware of being not sufficiently informed or being not included in the decision taking will be prone to depression. Regarding the information given, feedback from patients and caregivers should be taken. The preparation of the treatment facilities should be presented; and plenty of opportunities should be given to ask questions frequently [14].

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