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Surgical treatment of chronic osteomyelitis in children admitted from developing countries

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ABSTRACT

Background: The surgical management of chronic osteomyelitis in children is still challenging in developing countries. This study analysed the extent of the disease and the therapeutic regime. **Subjects and Methods:** This was a retrospective study in two primary health care hospitals from January 2009 to December 2013, 27 children (20 males and 7 females, mean age 7 years) admitted from developing countries who were treated for chronic osteomyelitis. Localization, duration of the disease, extent of the osseous involvement, spectrum of germs, number of previous and required surgical procedures and duration of hospital stay are reported. **Results:** A total of 16 cases had haematogenous and 11 cases post-traumatic aetiology. The mean duration of the disease was 18 months. On average, three (range, 1-12) previous surgical procedures were performed. The affected bones were: Tibia in 11, femur in 8, forearm in 6 cases, spine and humerus each in 1 case. *Staphylococcus aureus* was the responsible germ in 75%. On average, four (range, 2-8) surgical procedures were required. Osseous stabilizations were necessary in 17, plastic soft tissue reconstructions in 8 cases. In three cases with metaphyseal/diaphyseal defect, bone transfers had to be performed (2 × fibula-pro-tibia, 1 × rib for radius). The mean hospital stay took 8 (range, 4-20) weeks. Three local recurrences occurred within 3 months, all could be cured surgically. **Conclusions:** The surgical treatment of chronic osteomyelitis in children requires a radical osseous debridement. The knowledge of different plastic-surgical procedures is necessary to reconstruct osseous and/or soft tissue defects.

Key words: Childhood, chronic, developing country, osteomyelitis

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INTRODUCTION

In contrast to the industrialised countries, chronic osteomyelitis is seen much more frequently in developing countries.[1-7] The annual prevalence of osteomyelitis in the general population of Kenya is about 1:1000.[3] Chronic osteomyelitis is reported to be a considerable health care burden in many developing countries. In Gambia, for example, osteomyelitis accounted for 7.8% of paediatric surgical admissions and 15.4% of inpatient's days.[8]

Due to the way of living, traditions and the social situation, osteomyelitis plays an important role in the developing countries.[8-10]

In the industrialised countries, post-traumatic osteomyelitis plays only a minor role in children, in contrast to adults. However in developing countries severe manifestations of the post-traumatic osteomyelitis have to be noted more frequently. Due to the often insufficient medical care, especially in the rural areas and the inappropriate food supply, chronic osteomyelitis with long-lasting anamnesis and distinct findings can be the result even after minor injuries.[3,8,11-14]

Therefore, chronic osteomyelitis requires an interdisciplinary treatment concept of systemic and/or local antibiotics and surgical-orthopaedic procedures. Radical surgical debridement and sequestrectomy are necessary. Different plastic-reconstructive procedures of bone and soft tissue can also be indicated.

Due to the lack of adequate resources and specialists, this interdisciplinary treatment concept is very difficult to implement in developing countries.

We like to report of our experiences in the treatment of chronic osteomyelitis in children from developing countries transferred and admitted to our hospital by the

German aid organisation "Friedensdorf International" (International Peace village).

METERIALS AND METHODS

From January 2009 to December 2013, 27 children (20 males and 7 females) admitted from developing countries were treated in two neighbouring hospitals for chronic osteomyelitis. A total of 17 children came from Angola, and 10 were admitted from Afghanistan. The transfer of the children was arranged by the German aid organisation "Friedensdorf International Oberhausen." Both hospitals are primary health care hospitals, one of them with a level II trauma centre.

The aid organisation "Friedensdorf International Oberhausen" promotes primarily projects in the developing countries of Angola and Afghanistan. The decision for the transport to Germany was made by the local staff of the aid organisation in the developing country - based exclusively on social aspects; only impecunious people were selected. The delay between selection and transport to Germany was on average 3 weeks.

All children suffered from chronic osteomyelitis (i.e., duration >6 months). The mean age of the children at the time of admission was 7 years (range, 2-12 years).

Diagnostic procedures include blood tests and radiological investigations using plain film radiographs and magnetic resonance imaging (MRI) in cases where the extent of the bone or soft tissue involvement cannot be clearly defined.

Localisation and pathogenesis of the osteomyelitis, duration of anamnesis, the extent of the bone involvement, the spectrum of pathogenic microorganisms if isolated, the total number of previous surgical procedures, as well as the type and the number of the surgical procedures at our institution, were analysed. The surgical procedures included debridement, required stabilization and fixation techniques as well as plastic-reconstructive procedures of bone and soft tissue.

The duration of the hospital stay, the functional restriction of the affected joints and the recurrence rate were also recorded.

The follow-up care was at least 6 months, before the children could leave the hostel of the aid organisation and return to their home country.

After that time, the further follow-up was feasible in 18 children by regular contact of the aid organisation to its local office in the home country via e-mail or correspondence by letter.

Statements about the functional status were not possible. The mean follow-up period was 25 months (range, 11-39 months).

Statistical methods

No statistical method was needed for the current study.

RESULTS

A total of 16 cases of haematogenous osteomyelitis were seen, whereas a post-traumatic osteomyelitis due to an open fracture was diagnosed in 11 children. The mean duration of the disease was 18 months (range, 11-60 months) with an average of three (range, 1-12) previous surgical procedures.

The commonly used procedures were simple incisions and drainages of abscesses and osseous debridement. The most frequently affect bone was the tibia ($n = 12$) followed by the femur ($n = 7$), radius and/or ulna ($n = 6$) the spine and the humerus (each in one case). Discharging sinuses [Figure 1a] were seen in all children. In 16 cases, there was a solitary sinus; in 7 cases two sinuses and in 4 cases multiple sinuses had to be observed.

At the date of admission, none of the children had a temperature or fever. The blood tests of primary diagnostics included the full blood count, C-reactive protein (CRP) measurement, electrolytes and creatinine. In all cases, native plain film radiographs were taken from the affected bone [Figures 1b, 2a, 3a, 4a]. MRI was performed in 15 cases, where the osseous extent of the osteomyelitis could not be clearly defined [Figure 2b] and in those cases, in which joint involvement was suspected. Only three children presented elevated inflammatory blood tests (leucozytosis >12,000/ml, CRP-value >5 IE/L).

The radiographic investigations revealed a pseudoarthrosis [Figure 3a] in 13 children. Deviation of the axis in the anteroposterior or sagittal plane was detected in eight children, in five of them the fracture healed in this malposition. Sequestra could be definitively detected by plain film radiographs [Figure 1b] in seven cases and additionally by MRI in two cases. Joint involvement was detected by the MRI in two cases (1 × knee joint, 1 × ankle joint).

In all cases, swabs were taken from the ichor of the sinus at time of admission. Additional screenings were made for hepatitis, HIV and tuberculosis. *Staphylococcus aureus* as the responsible germ could be detected in 20 cases (74%), of which two could be identified as methicillin-resistant *S. aureus* (MRSA). The further detected pathogenic microorganisms were: Haemolytic streptococcus in 14 cases (54%) and Gram-negative germs (*Enterobacter*, *Proteus*, *Pseudomonas*, *Escherichia coli*) in seven cases (26%). Fourteen cases (52%) were polymicrobial; the cultures were negative in four patients (15%). There was no perceivable correlation between the detected germs and the affected bones.

Ampicilline in combination with sulbactam was given for primary intravenous antibiotic treatment. If necessary, the medication was adapted according to the resistance of the isolated microorganism. Linezolid was used in cases of MRSA-detection until the swap was negative after surgical treatment.

The average period of intravenous antibiotic treatment was 7 days (range, 3-12 days). Afterwards, the antibiotic was administered orally for 6 weeks. Nineteen out of the 23 children, where a microorganism could be identified received clindamycine as the sensitive antibiotic.

Multiple surgical procedures were performed with an average of 4 (range, 2-8) procedures per patient. The primary procedure consisted of debridement of the sinus and the affected bone, in nine patients with additional removal of sequestra, on average at the third (range, 1-6) hospital day.

In cases of a pseudoarthrosis, the edges of the bones were freshened, and an external fixator was used for stabilisation [Figures 3b and c]. The sinuses and the soft tissue cavities were treated using a vacuum-assisted closure (VAC) system. The dressings were changed every 3-4 days depending on the result of the microbiological swab. Each patient received on average three (range, 1-7) VAC procedures before the soft tissue and/or bone reconstruction became feasible. Negative results of the microbiological swabs, normal blood tests and the presence of well-vascularised granulation tissue were postulated as requirements to allow definitive wound closure.

In 17 patients, stabilisation of bone had to be performed due to pseudoarthrosis or due to fracture healing in malposition [Figure 3a]. Arthrodesis was necessary for two children, if the adjacent joint was involved (1 × ankle joint, 1 × knee joint).



Figure 1: An 8-year old boy presented with sinus of the right shank for 12 months after an open tibia shaft fracture. (a) Clinical picture. (b) Plain film radiograph (anteroposterior view) demonstrating a large sequestrum and periosteal new bone formation (involucrum)



Figure 2: A 10-year old boy presented with chronic osteomyelitis of his left tibia for 10 months after an open tibial shaft fracture. (a) Plain film radiograph (anteroposterior view). (b) Magnetic resonance imaging (coronal view) demonstrating the intramedullary extent of the osteomyelitis

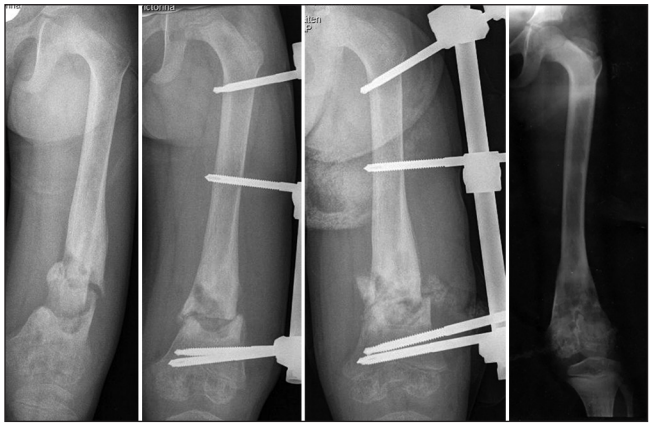


Figure 3: An 8-year old girl with post-traumatic osteomyelitis of her left femur for 10 months. (a) Plain film radiograph (anteroposterior view) showing non-union and sequestrum. (b) After sequestrectomy and stabilization using an external fixator. (c) Three months post-operatively. (d) 14 months post-operatively

Bone transplantations were necessary in three children in cases of diaphyseal or metaphyseal full-thickness bone defect [Figure 4a]. Average length of the bone defect was 5 cm (range, 4-6 cm). The contralateral fibula was used in two children to reconstruct the diaphyseal tibial defect [Figure 4b and c]. The distal diaphyseal defect of the radius of a 2-year-old girl was restored using a rib as bone transplant. In each case, the bone transplants were fixed with screws [Figure 4b and c].

A 12-year-old girl presented a shortening of her left femur of 10 cm; she was treated with the Ilizarow-method of callus distraction osteogenesis.

In 17 cases, the wounds could be closed by simple secondary sutures. Different plastic-reconstructive procedures were necessary for nine patients to close the soft tissue defect. Local muscle flaps were used in five patients (1 × thigh, 4 × shank) and local skin flaps were sufficient in four patients, split-thickness skin transplants were performed in 10 cases.

Length of hospital stay ranged from 4 to 26 weeks (mean 8 weeks). An unplanned surgical revision was necessary for eight children due to haematoma or persistent secretion of the wound. Single revision including cleaning, local debridement and drainage was sufficient in four children. The other four children received once more a VAC system, which had to be repeated on average 2 times (range 1-4 times) until the secondary closure of the wound could be feasible.

Three children received blood transfusions, each of them two red cell units, when the haemoglobin value was <6 g/L.



Figure 4: A 6-year old boy with a diaphyseal tibial defect after 14 months lasting haematogenous osteomyelitis. (a) Plain film radiograph (anteroposterior view) after contralateral fibula transfer. (b) Three months after additional shortening of the ipsilateral proximal fibula and cancellous bone graft. (c)

Further complications were not seen during the hospital stay. Afterwards, all children stayed for further 6 months in Germany; they were lodged at the hostel of the "Friedensdorf International Oberhausen." During this period, three children were admitted with a local relapse of osteomyelitis (1 × tibia, 2 × femur). All three cases required renewed surgical revision. Using local debridement and a twice VAC definitive wound healing could be obtained in all cases. After the definitive wound closure, the germ-adapted peroral antibiotic treatment was continued for 6 weeks.

A total of 15 children who received an external fixator for bone stabilisation was readmitted for implant removal on average after 13 weeks (range, 10-18 weeks) before they could depart in their home country.

The status of the other children was reviewed via phone or e-mail contact to the aid organisation. Further relapses did not occur.

Functional restrictions were observed in 13 children (48%). Six children (22%) had a leg length discrepancy of >2 cm, which had to be compensated by balancing of the sole. Fusions of the knee and the ankle joint had to be performed, each in one case.

Further, considerable restrictions of function were seen in four children. Due to cicatrisation of skin and muscles, the flexion of the knee joint was only up to 30° in two children. The range of motion of the elbow joint was restricted to 0°/60°/90° relating to extension and flexion in one child with involvement of the distal humerus and the proximal ulna. The 2-year-old girl with the diaphyseal defect of the radius and consequent bone substitution developed a radial abduction of the wrist joint. The range of motion of the wrist joint was 20°/0°/10° relating to extension and flexion. However, the rotation of the forearm was not restricted.

A further relapse of osteomyelitis could be excluded in 18 children by regular e-mail contact to the local office of the aid organisation in the children's home country.

Thus, the mean follow-up of 24 months (range, 11-39 months) was feasible. In two cases, the plain film radiographs of the affected bone were sent after 12 and 14 months, respectively [Figure 3d], but information about the functional status, possible leg length discrepancies or deviations of axis was not possible.

DISCUSSION

Chronic osteomyelitis is the consequence either of a haematogenous osteomyelitis or a complicated course of an open injury, that is, a post-traumatic osteomyelitis.

Chronic osteomyelitis in children is rarely seen in industrialised countries. However, in developing countries, its incidence is much more frequent.[3-7] The health care burden of chronic osteomyelitis in developing countries is reported to be essential.[8-10] Thus, for example in Uganda, 35% of all surgical procedures have been performed due to the diagnosis of osteomyelitis in 2010. One-third of these patients were children aged between 10 and 14 years.[9]

The causal relationship is considered to be the often insufficient medical care, especially in the rural areas. Thus, minor injuries or open fractures may lead to a chronic osteomyelitis. Otherwise, haematogenous osteomyelitis can manifest as chronic due to the lack of consequent antibiotic treatment.[3,4]

While in children the post-traumatic osteomyelitis is considered to be an extreme rarity in the industrialized countries, its proportion of the chronic manifestation is reported to be 40-60% in developing countries.[3-6] In our series, we saw a post-traumatic chronic osteomyelitis in 11 out of the 27 cases (40%).

Distinct stages of the disease have to be observed in developing countries due to the delay of onset of the consequent treatment. Hence, Onche and Obiamo[4] reported a mean interval of 13 months between the onset of the symptoms of osteomyelitis and the beginning of the consequent treatment in a hospital in Nigeria.

Besides the plain film radiographs to ascertain sequestra or periosteal new bone formation (involucrum) [Figure 1b] the MRI is considered to be suitable to determine the exact extent of the osteomyelitis in the medullary canal and of the soft tissue involvement.[1-3] Sonographic and scintigraphic investigations are not of importance in the diagnostics of chronic osteomyelitis,[11] they are relevant for the acute haematogenous osteomyelitis.

There exist different classification systems. The classification of Waldvogel[6] is geared to the duration and the aetiology of the osteomyelitis, but in a clinical practice it is not of major importance. The two common classification systems are those according to Cierny-Mader and to Solagberu. The classification of Cierny-Mader divides four stages according to the depth and length extension of the osteomyelitis.[6,13] The five stages of the classification of Solagberu are specific for developing countries and based on the chronological course of the disease. But both classifications correspond to the adult bone. The recently reported classification according to Jones *et al*.[8] considers the infantile conditions of the bone. Three types of osteomyelitis are divided: Type A - abscess, type B - sequestrum or involucrum and type C - sclerotic. We consider this classification as the most reasonable for the choice of the adequate surgical treatment.

By review of the literature, tibia and femur are reported to be the involved bone in about 80% of all cases, thus being the most frequently affected localizations.[1,2,7,8] In our series, these localizations were seen in two-thirds of the cases.

The frequently observed metaphyseal involvement of osteomyelitis in children can be explained by the decreased velocity of the blood flow and the lack of reticuloendothelial cells in this region of infantile bone.[2]

Staphylococcus aureus is reported to be the most common responsible germ of the osteomyelitis in the developing as well as in the industrialized countries, with a frequency of 70-80% of all detected microorganisms.[1,2,6,7,11-14] In our series, we found this germ in 75% of the cases. There are different information about the occurrence of resistance to methicillin in the developing countries. Most authors report a considerably lower resistance rate in developing countries in contrast to industrialized countries.[5,12,13] However, Mantero *et al*.[3] report a methicillin resistance rate of 48% in cases of detection of *S. aureus* in Kenya. In our series, we observed a methicillin resistance in two out of 20 (10%) confirmations of *S. aureus*.

There exist different statements in the literature about the period of the necessary antibiotic treatment.[1,2,11,12] However mostly an intravenous application for 1 week followed by a further peroral administration for 4-6 weeks is recommended, there is no evidence-based statement in the literature for a longer antibiotic treatment.[14] In cases of proved sensibility, clindamycin is favoured due to its good bioavailability and ability to penetrate bone adequately.[1,14]

In cases of negative cultures, antibiotics sensitive to staphylococcus are recommended due to its frequent incidence.

In developing countries, the potential risk of bone tuberculosis has to be taken into consideration with a long-term tuberculostatic medication necessary.

The main cornerstone of the treatment of chronic osteomyelitis in childhood, however, consists of adequate surgical debridement. The exclusive antibiotic treatment will not be sufficient especially in cases of formation of sequestra.[1,2,14]

Already Lautenbach[15,16] reported his surgical technique of irrigation and suction for the treatment of chronic osteomyelitis. Papineau *et al*.[17] presented their two-stage procedure consisting local debridement, irrigation and secondary cancellous bone graft. But the jetting liquid is proved to flow the way of lowest resistance (the so-called "highway-effect"). Therefore, it does not seem to be appropriate any longer.[1] It is indicated in the acute stage of the phlegmon of the medullary canal. In the cases of chronic osteomyelitis, however, the most important and effective procedure is still adequate surgical debridement.[1,2]

The resulting osseous defect requires an appropriate replacement and sufficient stabilization depending on the extent, localisation and periosteal blood supply. In some cases, the new bone formation (involucrum) is sufficient.

If the osseous defect is <2 cm and a good periosteal blood supply is preserved, a cancellous bone graft is considered to be appropriate. In cases of larger and full-thickness defects [Figure 4a], distraction osteogenesis described by Ilizarov[18] or single-step fibula-pro-tibia transfer[19] are reported for possible bridging of the defect. The Ilizarov-method takes much time; it requires a high compliance of the patient and is tainted with a high complication rate. However, the osseous blood supply will be improved by the distraction procedure. Thus, the osteomyelitis can be cured in most cases.[18]

Both methods, the distraction osteogenesis and the fibula-pro-tibia transfer are considered to achieve comparable functional results.[1] In two cases of a diaphyseal tibial defect, we decided in favour of the fibula-transfer due to the reduced treatment period. In cases of femoral defects, the fibula-transfer is considered to be not sufficiently bearing.[1] In that localization, the Ilizarov-method is preferred.

When sufficient new bone formation arose and good periosteal blood supply was preserved, bone replacement may be dispensable [Figure 1b].

Besides the bone reconstruction, the coverage of the soft tissue is of particular importance, especially when the defect is located at the shank. In one-third of our patients, different plastic-reconstructive procedures were necessary to cover the soft tissue defect. Local fasciocutaneous and muscle flaps are commonly used. There exist only a few reports in the literature about the use of VAC system in the surgical treatment concept of osteomyelitis.[20] The own experiences are encouraging especially in regard to the soft tissue conditioning. The negative pressure over the surface of wounds aids in the removal of fluids and increases the granulation tissue formation.

The recurrence rate after the assumed surgical curing of the osteomyelitis is reported to be 10-30%.[1,2] In our series, local recurrence requiring renewed surgical debridement had to be observed in three out of the 27 patients (11%) within 3 months after the discharge.

The statements about the frequency of functional restrictions of the affected joints and relevant leg length discrepancies differ and range between 2% and 30% after curing the osteomyelitis. We saw a leg length discrepancy of >2 cm in 6 out of the 27 children (22%). Four children (14.8%) developed relevant but well-compensated restrictions of range of motion of the knee or elbow joint.

CONCLUSION

The clinical picture of the chronic osteomyelitis in children from developing countries is characterized by a protracted course and more advanced stages of the disease. Radical osseous debridement is the most important aspect of treatment. Different reconstructive procedures and stabilizations of bone can be necessary depending on the resulting size and localisation of the defect and the preserved blood supply possible combined with new bone formation. The knowledge of different plastic-reconstructive procedures to achieve adequate soft tissue coverage is indispensable. The VAC system can play a crucial role.

ETHICAL CONSIDERATION

All data of the study have been approved by the local Ethics Committee; the responsible aid organisation gave its informed consent for all children prior to their inclusion in the study.

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