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Original Research Article

Children with Acute Osteomyelitis Caused by *Staphylococcus aureus*: Pathologic Fractures

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Abstract

Background: This frequent pediatric musculoskeletal infection, *Staphylococcus aureus* osteomyelitis, can change the way bones normally form and increase the chance of a fracture that is pathological. The purpose of this research was to assess the pathological fracture risk factors in children with osteomyelitis.

Methods: Between January 2020 to December 2022, sixteen children received treatment in a tertiary-care hospital for a pathological long-bone fracture brought on by osteomyelitis caused by *Staphylococcus aureus*. The 48 children in the control group, who matched in terms of methicillin susceptibility, age, and sex and had osteomyelitis due to *Staphylococcus aureus* but did not have a fracture, were contrasted with the patients.

Results: At a mean age of 8.6 years, those who fractured presented with osteomyelitis. Of the sixteen people, two had methicillin-susceptible *Staphylococcus aureus* (MSSA) and fourteen had methicillin-resistant *Staphylococcus aureus* (MRSA) isolates. It took an average of 71.1 days from the start of the illness to the fracture. There were notable differences in the length of hospital stay, The quantity of surgeries, duration of antibiotic treatment, and overall number of issues among each of the groups. MRI scans performed on the patients who had fractures at the time of admission showed a markedly higher frequency and circumferential size of subperiosteal abscesses. Also, more common in these patients was a conspicuous zone of unusually reduced marrow enhancement.

Conclusions: A dangerous condition called *Staphylococcus aureus* osteomyelitis can put kids at risk for pathologic fractures. It is recommended that children who fit the risk parameters described in this study for *Staphylococcus aureus* osteomyelitis be kept safe when bearing weight and have limited physical activity.

Keywords: *Staphylococcus aureus*, MRSA, Acute osteomyelitis.

Introduction

Pediatric patients frequently contract acute hematogenous osteomyelitis, which is usually identified by imaging, inflammatory markers, and clinical assessment. The prevalence of *Staphylococcus aureus*, in particular the CA-MRSA (community-acquired methicillin-resistant strain), has been rising [1]. The majority of *Staphylococcus aureus* infections in the Medical College in Orissa are caused by CA-MRSA. [2].

Osteomyelitis brought on by positive PVL. The clinical course of *Staphylococcus aureus* is typically more aggressive, involving longer hospital stays, a higher incidence of bacteremia, and more surgical procedures [3]. Even though pathologic fractures are uncommon among individuals with acute bacterial hematogenous osteomyelitis, this virulent variety may cause more structural impairment to the architecture of the bones. In the present work, it was studied at a pediatric center to find risk variables linked to pathological fractures among kids with acute *Staphylococcus aureus* hematogenous osteomyelitis, even though the majority of papers concentrate on adults.

Materials and Methods

Between January 2020 to December 2022, a tertiary-care pediatric hospital saw a retrospective examination of patients with acute osteomyelitis. Kids with a pathologic long-bone fracture who had received treatment for osteomyelitis caused by *Staphylococcus aureus* were identified. Age, sex, infection site, and

antibiotic sensitivity were used to compare this study group to a control group of kids receiving treatment for *Staphylococcus aureus* osteomyelitis but not breaking a bone. Individuals with illnesses linked to decubitus ulcers, sickle-cell anemia, and osteomyelitis brought on by other organisms were not included.

Initial Treatment Protocol

Within the confines of the emergency center, individuals presenting with clinical manifestations such as elevated body temperature, abnormal accumulation of fluid within tissues, discomfort, or an altered gait were subjected to a comprehensive evaluation aimed at determining the presence of a musculoskeletal infection. The evaluation encompassed a comprehensive physical examination, meticulous review of the patient's medical history, the starting point blood tests with a focus on inflammatory markers, and radiography. Advanced imaging methods, particularly magnetic resonance imaging (MRI), were mainly used for the confirmation and staging of musculoskeletal infections.

A little drill was utilized for bone decompression and to take a sample of bone for culture during the first osteomyelitis therapy operation. It was customary to evaluate the osseous defect's extent using imaging, inflammatory, and clinical parameters. Treatment regimens were tailored to the particular strain of bacteria involved, with cephalexin being used for MSSA infections, linezolid or Bactrim (sulfamethoxazole and trimethoprim) for clindamycin-resistant MRSA infections, and oral clindamycin for clindamycin-sensitive MRSA infections [4].

It was frequently necessary to return to the operating room when there was insufficient clinical improvement or when complications started to arise. The treating orthopedic physician made decisions about postoperative weight-bearing procedures based on the patient's age, the site of the fracture, and the infecting organism.

Data Collection

A thorough analysis of several characteristics related to hospital admission and patient outcomes, such as length of antibiotic treatment, number of surgical procedures performed, and length of hospital stay were performed. The microbiologic data from surgical site and blood cultures, as well as imaging tests were also analyzed.

A board-certified musculoskeletal radiologist (S.B.B.) evaluated each patient's imaging results retrospectively. The assessment utilized magnetic resonance imaging (MRI) techniques including multiplanar tau inversion recovery (STIR) and/or fat-suppressed T2-weighted, T1-weighted, and fat-suppressed T2-enhanced T1-weighted imaging T1-assigned sequences. These MRI scans were obtained as part of the initial investigation for the infection. The specific location under study dictated the adjustments made to the scan's area of matrix size, slice thickness, and view [3].

The MRI evaluation covered a number of characteristics, including the presence and degree of osteomyelitis, cortex integrity, intramuscular abscesses, marrow signal enhancement patterns,signs of deep vein thrombosis, and joint effusion. Subperiosteal abscesses were also assessed, along with their length, thickness, and % of bone circumference surrounded by the abscess on certain axial images. Radiographs were examined as well to verify any further fractures.

Statistical Analysis

Analyses of clinical, radiological, and microbiologic data were used to compare the two groups. When comparing continuous variables (such age and temperature), the Mann-Whitney U test was employed, and when comparing categorical variables (like sex), the Fisher exact test was utilized.

Results

Fracture Group

In our tertiary-care pediatric hospital, which treated 346 patients with acute hematogenous osteomyelitis caused by *Staphylococcus aureus* between January 2020 and December 2022, 4.6% of the patients experienced pathologic fractures. It took an average of 71.1 days from the start of the illness to the fracture. Numerous bones, including the proximal humerus (1), tibia (2), fibula (3), and femur (9), showed pathologic fractures. A segmental femoral fracture also damaged this region in one patient, while fifteen patients showed involvement of the metaphyseal-diaphyseal long bone. Only one child, fourteen months following the original debridement surgery, suffered a catastrophic injury unrelated to the fracture.

For the fracture group, the average follow-up period from the initial emergency department presentation was 21.4 months. Fourteen of these patients underwent non-operative treatment at first, with the upper limb immobilized in a shoulder immobilizer and the lower limb immobilized in a cast. Antegrade trochanteric nails were used for internal fixation on two older, heavier children. Because of the possibility of an imminent fracture, one of them also had preventive stabilization of the contralateral femur. Of the fractures, 87% resulted in osseous union, and the

remaining 11% needed surgery, such as internal fixation with bone grafting or external fixation with bone transfer. One patient experienced a significant angular femur deformity that required internal fixation and a realignment osteotomy at a different facility. A total of 40% of healed fractures with abnormalities were found in 5 patients who displayed mild to moderate angular deformities during the healing process. Additionally, one child experienced physeal arrest, which may have required limb length equalization surgery. Three children who had saucerization with sequestrum removal had successfully joined fractures, however they acquired sequestrum as a result of persistent osteomyelitis.

Non-Fracture Group

Forty-eight individuals with *Staphylococcus aureus* osteomyelitis who did not sustain fractures were included in the non-fracture group. The fracture group and these patients were matched with respect to age, gender, infection site, and antibiotic susceptibility. In the fracture group, the average age at presentation was 8.7 years, while in the non-fracture group, it was 8. In 87% of patients in both groups, MRSA was the causing bacterium. In the group that did not sustain a fracture, osteomyelitis was observed in the tibia (16), fibula (3), humerus (1), and femur (25). The average time between the initial presentation and follow-up for the non-fracture group was 9.3 months.

Clinical and Laboratory Findings

Patients in the fracture cohort exhibited clinical manifestations of osteomyelitis, on average, with a delay of 5.0 days compared to individuals in the non-fracture cohort, who sought medical attention at the hospital's emergency room 3.8 days subsequent to the initiation of symptoms. The results of the test and the body temperature exhibited comparable values between the two groups throughout the duration of the presentation. The mean duration of hospitalization was found to be significantly greater in the fracture cohort as compared to the non-fracture cohort. In both cohorts, the proportion of patients necessitating admission to the pediatric intensive care unit (ICU) and the length of their hospitalization in said unit exhibited comparable findings. The cohort of patients with fractures necessitated an extended course of parenteral antibiotic therapy, in conjunction with oral antibiotic therapy, as opposed to the cohort without fractures. In contrast to the non-fracture cohort, the fracture cohort exhibited a prolonged average duration of antibiotic treatment, encompassing both parenteral and/or oral administration.

Surgical Management

For purulent collections associated with Staphylococcus aureus osteomyelitis, first surgical treatment involving bone biopsy and abscess drainage was administered to every individual in the fracture group and nearly all participants in the non-fracture group. A single surgical session necessitated numerous procedures for certain individuals because of various sites of infection. Sixty-four percent of individuals in the fracture group needed more than one surgical session, compared to thirty percent of participants in the non-fracture group. Compared to the non-fracture group, which needed 1.3 surgical episodes on average, the fracture group needed 2.2 episodes. The fracture group needed 2.8 surgeries on average during the first hospital stay to treat the infection, while the non-fracture group only needed 1.4 surgeries. The fracture group had a longer interval among the initial and final surgical episodes than the non-fracture group.

Table 1: Surgical Treatment of the Infection at First If a Pathologic Fracture Is Found

	Fracture Group	Non-Fracture Group
Number of patients requiring multiple surgical episodes	64%	30%
Number of surgical episodes per patient	2.2	1.3
Time interval between the first and last surgical episode in patients requiring multiple episodes	16.0	7.9
Number of surgical procedures per patient	2.8	1.4
Number of complications (both medical and surgical) per patient	5.4	1.2
Number of patients requiring future surgery for delayed complications	40%	5%

Surgical Complications

Compared to the non-fracture group, which had an average of 1.2 issues, the fracture group had an average of 5.4 surgical or medical complications. Compared to 5% in the non-fracture group, 40% of patients in the fracture group experienced long-term sequelae that required or were likely to require additional surgery.

Magnetic Resonance Imaging

Within the cohort of patients with fractures, magnetic resonance imaging (MRI) was performed on 14 out of the total 17 individuals upon admission. The

remaining patient, due to unavailability of MRI, underwent contrast-enhanced CT scanning as an alternative diagnostic modality. The MRI results of the 48 individuals in the non-fracture group were contrasted and compared to the research findings. No substantial differences were detected in the osteomyelitis extent among the groups when considering bone length. In contrast to the non-fracture group, where only 56% of individuals exhibited the presence of a subperiosteal abscess, a significantly higher proportion of patients (93%) within the fracture group, consisting of 14 individuals, manifested this particular medical condition. There was no statistically significant difference observed in the dimensions, specifically the length and thickness, of subperiosteal abscesses when comparing the two groups. In contrast to 49% of the 27 individuals in the non-fracture group, it was observed that the maximum circumferential extent of subperiosteal abscesses in the fracture group was ≥50% of the bone circumference in 92% of the 13 patients. Among the cohort of 14 individuals in the fracture group, a notable 92% exhibited a distinct zone characterized by abnormally diminished enhancement of bone marrow on gadolinium-enhanced fat-suppressed MRI evaluations. In contrast, only 23% of the non-fracture group displayed a similar phenomenon.

Discussion

Destructive processes can result in faults in the architecture of the bone, which can weaken the bone and perhaps lead to fractures [5]. Compared to adult bones, children's bones are more flexible, meaning that a fracture would need to cause a more substantial disruption of normal mineral content and architecture [6].

Bone abnormalities brought on by infections, underlying bone disorders, or cancer can lead to pathologic fractures. Because chronic osteomyelitis involves both bone resorption and new bone creation, it can, albeit rarely, result in pathologic fractures. The majority of reported cases of chronic osteomyelitis are in children [7]. Despite being the most frequent cause of osteomyelitis, *Staphylococcus aureus*-related pathologic fractures are uncommon when compared to fractures brought on by other microbes [8].

The occurrence of CA-MRSA (community-acquired methicillin-resistant *Staphylococcus aureus*) has exhibited a notable escalation, thereby rendering the empirical strategy for antibiotic intervention increasingly intricate. Compared to other *Staphylococcus aureus* isolates, osteomyelitis brought on by CA-MRSA isolates harboring PVL genes is linked to a more aggressive course of the illness and less favorable results [9].

The intensity of the CA-MRSA infection is influenced by several virulence variables. Because the epidemic clone of CA-MRSA expresses PVL, a cytotoxin that harms white blood cells, it is believed to induce more violent disease. Pvl1 *Staphylococcus aureus* osteomyelitis in children is associated with a higher frequency of feverish days and consequences. Deep vein thrombosis, subperiosteal abscess, septic arthritis, and pyomyositis are examples of prevalent local and extraosseous consequences.

It is crucial to identify and treat CA-MRSA musculoskeletal infections as soon as possible. This includes using the right antibiotics and performing aggressive surgical drainage [10]. Despite active care, surgical intervention is frequently necessary, and long-term morbidity is a possibility.

The fracture group had more complicated infections, required more involved surgical procedures, longer hospital admissions, longer antibiotic courses of therapy, and more problems overall, suggesting that the severity of the infection played a role in the pathologic fractures. An elevated risk of fractures was linked to MRI abnormalities such as subperiosteal abscesses, intramuscular abscesses, significant circumferential area of the abscess, and a strong zone of reduced marrow enhancement [11].

Pathologic fractures frequently displayed osteopenia on radiographs, possibly as a result of osteomyelitis-induced bone loss and limb inactivity. Based on bone density in individuals with osteomyelitis, more research employing CT-based structural analysis may be able to discover additional fracture risk factors [12].

Conclusion

In short, compared to children without fractures, the study with 16 children who experienced pathologic long-bone fractures as a result of acute *Staphylococcus aureus* hematogenous osteomyelitis suggested a higher risk of sequelae associated to osteomyelitis. In order to stop these fractures, a number of possible risk factors were found. Extended hospital stays and several surgical operations have been linked to a higher risk of fractures. It is essential to thoroughly analyze imaging investigations, particularly the circumferential extent of subperiosteal abscesses and the transition zones of marrow ischemia. Pediatricians should be aware of this possible outcome when caring for patients who have CA-MRSA osteomyelitis. Handling *Staphylococcus aureus*-induced pediatric osteomyelitis can be difficult. Protected weight-bearing and activity limits may be recommended for young patients who exhibit the risk variables described in this study in order to lower the risk of pathologic fractures and the problems that follow. Once the child

is pain-free, radiographs show that the bone is mending, and inflammatory indicators go back to normal, full weight-bearing can be resumed.

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