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ORIGINAL PAPER

Current data on acute haematogenous osteomyelitis in children in Southern Israel: epidemiology, microbiology, clinics and therapeutic consequences

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Abstract
Background Acute haematogenous osteomyelities (AHO) is the most common form of osteomyelitis, occurring when bone is infected secondary to transient bacteremia. The prevalence, aetiology and outcome of AHO may vary from region to region and period to period. The study objectives were to define the epidemiology, clinical, laboratory and imaging characteristics and treatment consequences of AHO in children in southern Israel.
Methods This was a retrospective cohort study, enrolling all children <16 years of age hospitalized with AHO. Epidemiologic, clinical, laboratory and imaging data were recorded from medical charts.
Results Ninety-one patients were diagnosed with AHO (52.7 % <4 years of age). Most children (80.24 %) did not receive antibiotic treatment prior to diagnosis. During 2005–2012 the AHO incidence was 5.6:100,000; the AHO incidence in the Bedouin and Jewish population was 7.3 and 4.1:100,000, respectively. Fifty-four (57.8 %) patients were afebrile at admission and 34 (37.4 %) showed leukocytosis >15,000/mm^3. The most involved bone was tibia (39.6 %), followed by femur (19.8 %), humerus (8.8 %) and pelvis (8.8 %). Positive cultures were reported in 26 (28.6 %) patients. The most common pathogen was methicillin-susceptible *Staphylococcus aureus* (MSSA, 18 patients, 19.8 %). There was only one case of MRSA. More positive cultures were recorded among children requiring surgery compared to children treated conservatively ($P < 0.01$). MSSA representation in cases requiring surgical intervention was higher than in cases treated conservatively ($P = 0.01$). There were nine bone biopsies and 33 bone aspirations (MSSA in 44.4 % and 24.2 %, respectively). The longest hospitalization was observed in patients with humerus-AHO (14.8 ± 12.2 days). There was no difference in the number of days of hospitalization between patients who received previous antibiotics compared with children who did not receive antibiotics before admission.
Conclusions Tibia was the most frequently involved bone, but humeral AHO required more surgical intervention and longer hospitalization. Negative cultures were frequent, MSSA was the most commonly involved pathogen and MRSA was rare. Culture positive AHO was associated with higher requirement for surgical intervention.

Keywords Acute haematogenous osteomyelitis · Children · *Staphylococcus aureus* · *Kingella kingae* · Surgery · Children · Antibiotics

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Introduction

The diagnosis of acute osteomyelitis (AO) is established if the patients fulfill the following criteria: (1) symptoms and clinical signs characteristic or suspicious of bone and/or joint infection with a duration of <two weeks and (2) one or more of the following criteria: positive bone culture or diagnostic bone biopsy, radiologic findings suggestive of osteomyelitis (swelling of deep soft tissues and/or periosteal reaction and/or bone

destruction at some point during hospitalization) and/or pus from bone as intra-operative finding [1].

The disease is common in childhood and is due to bacterial infection. Microorganisms may penetrate bone as a complication of bacteremia (acute haematogenous osteomyelitis [AHO], by direct contamination during trauma or surgery or by bacterial invasion from local infection). In children, osteomyelitis is caused in most of the cases as a result of transient bacteremia.

The incidence of osteomyelitis is evaluated to be around 1:5000 cases in the paediatric population in the United States [2]. In Memphis, the rates of musculo-skeletal infections among hospitalized children peaked from 2.6 to 6:1000 hospitalizations between 2000 and 2004 [3]. In Scotland, the incidence of AO was 3:10,000 children, and a 44 % drop in frequency was reported after the introduction of *Haemophilus influenzae* vaccination [4]. In Australia, AO incidence among children <13 years of age was 8:10,000 during 1998–2002 [5], and in New Zealand it was 1:4000 during 1997–2008 [6]. In Southern Israel, Meller et al. reported 68 cases of paediatric osteomyelitis during 1970–1982 [7], of them 86.7 % required surgery and 17 % developed chronic osteomyelitis. The highest incidence of AO is reported during the first two decades of life; at least 25 % of the affected children are <one year and 50 % are <five years of age [8].

AHO develops mainly at one site. Diaphyseal bones are involved more often than cancellous bones or vertebrae [9]. *Staphylococcus aureus* is the most common cause of AO, followed by *Kingella kingae*, *Streptococcus pyogenes* and *Streptococcus pneumoniae* [2, 10–12]. An increase in the incidence of infections caused by methicillin-resistant *S. aureus* (MRSA) has been recorded in recent years [3, 12, 13]. *Escherichia coli* and group B *Streptococcus* are common pathogens isolated in AO in neonates [14] and group A *Streptococcus* is common in infants and children. *Kingella king*ae was described in children <three years of age [15] and in some countries was described as the main aetiologic agent of the disease [15, 16].

Current recommendations of the Infectious Diseases Society of America for the treatment of AO require tailored-to-pathogen antibiotic therapy and a longer duration of treatment (4–6 weeks) in cases caused by MRSA [17].

We postulated that the epidemiology, microbiology and clinical outcomes of AHO vary between one place to another and from one time period to another. In this paper we present comprehensive data on AHO in Southern Israel between 2005 and 2012. We reviewed its incidence, clinical, laboratory and imaging characteristics, pathogens distribution and specific bone involvement, relationship between pathogens, involved bones and need for surgical treatment, as well as the antibiotic treatment administered and disease outcome.

Patients and methods

This was a retrospective cohort study (level of evidence IV-case series). The methodology was approved by the institutional review committee. All patients <16 years of age hospitalized at the Soroka University Medical Center with the diagnosis of AHO were enrolled. Patients with symptoms >two weeks prior to admission (chronic osteomyelitis), patients with comorbidies like congenital sensitivity to pains, immunosuppression, sickle-cell disease, malignancies, patients with AHO following trauma or infection of surgical wounds and patients with infection of orthopaedic fixation devices were excluded. Our medical centre is the only general hospital in Southern Israel and provides primary/tertiary health services to the entire population of the region. It served a population of >800,000 inhabitants in 2012, of them >250,000 children <18 years of age. The paediatric emergency room of the hospital accepts around 36,000 visits/year.

In Southern Israel, two paediatric populations live side by side: Jewish children, largely urban with a Western lifestyle, and Bedouin children, formerly composed of desert nomads, and now in transition to a Western lifestyle. Children belonging to the two populations differ in disease patterns and rates but both have access to the same medical community and hospitalization services. Hospitalization rates due to respiratory and gastrointestinal infections are more prevalent among Bedouin children [18–21].

The diagnosis of AHO was based on consensus criteria [1, 2, 8, 10, 12, 22] as follows:

1. Clinical and laboratory criteria

   – Fever >37.5 °C
   – Leukocytosis (WBC >15,000/mL)
   – Raised erythrocyte sedimentation rate (ESR) > 20 mm
   – Raised C-reactive protein (CRP) > 1 mg/L
   – A positive blood culture

   Plus

2. One or more of the following:

   – Positive technetium bone scan
   – Bony bone tenderness and/or swelling and redness
   – Findings consistent with osteomyelitis on plain X-ray, CT scan or MRI
   – Positive microbiological culture from a bone biopsy or bone aspirate

At admission, according to hospital written protocol, ESR/CRP and WBC were obtained in the PER and X-rays were performed routinely to exclude trauma or malignancy. Every effort was done to obtain biologic material for culture (blood and bone cultures). Bone aspiration for biological material was performed when the clinical picture was significant (presence of point tenderness + no evidence of fracture on X-rays). An aspiration was performed in the first hours after admission and before initiation of antibiotic therapy. In some cases, a biopsy or an aspiration was performed based on the clinical picture alone, as mentioned in the presented protocol. The biopsy was performed in cases requiring open surgery when no clear pus was obtained.

Oropharyngeal *K. kingae* carriage cultures were not obtained routinely in patients with clinically compatible illness. Magnetic resonance imaging (MRI) was not available in our institution during the study period on an emergency base.

The computerized charts of the patients were reviewed and data was collected on demographic factors, medical history, duration of symptoms and previous antibiotic treatment, clinical, laboratory and imaging findings, etiologic agent and its antibiotic susceptibility, antibiotic therapy and its duration and length of hospitalization.

The antibiotic treatment protocol for AHO at our hospital consisted of cefazolin 100–150 mg/kg/day divided in three daily doses or cefuroxime 150–200 mg/kg/day divided in three daily doses or amoxicillin/clavulanate 220 mg/k/day divided in four daily doses, for a duration of four to six weeks.

Statistical methods

The data were analyzed using the Statistical Package for Social Sciences 18.0 (SPSS 18.0) software. The data were analyzed using the chi square test and the Fisher's exact test as appropriate; a P value below 0.05 was considered significant.

Results

A total of 231 patients were registered with a diagnosis of ICD-9 matching AHO, of whom 91 were left after excluding criteria. 52.7 % of the children were <four years of age, and 70.6 % were healthy with no prior disease history. Most children (80.24 %) did not receive antibiotic treatment prior to AHO diagnosis.

During 2005–2012 the incidence of AHO was 5.6:100, 000; the AHO incidence in the Bedouin and Jewish population was 7.3 and 4.1, respectively (Table 1). AHO incidence in Bedouin children was higher than in Jewish children ($P = 0.006$). AHO incidence in children <five years of age was 8.3:100,000, with no difference between Bedouin and Jewish children ($P = 0.1$). No differences were recorded in AHO incidence during the study period among the whole population ($P = 0.07$, chi-square for linear trends in proportions) and also among the two ethnic groups studied (Jewish and Bedouin, $P = 0.15$ and $P = 0.69$, respectively).

Fifty-four (57.8 %) patients were afebrile at admission and 34 (37.4 %) showed leukocytosis > 15,000/mm^3 (Table 2); 20.9 % and 60.7 % of patients had an ESR > 40 or >20 mm/h, respectively.

All patients underwent an X-ray of the involved limb (positive findings suggestive of osteomyelitis in 37.4 %). Eighty-two (90.1 %) patients underwent a bone scan (positive in 30.5 %; Table 3). Of 34 children diagnosed with osteomyelitis on X-ray, only 6 (21.4 %) had positive bone scans; there were 19 (35.2 %) patients with proven AHO, with no evidence on X-ray, but positive bone scan.

The most common bone involved in AHO was tibia (39.6 %), followed by femur (19.8 %), humerus (8.8 %) and pelvis (8.8 %) as shown in Table 4. The calcaneus bone was involved in five (5.5 %) patients (Fig. 1).

Twenty-six (28.6 %) patients had positive cultures with growth of bacteria considered pathogenic to their disease. The most common pathogen was methicillin-susceptible *Staphylococcus aureus* (MSSA, isolated in 18 patients, 19.8 %), followed by *Streptococcus pyogenes* (4, 4.4 %; Table 5). There was only one case

Table 1 Incidence of acute haematogenous osteomyelitis among children < 15 years in Southern Israel, Beer Sheva District

Incidence/population	2005	2006	2007	2008	2009	2010	2011	2012	Overall
Total (Jews/Bedouins)	10 7/3	12 5/7	18 7/11	12 3/9	7 3/4	16 8/8	9 1/8	5 0/5	89 34/55
Total population* (Jews/Bedouins)	185.4 102.5/82.8	189.1 103.0/86.0	192.9 104.0/88.9	196.6 104.8/91.9	199.9 103.7/96.2	203.6 104.7/98.9	207.2 106.5/100.7	212.1 108.4/103.7	1586.8 837.6/749.1
Annual incidence** (Jews/Bedouins)	5.4 6.8/3.6	6.3 4.9/8.1	9.3 6.7/12.4	6.1 2.9/9.8	3.5 2.9/4.2	7.9 7.6/8.1	4.3 0.9/7.9	2.4 0.0/4.8	5.6 4.1/7.3
0–5 years									
Total (Jews/Bedouins)	6 5/1	9 4/5	9 4/5	6 1/5	3 1/2	9 3/6	4 0/4	2 0/2	48 19/29
Total population* (Jews/Bedouins)	70.1 35.9/34.1	70.7 36.1/34.5	71.2 36.6/34.6	71.5 37.0/34.6	71.6 36.8/34.8	72.8 37.4/35.4	74.4 38.3/36.2	77.0 39.6/37.4	579.3 297.7/281.6
Annual incidence** (Jews/Bedouins)	8.6 13.9/2.9	12.7 11.1/14.5	12.6 10.9/14.5	8.4 2.7/14.5	4.2 2.7/5.7	12.4 8.0/16.9	5.4 0.0/11.0	2.6 0.0/5.3	8.3 6.4/10.3

* in thousands, ** per 100,000

Table 2 Clinical signs and symptoms plus laboratory data at admission

Measure	Number of patients (%)
Number of days of symptoms before admission	
• Mean ± SD	4.2 ± 3.5
• Median	3
Prior antibiotic therapy at diagnosis	16 (17.6 %)
Fever	
- ≤ 38 °C	54 (59.3 %)
- 38.1–39 °C	25 (27.5 %)
- > 39 °C	12 (13.2 %)
WBC > 15,000/mm^3	34 (37.36 %)
ESR (mm/h)	
< 40	58 (63.7 %)
> 40	35 (20.9 %)
Missing data	14 (15.4 %)
ESR (mm/h)	
< 20	19 (20.9 %)
> 20	58 (63.7 %)
Missing data	14 (15.4 %)
CRP (mg/L)	
> 1	17 (18.7 %)
< 1	60 (65.9 %)
Missing data	14 (15.4 %)

Table 4 Bones involved in episodes of acute haematogenous osteomyelitis (AHO)

Bone	Occurrences
Tibia	36 (39.6 %)
Femur	18 (19.8 %)
Humerus	8 (8.8 %)
Pelvis	8 (8.8 %)
Calcaneus	5 (5.5 %)
Phalanx lower extremity	4 (4.4 %)
Phalanx upper extremity	2 (2.2 %)
Ulna	2 (2.2 %)
Radius	1 (1.1 %)
Other	6 (6.6 %)
Not mentioned	1 (1.1 %)

of MRSA. No cases of *Kingella kingae*-AHO were recorded.

Table 6 presents the distribution of the main pathogens according to ethnicity and age. No difference was recorded in the distribution of MSSA between Bedouin and Jewish patients. No difference was recorded between the numbers of Bedouin children with positive cultures compared to the Jewish children with positive cultures. Significantly more positive cultures were recorded in patients older than five years compared with patients younger than four years (18/43, 41.9 % vs. 8/48 16.7 %, $P = 0.008$).

There were nine bone biopsies and 33 bone aspirations, with MSSA emerging as the most frequently isolated pathogen (44.4 % and 24.2 %, respectively).

More positive cultures were recorded among children requiring surgery compared with children treated conservatively ($P < 0.01$). MSSA representation in cases requiring surgical intervention was higher than in cases treated conservatively ($P = 0.01$).

No difference was observed in WBC counts >15,000/mm^3 and ESR values between children with positive cultures and those with negative cultures. No difference was found between the levels of pyrexia between the culture-positive and the culture-negative patients.

The highest number of days of hospitalization was observed in patients with AHO of humerus (14.8 ± 12.2 days). This number was higher compared with children with AHO of the tibia (8.1 ± 4.3 days; $P = 0.017$).

Most (76.9 %) patients with AHO were treated with cephalosporins (cefazolin in 46.5 % of patients, followed by cefuroxime and ceftriaxone, 18.7 % and 7.7 %). Methicillin was used in six (6.6 %) patients. 19/91 patients required surgery in addition to antibiotic therapy. Surgery consisted of drainage of pus, copious irrigation and drain placement. Most frequent surgical interventions were performed on tibia (8/21 cases).

The overall length of symptoms before admission was 4.24 ± 3.52 days. The overall length of hospitalization was 9.18 ± 6.52 days. There was no difference in the number of days of hospitalization between patients who received previous antibiotics (11.12 ± 7.35) compared with children who did not receive antibiotics before admission (8.75 ± 6.38; $P = 0.246$).

Table 3 Imaging data from 91 patients diagnosed with acute haematogenous osteomyelitis (AHO)

Measure	Evidence of AHO in the imaging modality	No evidence of AHO in the imaging modality
X-ray ($N = 91$)	34* (37.4 %)	57 (61.5 %)
Bone scintigraphy ($N = 82$)	25 (30.5 %)	57 (69.5 %)
% with X-ray evidence of AHO ($N = 34$)	6 (21.4 %)	22 (78.6 %)
% w/o X-ray of AHO ($N = 57$)	19 (35.2 %)	35 (64.8 %)
Computerized tomography ($N = 3$)	1 (33.3 %)	2 (66.7 %)
% with X-ray evidence of AHO	1	1 (50 %)
% w/o X-ray evidence of AHO	–	1 (50 %)

* All patients with evidence of AHO in plain radiograph had also an additional bone scan

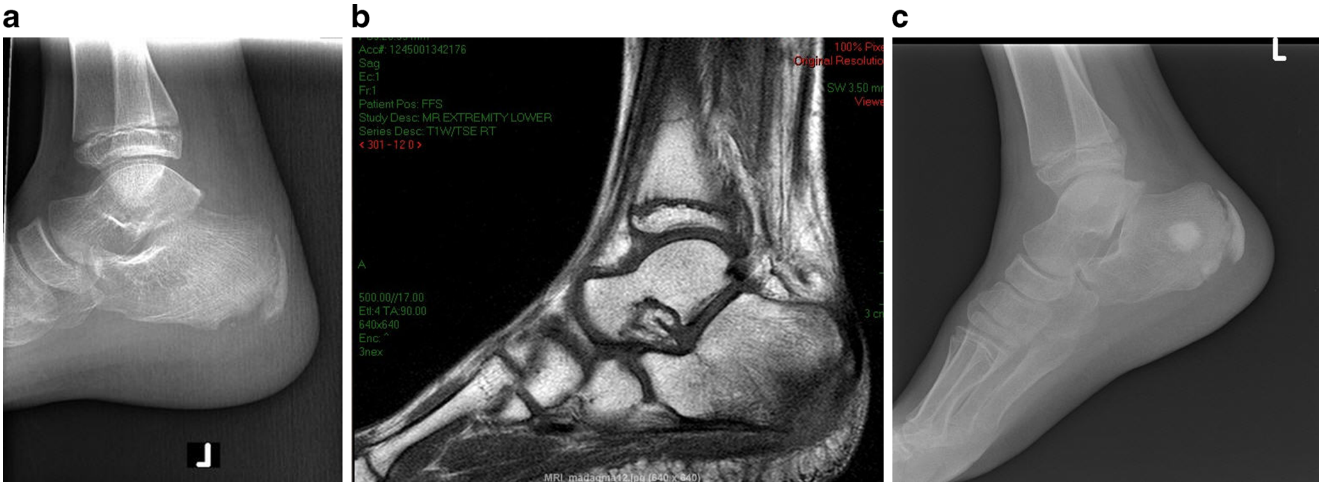

Fig. 1 Lateral radiograph (**a**) and MRI (**b**) of an 11-year-old male patient with culture-negative osteomyelitis of calcaneus. Following curettage, slow-release custom made cement impregnated with Clindamycin+ Gentamicin+Vancomycin was left in place. The patient was asymptomatic after one week and radiographic bone healing was established after one month (**c**). The case illustrates the synergy between local and systemic antibiotic therapy

None of the 91 patients developed chronic osteomyelitis after a one-year follow-up.

Discussion

Our institution policy is to admit children when AHO is suspected. The cases are managed in the paediatric departments according to established protocols. Children are routinely seen by an orthopaedist at admission for possible bone aspiration. Further involvement of paediatric infectious disease or orthopaedic consultants is dependent on course of the disease. Our hospital serves exclusively almost the entire Southern Israel area (referral area around 250,000 children) and therefore the real AHO incidence in our region could be calculated in this study as population-based data.

We found that the incidence of AHO in Southern Israel was 5.6:100,000 and was significantly higher in Bedouin children compared with Jewish children. We found that most patients with AHO did not have fever >38.0 °C, leukocytosis >15,000/ mm^3, ESR values >20 mm/hr or abnormal CRP values at admission. The most common bones involved in AHO were tibia and femur, and AHO of the humerus required in most cases surgical intervention compared with AHO of the femur. Most patients had negative peripheral cultures at diagnosis, but the number of cases with a positive culture was higher among children requiring surgical intervention compared to children treated conservatively with antibiotics only. The most common pathogen isolated in our study was MSSA, with a higher representation in cases requiring surgical intervention compared with cases treated conservatively. Significantly more positive cultures were recorded in patients older than five years compared with patients younger than four years. No difference was

Table 5 Microbiologic data (peripheral blood cultures + bone cultures)

Pathogen	Number of episodes (%) $N=91$	Biopsy (bone) $N=9$	Bone culture at bedside (aspiration) $N=33$
Methicillin-susceptible *Staphylococcus aureus*	18 (19.8 %)	4 (44.4 %)	8 (24.2 %)
Streptococcus pyogenes	4 (4.4 %)	1 (11.1 %)	2 (6.1 %)
Methicillin-resistant *Staphylococcus aureus*	1 (1.1 %)	–	1 (3.0 %)
Entrerococcus casseliflavus	1 (1.1 %)	–	–
Proteus mirabilis + *Morganella morganii*	1 (1.1 %)	–	–
Coagulase negative *Staphylococcus*	–	–	2 (6.1 %)
Group C *Streptococcus*	1 (1.1 %)	–	–
Culture-positive patients	26 (28.6 %)	5	13
Culture-negative patients	65 (71.4 %)	4	20

Table 6 Distribution of main pathogens according to ethnicity and age

Pathogens	Ethnicity		Patient age Mean ± (SD)	Patient age	
	Jews (35) N (%)	Bedouins (56) N (%)		0–4 years *N* = 48	5–16 years *N* = 43
Methicillin-susceptible *Staphylococcus aureus*	6 (17.14 %)*	12 (21.4 %)*	9.0 ± 2.8	2 (4.2 %)	16 (37.2 %)
Streptococcus pyogenes	2 (5.7 %)	2 (3.6 %)	3.8 ± 4.3	3 (6.3 %)	1 (2.3 %)
Methicillin-resistant *Staphylococcus aureus*	–	1 (1.8 %)	3.09	1 (2.1 %)	–
Enterococcus casseliflavus	1 (2.9 %)	–	1.05	1 (2.1 %)	–
Proteus mirabilis + *Morganella morganii*	–	1 (1.8 %)	0.10	1 (2.1 %)	–
Group C *Streptococcus*	–	1 (1.8 %)	8.09	–	1 (2.3 %)
Culture-positive patients	9/35 (26.9 %)	17/56 (30.1 %)	7.2 ± 4.0	8/48 (16.7 %)#	18/43 (41.9 %)#
Culture-negative patients	26/35 (74.3 %)**	39/56 (69.9 %)**	4.5 ± 4.1	40/48 (83.3 %)	25/43 (58.1 %)

*$P = 0.62$; **$P = 0.13$; # $P = 0.008$

found in the need for surgical intervention and the number of days of hospitalization among patients receiving antibiotic therapy prior to hospitalization compared with children who did not receive antibiotic treatment before hospitalization.

The low rate of positive blood and bone cultures among confirmed AHO cases is somewhat surprising and may be related, in part, to previous antibiotic use in the community. With respect to the high rate of negative bone scintigraphies, we may explain it, at least in part, by the timing of the examination which could have been too early during the development of the pathologic process.

It seems that incidence of AHO in developed countries is around 3–8:100,000 [6, 12, 13, 23, 24] and the numbers rise in undeveloped countries (42.8:100,000 in Polynesian children [25]). AHO incidence numbers reported in our region were comparable with the numbers reported in the western literature but the incidence of AHO was higher among Bedouin children compared with Jewish children. The laboratory data at admission were inconclusive (60 % of the patients had normal body temperature, 63 % had WBC counts <15,000 cells/mm^3 and 66 % patients had normal CRP values). Comparing clinical and laboratory parameters on similar literature reports provided equivocal findings. For example, we found that the WBC count may be normal in the majority of the patients, similar to the data of Mitha et al. [24], but we reported different findings with respect to temperature and CRP values. Gafur et al. [9] reported that of 813 children with AHO in New Zeeland, only 32 % had an abnormal leukocyte count, average ESR was 41,5 mm/h and the average CRP was 86 mg/L (reported abnormal in 82 % of the cases). Our data, as well as data recovered from other studies, reveals big variations in body temperature, CRP values and WBC counts among children with AHO; therefore, it seems reasonable to suggest that fever and inflammatory parameters measurement are, probably, not reliable and helpful enough in order to diagnose or rule/out AHO.

The number of negative peripheral blood and tissue cultures reached 71 % in our study, a percentage higher than described in the literature (24–68 %) [26, 27]. The high number of negative cultures may bring about serious dilemmas to the treating clinician when choosing the appropriate antibiotics, and this problem becomes even bigger in the era of frequent resistance of the aetiologic agents of AHO to most antibiotics (in particular MRSA). Pääkönen et al. [26] reported 345 cases of osteomyelitis and septic arthritis in children aged three months to 15 years and found negative blood or bone cultures in 23 % of the patients. The authors did not find differences in the need for surgery or clinical outcome between patients with positive and those with negative cultures. In our patients, we did not find differences between the ESR or WBC counts in patients with positive cultures compared with those with negative cultures. When comparing the group of children who required surgery with the group treated with antibiotics only, the overall rates of positive cultures were higher among patients who required surgery.

During 2013–2015 we retrieved six relevant papers (7 together with our study) focusing on the epidemiology, microbiology, clinical presentation, affected bones, surgical/conservative management and outcome of AHO [6, 24, 26, 28–30]. The disease incidence was reported, in addition to our study, in only two studies [6, 24] and reached 3:100,000 and 1:4000, respectively. The average age at diagnosis was between 3.6 and eight years and *S. aureus* was the main etiologic agent in all studies. In our study, we found that 18 % of children received antibiotics before hospital admission and there were no reports on pre-admission antibiotherapy in the other studies. Pre-admission antibiotic therapy may be an important diagnostic issue that may explain the relatively low number of positive blood and tissue cultures in children with AHO. In our study, the most involved bones were the tibia and the femur bones, findings similar to those reported by Street et al. [6]. Surgical therapy was reported in four of the six mentioned studies and was requested in 21–61 % of the patients.

The main limitation of our study derives from its retrospective format, leaving the possibility that some information extracted from the medical charts could have been missed. However, the considerable number of patients enrolled and the volume of collected data provided, in our opinion, a comprehensive picture on the epidemiology, clinical and microbiologic picture and outcome of AHO in our region. During the study period, magnetic resonance imaging (MRI) was not available for use on an emergency basis and was used only in sporadic cases of AHO. It is possible that the regular use of MRI may allow faster diagnosis and therefore may influence the outcome of AHO, a hypothesis that should be confirmed in the future. Furthermore, PCR for detection of *K. kingae* in the blood/biopsies/aspirations was not used as a diagnostic tool in our study. It is possible that its use might have increased the positivity rates for *Kingella* in our study, but we cannot confirm it. In addition, when treating a cases of osteoarticular infection, the physicians should be aware that while positive oropharyngeal swabs for *K. kingae* by themselves do not prove the disease is caused by this germ, a highly presumed case of osteoarticular infection may be considered as caused by this pathogen in the presence of a clinically compatible illness [31].

In summary, the incidence of AHO in southern Israel was 5.6/100,000 in the population and was significantly higher in Bedouin children compared with Jewish children. Tibia was the most frequently involved bone but humeral AHO required more surgical intervention and longer hospitalization. Negative cultures were frequent, MSSA was the most commonly involved pathogen and MRSA was rare. Although *Kingella kingae* is often described as an important etiologic agent in septic arthritis, we did not confirm this finding for the AHO cases. Culture positive AHO was associated with higher requirement for surgical intervention.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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