Research Article

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Profile of Common Osteo-Articular Infections in Children's Limbs at the Albert Royer Children's Hospital in Dakar (Senegal): Contribution of the Radiography- Ultrasound Couple

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ABSTRACT

Bone and joint infections are common in children. These are diagnostic and therapeutic emergencies because of the septic and functional risks, especially during the first months of life. The frequent negativity of the samples justifies the use of medical imaging.

The general objective of our study was to determine the contribution of radiography and ultrasound in their management and the specific objectives to describe their epidemiological, clinical and biological aspects and to compare them with radiological aspects.

An observational, retrospective, cross-sectional, descriptive and analytical study over 3 years involved 150 children from the Albert ROYER Childrens University Hospital Center in Dakar, Senegal. Chi-Deu Pearson and Fischer tests were used for statistical analysis.

Septic arthritis accounted for 44%, acute osteomyelitis 18.7%, chronic osteomyelitis 11.3%, subacute osteomyelitis 2% and osteoarthritis 24%. Older male children were the most affected. The average consultation time was 13.65 days. The main signs were pain (97.3%), impotence (83.3%) and fever (72.7%). 13.3% of patients had sickle cell disease and 36% reported initial trauma. The front door was rated at 21.3%.

The standard radiograph, 73.4% pathological, showed early signs of the soft tissues and late bony signs. Ultrasound, 97.5% pathological, had guided the puncture. Bacteriological examination implicated staphylococcus in 65.2% of patients.

Septic arthritis was present at all ages. Osteoarthritis was more common in neonates. Osteomyelitis was seen especially in infants and older children. The predominant locations in the lower limb (89%) were "near the knee" but "far from the elbow" in the upper limb.

There were statistically significant associations between the bone sequestrum, the cutaneous portal of entry and the sickle cell site; between the fistulous path, the cutaneous portal of entry and the staphylococcus; between sickle cell disease and the absence of periosteal apposition.

These results confirmed the importance of radiography and ultrasound in the management of bone and joint infections in children.

Keywords
Infection, Bone, Child, Radiography, Ultrasound.

Introduction
Osteo-articular infections (OAI) include several anatomo-clinical entities including osteomyelitis (OM) hematogenous infection of the bone and bone marrow, osteoarthritis (OA) metaphysoepiphyseal infection spread to the joint and septic arthritis (SA) primary infection of the joint synovium.

They are common and affect all ages. These are diagnostic and therapeutic emergencies because of the septic and functional risks with extreme severity in the first months of life [1,2]. The frequent negativity of blood and bone samples justifies the use of medical imaging [3].

The general objective of our study is to determine the contribution of radiography and ultrasound in the management of common OAI of the limbs in children. The specific objectives are: describe the epidemiological, clinical, biological and radiological aspects of IOA in children; compare radiological and ultrasound aspects with epidemiological, clinical and biological data.

Patients and Methods
A retrospective, descriptive and analytical study conducted in the Department of Radiology and Medical Imaging of the Albert Royer Children's University Hospital Center (Dakar, Senegal)., from January 1, 2018, to November 31, 2020, or 3 years, had made it possible to include 150 children aged 0 to 15 years who have had an X-ray and/or an ultrasound exam.

Ultrasounds were performed on a Samsung Medison R3 device equipped with a high-frequency linear probe (7-16 MHz). The morphological examination analyzed the bursae, the joint cavity and capsule, the periosteum, the cortical bones, the soft parts (muscles, fascia and subcutaneous cell tissue). Color Doppler and/or Energy mapping looked for hyperaemia. She had allowed the puncture of joint fluid, collections, metaphyseal or soft tissue for cytobacteriological examination (CBE).

The radiographs, taken on a Colenta bone-lung table, included AP and lateral views, taking the joints above and below in the OM, centered on the joint and taking the bone segments above and below when an SA or OA were suspected. The analysis concerned the metaphysis, the epiphysis, the growth plate, the diaphysis, the joint line, the cortex, the periosteum, the fatty edges and the soft tissues. The parameters studied were:
- Anamnestics including age: newborn (0-28 days), infant (1-30 months), small child (31-60 months), big child (72-132 months) and adolescent (144-180 months); gender (male or female); the terrain (sickle cell disease, malnutrition); the existence of an initial trauma; time to diagnosis,
- Clinics: fever, deterioration in general condition (AEG), pain, functional impotence, lameness, existence of a portal of entry (PE), local inflammatory signs, joint mobility, patellar shock,
- Biological: blood count (CBC), C Reactive Protein (CRP), sedimentation rate (SR),
- Bacteriological: germs isolated from blood culture or CBE
- Ultrasound: collections (intra-articular, sub-periosteal or soft tissues), hyperaemia, cortical abnormalities, densification of soft tissues,
- Radiographic: bone damage (demineralization, osteocondensing or mixed osteolytic lesion, periosteal apposition, sequestrum, involucrum, hypertrophy, pathological fracture), soft parts (filling of fatty bursae, displacement of fatty edging, densification), articular (widening, pinching of joint space, septic dislocation.

Data entry was done on Sphinx and analysis on Statistical Package for the Social Sciences 14 (SPSS14). Pearson's chi-square test and Fischer's accuracy test were used with a significance level of $p < 0.05$.

Patient Characteristics
Epidemiological
150 cases of OAI over 35 months represents an annual average of 38.3 cases. The average age of patients in our series was 6.14 years with extremes of 14 days and 15 years. AS represented 66 cases (44%), followed by OM 48 cases or 48% including 28 cases of acute osteomyelitis (AOM) (18.7%), 17 cases of chronic osteomyelitis (COM) (11.3%) and 3 cases of subacute osteomyelitis (SAOM) (2%). OA was noted in 36 cases (24%). OAI involved all ages and were more frequent in older children (51 cases or 34%), followed by infants (38 or 25.3%), small children (30 or 20%), adolescents (24 or 16 %) and neonates (7 or 4.67%) (Figure 1). In newborns, only AS and OA were noted with a predominance of the latter. OM was only seen after the neonatal period.

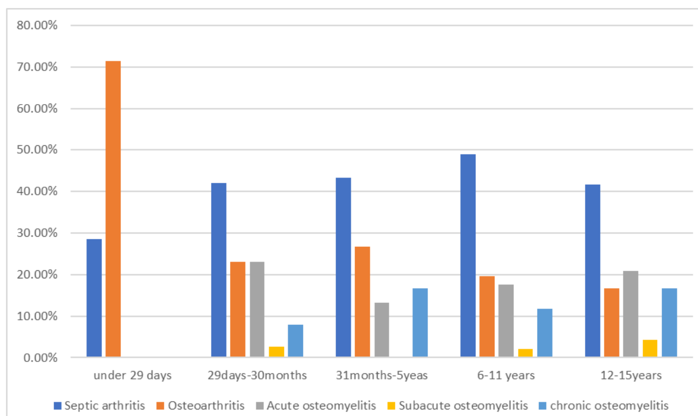

Figure 1: Distribution of OAI by age group.

Our cohort comprised 110 boys (73.3%) and 40 girls (26.7%), i.e. a sex ratio of 2.75. The ratios were 2.69 for OM (35 boys, 13 girls), 3.71 for SA (52 boys and 14 girls) and 1.77 for OA (23 boys, 13 girls).

Clinical
The average consultation time was 13.65 days, the extremes 6 hours and 1 year. 20 patients had sickle cell disease (13.3%), and only one patient presented with severe acute malnutrition. The portal of entry (PE) found in 32 patients (21.3%), was cutaneous (17 cases or 53.2%) with a p=0.008), pharyngeal (8 cases or 25%), pulmonary

(5 cases or 15.6%) and urinary (2 cases or 6.2%). Cutaneous PE predominated in COM with p=0.008. Recent trauma was noted in 52 children (36%) and concerned 63% of AOM, 66.6% of SAOM, 39% of COM, 25.7% of AS and 3.1% of OA.

72.7% of patients presented with fever, of which 45% had SA, 23.9% OA, 20.2% AOM, 9.2% COM and 1.8% SAOM. Pain was present in 146 patients (97.3%), functional impotence in 125 (83.3%) and lameness in 78 (52%). The percentages of this triad varied according to the type of OAI. Physical examination showed swelling in 78 patients (52%), local heat (76 patients or 50.6%), soft tissue edema (62 patients or 41.3%) and joint limitation (64 patients or 42.7%). Patellar shock was also noted in 17 patients (11.3%), redness (13 patients or 8.6%), limb length inequality (6 patients or 4%), joint stiffness (5 patients or 3 .3%) and fistula (2 patients or 1.3%).

Biological

CBC performed in 138 patients (92%) showed hyperleukocytosis in 116 (84%), leukopenia in 6 cases (4.3%) and was normal in 16 patients (11.6%). The CRP assay in 137 patients showed an elevation in 125 (91.2%) and was normal in 12 (8.8%). The acceleration of SR sought in 81 patients (54%), showed an acceleration in 71 (87.6%).

Bacteriological

9 patients had benefited from a blood culture which was negative. CBE performed in 46 patients was positive in 23 (50%) (Table 1).

Table 1: Distribution of germs according to age

Ages / Germes	0-28 jours	29 jours-30 mois	31 mois-5ans	6-11 ans	12-15 ans	Total
Staphyloccocus Aureus	0 0,0%	5 33,3%	1 6,7%	5 33,3%	4 26,7%	15 100,0%
Streptoccocus Pneumoniæ	1 33,3%	0 0,0%	1 33,3%	1 33,3%	0 0,0%	3 100,0%
Streptoccocus Pyogenes	0 0,0%	0 0,0%	1 100,0%	0 0,0%	0 0,0%	1 100,0%
Klebsiella Pneumoniæ	1 33,3%	2 66,7%	0 0,0%	0 0,0%	0 0,0%	3 100,0%
Pseudomonas Aeruginosa	0 0,0%	0 0,0%	0 0,0%	1 100,0%	0 0,0%	1 100,0%

Table 2: Distribution of germs according to the type of IOA

	OMA	OMC	AS	OA	TOTAL
Staphylococcus aureus	2	5	6	2	15
Streptococcus pneumoniae	0	0	2	1	3
Streptococcus pyogenes	0	0	1	0	1
Pseudomonas aeruginosa	0	0	0	1	1
Klebsiella pneumoniae	0	0	1	2	3
TOTAL	**2**	**5**	**10**	**6**	**23**

Aspects of lesions

OAI mainly affected the lower limb (133 cases or 89%), much less the upper limb (17 cases or 11%). They predominated on the left side (87 cases or 58% against 63 cases for the right side or 42%). The OM mainly affected the metaphysis, lower femoral, upper tibial and lower humeral and was multifocal in one patient (Figure 2).

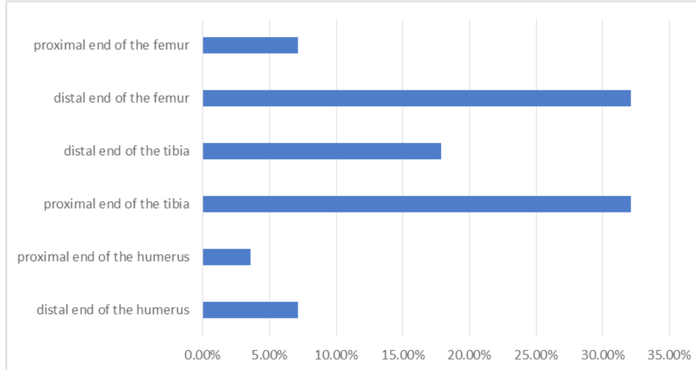

Figure 2: Distribution of bone lesions according to their site

SA mainly affected the knee (50%) and the hip (37.8%). The OA was mostly localized to the hip (19 cases or 52.7%). There were shoulder-elbow associations (3 patients or 8.3%), knee-ankle (1 case) and shoulder-hip-knee (1 case) (Figure 3).

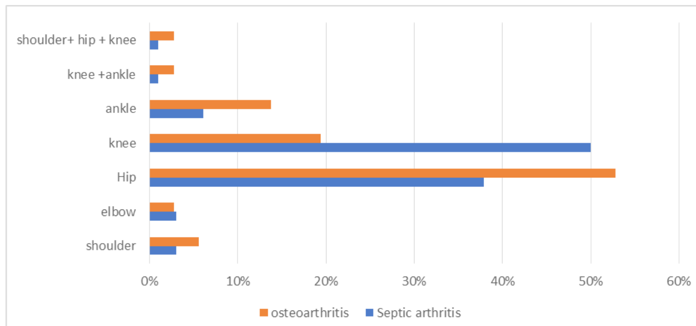

Figure 3: Distribution of Joint Damage According to their Site.

In ultrasound

Subperiosteal, articular lesions or soft tissue collections predominated in acute forms (Table 3, Figures 5, 9).

Table 3: Ultrasound abnormalities according to the type of OAI

	AOM		SAOM		COM		SA		OA	
Subperioseal abcess	19	86,36%	1	50%						
Soft tissue infiltration	7	36,9%	2	100%	10	83,4%	9	16,07%	16	51,6%
Abcès parties molles	2	10,5%	1	50%	7	58,4%	7	12,5%	12	38,7%
Cortical irregularity					6	50%			15	48,4%
Fistulous tract					4	33,3%				
Joint collection							50	89,3%	28	90,3%
Synovial hyperaemia							10	17,8%	8	25,8%

In Radiography

Osteolytic lesions and periosteal apposition predominated in AOM, SAOM and COM. Osteolytic lesions were constant in OM.

Soft tissue densification and periosteal apposition occurred in acute forms (Table 4, Figures 4-8).

Figure 4: 4-year-old child, AOM of the humerus, X-rays of the left arm. A (J3): clarity of the soft tissues adjacent to the humeral diaphysis (→); B (D12): densification and heterogeneous appearance of the soft tissues (→) continuous unilamellar periosteal apposition (→).

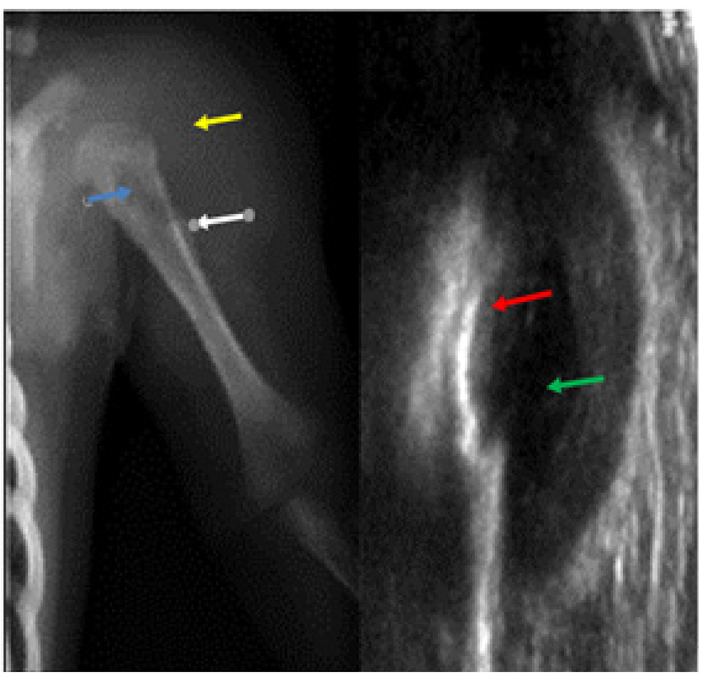

Figure 5: 24-month-old infant, upper left humeral metaphyseal AOM on D15.
A (X-ray): lacuna (blue arrow), periosteal apposition (→), densification of the soft tissues (→); B (Echography): hypoechoic collection under periosteum, (✚), cortical gap (→).

Table 4: Radiological abnormalities according to the type of AOI.

	OMA		OMSA		OMC		AS		OA	
Soft tissue densification	4	21,05%	2	66,6%	9	52,9%	20	50%	11	34,3%
Bursae opacity							24	60%	12	37,5%
Répression of faty edging					3	17,6%	19	47,5%	15	46,8%
Ostéolysis	3	15,8%	3	100%	9	100%			16	50%
Osteocondensation					3	17,6%	1	2,5%	10	31,2%
Mixed lésions					8	47,1%				
Bone sequestrum					8	47,1%				
Périostal apposition	3	15,8%	2	66,6%	9	52,9%				
Deminéralization			1	33,3%	10	58,8%	19	47,5%	6	18,7%
Involucrum					4	23,5%				
Modeling disorders					2	11,7%				
Pathological racture					1	5,8%				
Joint enlargement							6	15%	9	28,2%
Joint pinching									2	6,25%
Septic dislocation							1	2,5%	2	6,25%

Correlations

Concerning radiography, the consultation delay was significantly associated with bone demineralization (p=0.005), osteosclerosis (p=0.012), periosteal apposition (p=0.000) and bone sequestration (p= 0.047). Cutaneous PE was significantly correlated with bone sequestrum (p=0.016) and sickle cell disease (p=0.039). Cutaneous PE was found in 37.5% of patients with bone sequestration. There was a statistically significant link between the absence of periosteal apposition and sickle cell disease (p = 0.027). 70% of sickle cell patients had no periosteal apposition.

Regarding ultrasound, the fistulous tract was significantly linked to cutaneous PE (p=0.013) and to the isolation of staphylococcus aureus (p=0.007). Intra-articular effusion was correlated with joint limitation (p=0.008). Subperiosteal abscess was weakly correlated with hyperleukocytosis with a p = 0.05 but a significant Fischer accuracy test of 0.04.

Comments

On the epidemiological level, OAI are frequent in our regions and the child constitutes a particular field. Our annual average is close to that of Ngom in Senegal, which reports 162 patients over a period of 48 months, i.e. an average of 40.5 [4]. It is higher than that reported by Kiemtore in Burkina-Faso (12 cases per year) in a study based on epidemiological, clinico-biological and therapeutic criteria [5]. Bonhoeffer and al mention an average of 4.5 cases at Bale’s Children's Hospital in Switzerland in a study of AOM and SA [6]. A French multicentre study reports 58 cases per year but includes cases of spondylodiscitis [7]. In our series, IOA are frequent in older children (34%), in accordance with the literature where the peak is 5-10 years [2,8]. Male predominance is confirmed by Moulot in Ivory Coast [2], Hamri in Morocco [9] and Grimpel in France [10] with respectively sex ratios of 1.69; 1.78; 2. In our study, SA is the most frequent (44%) as for NGOM (40.6%) [4] and Hamri (39.7%) [9]. The predominance of COM in MOULOT's study (48.3%) can be explained by the average time to diagnosis of 37.6 days [2]. SA is more common in older children



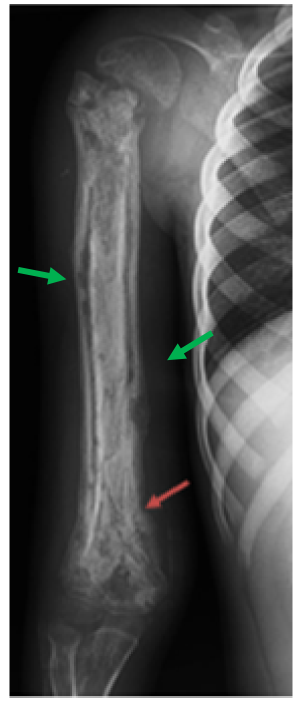

Figure 6: 8 years, SAOM of the left ulna, day 20. Radiography of the left wrist.

Osteolysis of the distal end of ulna Lodwick type I B centro-medullary metaphyseal-diaphyseal seat (◆), bone hypertrophy (→), densification of the soft tissues (→).

Figure 7: 11 years old, DIAPHYSICAL CMO at 2 months. X-ray of the right arm.

Diffuse mixed bone lesions, periosteal appositions (→).

Figure 8: 24 months, CMO with INVOLUCRUM. X-ray of the left femur in profile. Demineralization, para-osteal ossification (→), densification of the soft tissues.

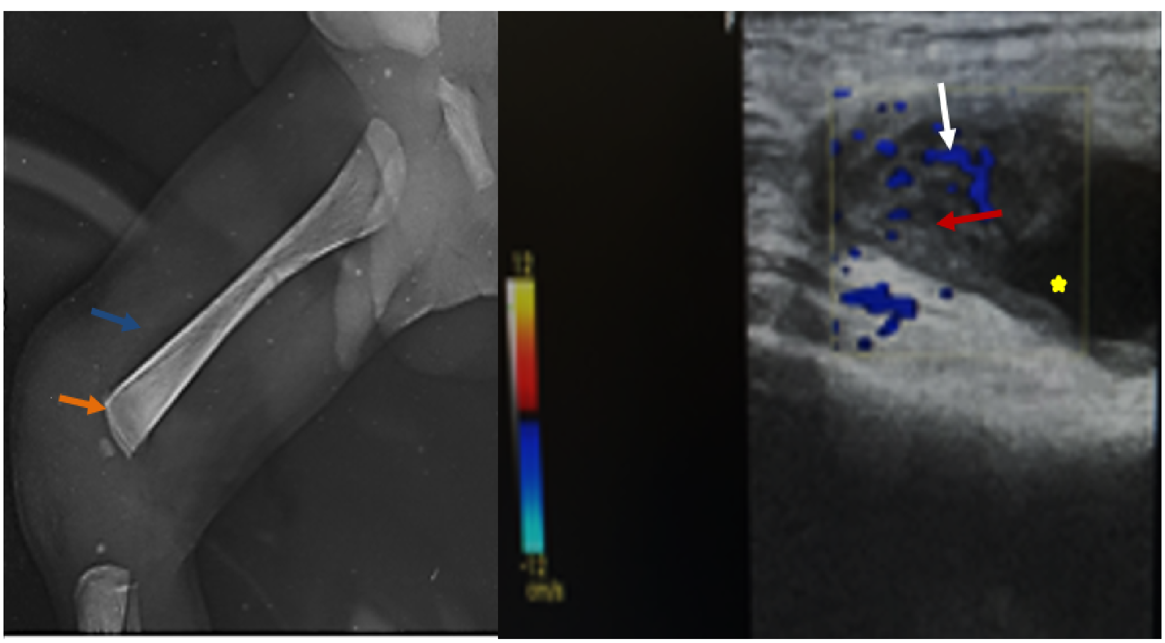

Figure 9: 45 days, SA OF RIGHT KNEE.
A (Radiography): densification of the soft tissues (→), filling of the subquadriceps serous bursa (→); B (Echography): subquadricipital hypoechoic effusion (★), synovial thickening (→), hyperaemia around the collection (→).

with an average of 6.46 years, in accordance with the results of Teklali who reports the average age is 6.5 years [11]. OA is more frequent in neonates (71.4%) in agreement with the results of Hamri [9] and Moulot [2]. AOM is present in all age groups except newborns, with two peaks for older children and infants and an average age of 6.12 years. COM is more common in older children with an average age of 7.1 years. Our results agree with those of Moulot [2], Hamri [9] and Grimprel [10] who showed the frequency of OM in older children with a peak at 5-10 years. As in our series, the male sex is the most represented regardless of the type of OAI for most authors [2,9,10]. Clinically, our relatively short average consultation time of 13.65 days can be explained by the existence in our hospital of an ambulatory care unit for sickle cell patients. This period shortens with the standard of living as attested by Hamri in Morocco [9] with 8.37 days and Bonhoeffer in Switzerland [6] with 3 days. Sickle cell disease is the main defect observed (13.3%). Doit [12] mentions it in 6.8% of cases and Moulot 17.3% [2]. Maiga [13] reports 51% of patients with sickle cell disease in a series concerning OM. The detection of a portal of entry in 21.3% of patients is more frequent than for Timsit (16%) [14], Teklali (19%) [11] and Ngom (6.8%) [4]. Cutaneous PE is correlated with the occurrence of COM (p=0.008) in our study. In the literature, there is a link between cutaneous PE and chronic recurrent multifocal osteomyelitis in children [15] in the context of SAPHO syndrome (Synovitis, Acne, Palmoplantar pustulosis, Hyperostosis and Osteitis). Initial trauma is found in a third of our patients, confirmed by Ngom (33.3%) [4] and Hamri (32%) [9]. In our patients, the fever-pain-functional impotence triad associated with local inflammatory signs was the main indication for imaging as mentioned in various studies [2,16,14].

Biologically, the abnormalities are not specific. Hyperleukocytosis is almost the rule in our study as for Ngom, Ben Ghachem and Trifa and leucopenia is rare, but a normal blood count does not eliminate OAI [4,17,18]. Elevated CRP [14,17,18] and SR [16] are also reported. Some authors link the values of inflammatory markers to the type of IOA. For Timsit, CRP would be higher in AS than in AOM [14]. As for our series, Zahrae states that blood leukocytosis does not differ significantly according to bone or joint location [19].

At the bacteriological level, the blood culture is negative in our series, but the CBE is positive in half of the cases as reported by Hamri (50.4%) [9] and Ngom (57%) [4] but higher than the rate of positivity of Timsit (29%) [14] and Teklali (26.8%) [11]. Bacteriological diagnosis occupies a fundamental place because it makes it possible to highlight the pathogenic agents responsible for the OAI. It depends on the quality of the sample and the method used in the laboratory [20]. The positivity rate is highly variable, ranging from 18 to 82% depending on the publications [19]. Staphylococcus aureus is the most incriminated pathogen. In our series, it is isolated in more than half of the samples and at all ages except newborns, with a predominance in children. It is the only germ present on sickle cell ground but concerns only one case. It represents 63% of isolated germs for Bonhoeffer [6], 36.36% for Timsit [14], 70% for Teklali [11], 81% for Labbe [21] and 59% for Trifa [18]. Streptococcus pneumoniae is the second germ and concerns small children (33.3%). In the literature, streptococci, including pneumococci, are the most frequent after staphylococci and occur preferentially between 3 months and 5 years, the period of pneumococcal bacteraemia [14,22]. However, it should become rare since it is targeted by the seven-valent conjugate vaccine. Group A streptococcus often isolated in neonatal hospitalization [18] is present in 4.3% of our patients, less than for Trifa (13%),) [18], Labbé (7.5%) [21] and Timsit (8%) [14]. Klebsiella pneumoniae isolated in 13% of cases, which is higher than the results of Trifa (9.4%) [20], Moulot and Hamri (1.7%) [2,9]. Pseudomonas aeruginosa is associated with staphylococcus in 1 patient (4.35%) aged 11 with a cutaneous fistula, in accordance with data from Titécat (3.6 ± 1.2%) [22] and Abuamara (2%) [23]. It is a classic germ of penetrating wounds in adolescents [22], responsible for nosocomial infections in the DIA study at the CHNU de Fann in Dakar, Senegal [24]. Kingella kingae, recently recognized as the main pathogen of OAI, particularly SA [25], was not found in our series. Negative bacteriological samples can be explained by the absence of a deep bone sample or by taking antibiotics [10]. Our laboratory does not have an incubator in an anaerobic environment and a molecular biology technique by gene amplification (Polymerase Chain Reaction or PCR).

In imaging, the predominant involvement of the lower limb, the preferential localization of SA in the knee and hip is reported by Timsit [14], Teklali [11], Ngom [4] and Guèye [26]. In our patients, the AOM reached the metaphyses "close to the knee", confirming the results of NGOM [4] and Hamri [9]. COM is thus more frequent in the lower limb, in accordance with data from the literature [4,17]. In the upper limb, the locations of the AOM are “close to the elbow” as for Ngom but contrary to the data in the literature [9,14,11,4]. For Hamri, the involvement of the shoulder and the elbow are equivalent [9]. Ultrasound is pathological in 97.5% of our patients and highlights the subperiosteal abscess in 86.36% of AOM cases, joint collection in 89.3% of AS and 90.3% of O.A. According to some studies, its sensitivity is 90% in the case of intra-articular effusion and around 40 to 90% in the case of subperiosteal abscess. It allows a better analysis of the soft tissues and the juxta-osseous structures than the standard radiography, highlights a collection, allows its quantification and guides the puncture. A normal ultrasound does not rule out an OAI [1,27]. Radiography is pathological in 73.4% of our cases in the acute forms (OMA, AS and OA) with early signs of the soft tissues. They are typically visible in 48-72 hours [28] unlike bone lesions (1-2 weeks) [29,30]. Many authors have a high percentage of normal radiographs: 85% for Timsit [14]; 71.5% for Chambers [31]; 91% for Teklali [11]; 57.7% for Hamri [9] and 59% for Ngom [4]. These soft tissue abnormalities persist in the CMO whose bone lesions are constant. Para-osteal ossifications, sequestrations, pathological fractures or bone deformities are observed in advanced forms [9,4]. The long delay in consultation explains the appearance of bone lesions in the chronic stage [32]. The statistically significant link between cutaneous PE and bone sequestration is explained by the existence of foci of cutaneous dissemination that are often hidden or neglected, thus favoring the evolution towards chronicity. The Sickle cell disease favors the occurrence of sequestration because it is responsible for osteopenia and infarction, explaining the absence of periosteal reactions [33,34]. The significant link between subperiosteal abscess and blood leukocytosis is explained by the recruitment of neutrophils directed against host bacterial enzymes and toxins during the inflammatory reaction [35]. The significant association between joint effusion and mobility limitation may be explained by the presence of lytic enzymes in purulent joint fluid that destroy joint cartilage [1,32,3]. The fistulous tract is significantly correlated with cutaneous PE and the isolation of staphylococcus aureus, in accordance with data from the literature because staphylococcal COM causes purulent discharge through the fistulas [5].

Conclusion

In the absence of scintigraphy and Magnetic Resonance Imaging, the radiography-ultrasound couple occupies a primordial place in our practice in the diagnosis and management of OAI. In acute forms, ultrasound highlights subperiosteal end soft tissue collections and allows emergency puncture, while radiography detects early indirect signs such as soft tissue densification and repression of fatty edges. Sickle cell disease is significantly correlated with certain epidemiological, clinical, biological, ultrasound and radiological aspects.

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