Pyogenic Spinal Infections Without Disc Involvement in Childhood

María Emilia Moreiro Varela,[*,] María Gabriela Miranda,[*,**] María Arnelix López Friera,[**] Claudio A. Fernández[*]**
[*]*School of Medical Sciences, Universidad Nacional de La Plata, Buenos Aires, Argentina*
[**]*Orthopedics and Traumatology Service, Hospital de Niños "Sor María Ludovica", La Plata, Buenos Aires, Argentina*

ABSTRACT

Introduction: Pyogenic spinal infections in children include spondylodiscitis, spondylitis, facet joint septic arthritis, paraspinal and perivertebral abscesses, meningitis, myelitis, and their associations. *Staphylococcus aureus* is the most common causative microorganism. **Objective:** To determine the prevalence of spinal bone infections and pyogenic perivertebral abscesses in children and to evaluate the usefulness of Ju's algorithm. **Materials and Methods:** Nine children without comorbidities presenting with pyogenic spinal infection and preserved disc integrity were included. **Results:** A higher frequency was observed in children older than eight years. The most prevalent clinical triad was pain, fever, and antalgic postures. Ju's algorithm proved to be reliable. One case of facet joint septic arthritis, four cases of spondylitis, and eight perivertebral abscesses were identified, five associated with bone infection. On CT, bone lesions showed a lytic or mottled appearance, while MRI demonstrated typical infectious patterns. Bone specimens obtained by percutaneous and transoral biopsy confirmed acute osteomyelitis. *S. aureus* was isolated in seven of nine patients. Antibiotic therapy was effective; however, six children required surgery: five for abscess drainage and one for a pedicle subtraction osteotomy due to residual kyphosis. **Conclusions:** Spinal infection with preserved disc integrity was prevalent in late childhood and adolescence. Its association with abscess formation and *S. aureus* infection was significant. We recommend the application of Ju's algorithm and, in cases of negative blood cultures, performing bone biopsy for bacteriological identification and histopathological confirmation, surgical drainage of soft tissue abscesses, and targeted antibiotic therapy.
Keywords: Children; spinal infection; pyogenic abscesses; *Staphylococcus aureus*.
Level of Evidence: IV

Infecciones espinales piógenas sin afectación discal en la infancia

RESUMEN

Introducción: Las infecciones espinales piógenas en la infancia incluyen entidades, como espondilodiscitis, espondilitis, infección facetaria, abscesos para y perivertebrales, meningitis, mielitis y sus asociaciones. *Staphylococcus aureus* es el microorganismo habitual. **Objetivos:** Determinar la prevalencia de infecciones óseas espinales y abscesos piógenos perirraquídeos, y evaluar la utilidad del algoritmo de Ju. **Materiales y Métodos:** Se incluyó a 9 niños con infección espinal piógena e indemnidad discal, sin comorbilidades. **Resultados:** La frecuencia fue mayor en niños >8 años. La tríada prevalente incluyó dolor, fiebre y posturas antiálgicas. Se demostró que el algoritmo de Ju es confiable. Se detectaron una artritis facetaria, 4 espondilitis y 8 abscesos perivertebrales, 5 asociados a una infección ósea. En la tomografía computarizada, las lesiones óseas tenían un aspecto lítico o atigrado. La resonancia magnética mostró el patrón típico de infección. Los especímenes óseos, obtenidos por punción percutánea y transoral, fueron informados como osteomielitis aguda. En 7 de 9 pacientes, se aisló *S. aureus*. La antibioticoterapia fue eficaz para curar la enfermedad. Sin embargo, 6 niños requirieron cirugía: 5 para drenar abscesos y uno para una osteotomía de sustracción pedicular en una cifosis secuelar. **Conclusiones:** La infección vertebral con disco indemne fue prevalente en la segunda infancia y la adolescencia. La asociación con abscesos fue significativa, así como la identificación de *S. aureus*. Recomendamos la aplicación del algoritmo de Ju y, ante hemocultivos negativos, la biopsia ósea para la determinación bacteriológica y la certeza histopatológica, el drenaje quirúrgico de los abscesos de partes blandas y la antibioticoterapia específica.
Palabras clave: Niños; infección espinal; abscesos piógenos; *Staphylococcus aureus*.
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Received on July 19th, 2024. Accepted after evaluation on June 23rd, 2025 • Dr. CLAUDIO A. FERNÁNDEZ • claudioalfredofernandez619@gmail.com https://orcid.org/0000-0003-2350-3885
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INTRODUCTION

Pyogenic spinal infections in childhood are uncommon. Spondylodiscitis predominates; however, other entities may occur, including spondylitis, facet joint infection, meningitis, myelitis, abscesses concomitant with bone infection, and primary perivertebral septic collections.[1] Regardless of the presentation, the inoculum enters via the hematogenous route (Figure 1).[2]

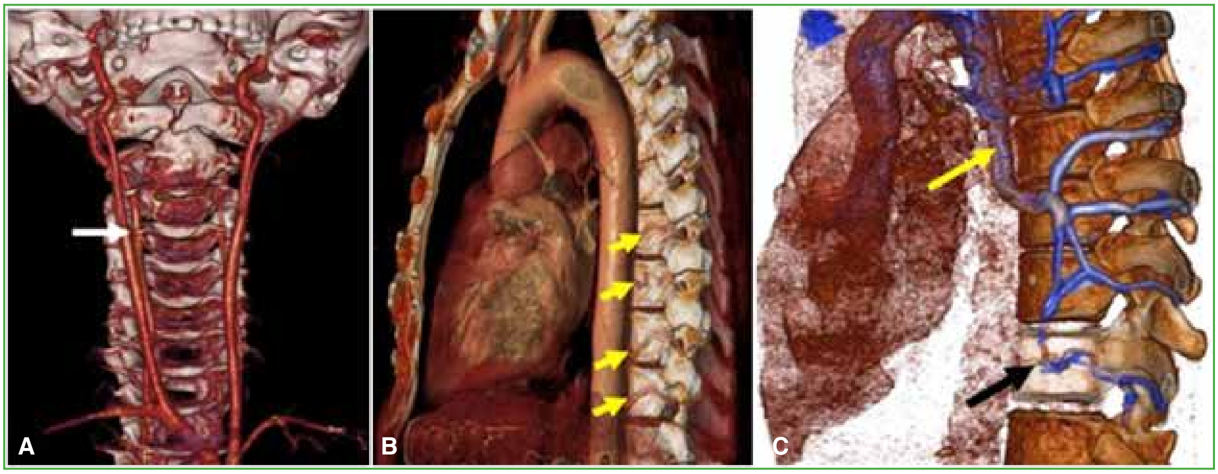

Figure 1. Spinal computed angiography. **A**. Vascular supply of the cervical spine, which depends primarily on the vertebral arteries. **B**. Segmental arteries arising from the aorta that supply the equator of the vertebral body (yellow arrows). **C**. Venous drainage of the thoracic spine into the azygos vein (yellow arrow). The black arrow indicates an intercostal arteriovenous bundle. (Images taken from *Libro de Cátedra*, O. A. Romano and C. A. Fernández, SEDICI 2023; reproduced with permission).

In recent decades, the epidemic of methicillin-resistant *Staphylococcus aureus* (MRSA) has substantially altered the spectrum, prevalence, and prognosis of skeletal infections.[3,4] The Pan American Health Organization has reported alternative etiologies according to age stratification (Table 1).[5]

In prior studies, spinal osteomyelitis accounts for 1% to 2% of all bone infections.[6]

The objectives of this study were to determine the prevalence of spondylitis and pyogenic paraspinal abscesses in children and to assess the usefulness of Ju's algorithm.

Table 1. Most common microorganisms in osteoarticular infections in childhood and adolescence according to the Pan American Health Organization[5]

Age	Common microorganisms
<1 month	*S. aureus*, Gram-negative bacilli, streptococci, *Neisseria gonorrhoeae*, *Treponema pallidum*
1-3 months	*S. aureus*, Gram-negative bacilli, *Haemophilus*
From 3 months to 5 years	*S. aureus*, streptococci, *Haemophilus*, *Kingella kingae* (gram-negative)
>5 to 18 years	*S. aureus*, streptococci, *Neisseria meningitidis*, *Kingella kingae*

MATERIALS AND METHODS

A descriptive, retrospective observational case series was conducted at a multidisciplinary pediatric referral institution in the Province of Buenos Aires, covering the period from October 2004 to December 2023.

Inclusion criteria were: children up to 15 years of age with a primary pyogenic infection of the spine, without disc involvement or comorbidities, who met two or more of the following requirements: 1) Clinical presentation: spinal pain, refusal to walk or limping, limited range of motion, abnormal postures, and febrile syndrome. 2) Biological pattern of infection: decreased hematocrit or hemoglobin concentration; increased C-reactive protein (CRP) or erythrocyte sedimentation rate (ESR). 3) Bacteriological confirmation: identification of the organism on blood culture or aspiration specimen; histopathological confirmation; or any combination of these variables. 4) Imaging findings suggestive of infection. Exclusion criteria were: children with systemic disease, surgical site infection, tuberculosis, and incomplete medical records. We applied the predictive algorithm for *S. aureus* osteomyelitis described by Ju et al., which includes the following factors: leukocytosis >12,000 cells/mm³, hematocrit <34%, temperature >38°C, and CRP ≥13 mg/L, with the following expected probability of diagnosis: no factors = 0%, one = 1%, two = 10%, three = 45%, and four = 92%.[4]

In addition to demographic data, we recorded time to presentation/evolution and follow-up, infection location, biological and histopathological parameters, imaging studies, and antibiotic therapy. The classification of bone infection as acute or chronic was based on histopathological confirmation, not on duration of symptoms.

Statistical Analysis

The nonparametric Wilcoxon rank test and Pearson's correlation coefficient were used (SPSS 17®). A p value ≤0.05 was considered statistically significant.

RESULTS

Eleven medical records met the aforementioned criteria. Two were excluded due to the lack of imaging documentation. The sample represented 81% of the cases admitted during the study period. The cohort included nine patients with a mean age of 9.6 years (range, 3 months–15 years), with a male-to-female ratio of 6:3. The mean prodromal period was 6 days (range, 48 hours–5 months). Mean follow-up for bone infections was 1.8 years (range, 12–36 months), whereas for primary abscesses without skeletal involvement, the mean follow-up was 9 months (range, 6–18 months).

The predominant clinical presentation included pain, febrile syndrome, limited range of motion, and antalgic postures. No patient developed neurological deterioration. Blood cultures were negative except in two cases, and all patients had a Ju index of 92%, except for one patient ($p < 0.002$) (Table 2).

Table 2. Ju parameters (underlined)

Case	Leukocytosis	CRP	Hematocrit-Hemoglobin	ESR	Fever	MRSA	MSSA	Pathological anatomy	Ju parameters
1	X	X	X	X	X	X		AHO	92
2	X	X		X	X		X	AHO	92
3								AHO	0
4	X	X	X	X				AHO	92
5	X	X	X	X	X		X	AHO	92
6	X	X	X	X	X	X		Abscess	92
7	X	X	X	X	X	X		Abscess	92
8	X	X		X	X	X		Abscess	92
9	-	X	X	X	X		X	Abscess	92

Inferential statistics were used to analyze the variables with Wilcoxon's nonparametric rank tests and Pearson's correlation coefficient. For bone infection and abscesses, all were significant in view of the final definitive diagnosis (bacteriological or histological), p <0.002.
CRP = C-reactive protein; ESR = erythrocyte sedimentation rate; MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-sensitive *Staphylococcus aureus*; AHO = acute hematogenous osteomyelitis.

Eight abscesses were identified in nine patients (p = 0.005): three were associated with spondylitis and one with facet joint arthritis; the remaining four were primary abscesses (Figure 2).

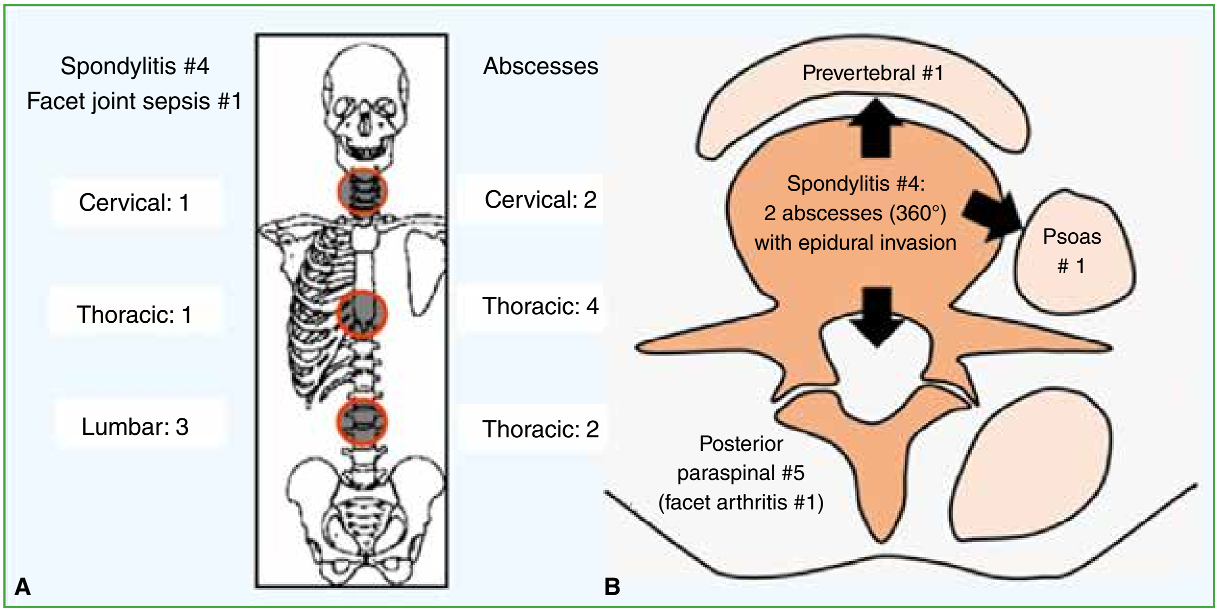

Figure 2. **A**. Topographic anatomical distribution of bone infections and spinal abscesses. **B**. Axial plane distribution. Note the presence of eight abscesses: two somatic with epidural extension, one prevertebral, one psoas, and four posterior paraspinal abscesses.

Abscesses associated with spondylitis resolved with antibiotic treatment, whereas the remaining abscesses required surgical drainage, including those in two children whose diagnosis in the emergency department was made exclusively by ultrasound. *Staphylococcus aureus* was isolated in seven patients (p = 0.001), including four cases of MRSA and three of MSSA (Figures 3-6).

Figure 3. 13-year-old boy with back pain and febrile syndrome. Elevated acute-phase reactants, fluid collection involving the multifidus muscles and the T9–T10 facet joints. Surgical drainage and lavage were performed. Methicillin-sensitive *Staphylococcus aureus* was isolated, and histopathology was consistent with acute osteomyelitis. **A and B**. Magnetic resonance imaging of the thoracic spine, sagittal and axial sections. The abscess described is evident.

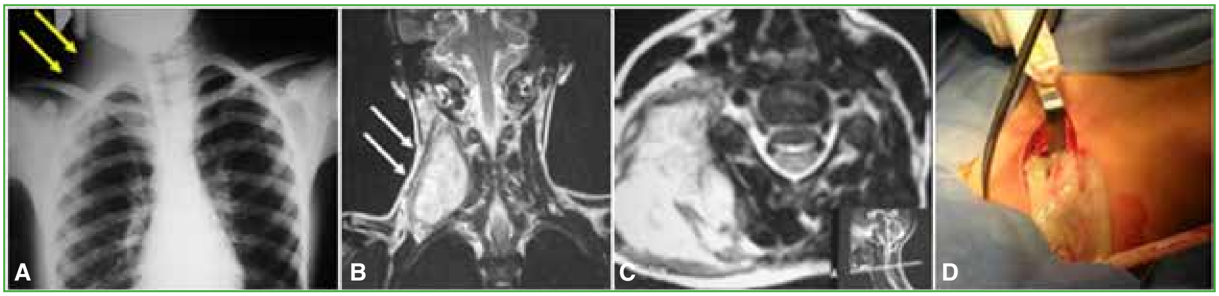

Figure 4. 13-year-old boy with laterocollis, pain, and acute febrile syndrome. **A**. Anteroposterior radiograph of the chest and shoulders. Yellow arrows indicate soft tissue swelling in the cervical region. **B and C**. Magnetic resonance imaging of the neck and supraclavicular region, coronal and axial T2-weighted sequences, showing a large primary abscess.
D. Intraoperative image demonstrating purulent drainage. Isolated pathogen: methicillin-resistant *Staphylococcus aureus*.

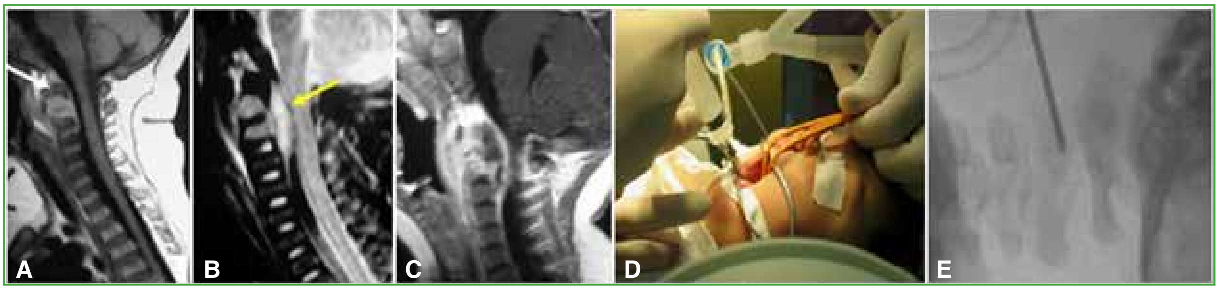

Figure 5. 3-month-old infant with febrile syndrome, episodes of inconsolable crying, opisthotonos, and laterocollis of one month's duration. **A**. Magnetic resonance imaging of the skull base and cervical spine, sagittal T1-weighted sequence. C2 spondylitis (white arrow); note preservation of the C2–C3 disc. **B**. Same study, T2-weighted sequence. Perivertebral abscess with epidural extension anterior to the tectorial membrane (dark interface) (yellow arrow). Extension of the abscess toward the skull base below the clivus. **C**. Same study, T1-weighted sequence with gadolinium contrast, showing marked peripheral enhancement. **D**. Transoral biopsy puncture. **E**. Image intensifier view confirming correct placement of the Jamshidi needle. Methicillin-sensitive *Staphylococcus aureus* was isolated. Histopathological confirmation of acute osteomyelitis. Excellent response to antibiotic therapy, rest, and cervical immobilization with a brace. (Images taken from *Libro de Cátedra*, O. A. Romano and C. A. Fernández, SEDICI 2023; reproduced with permission).

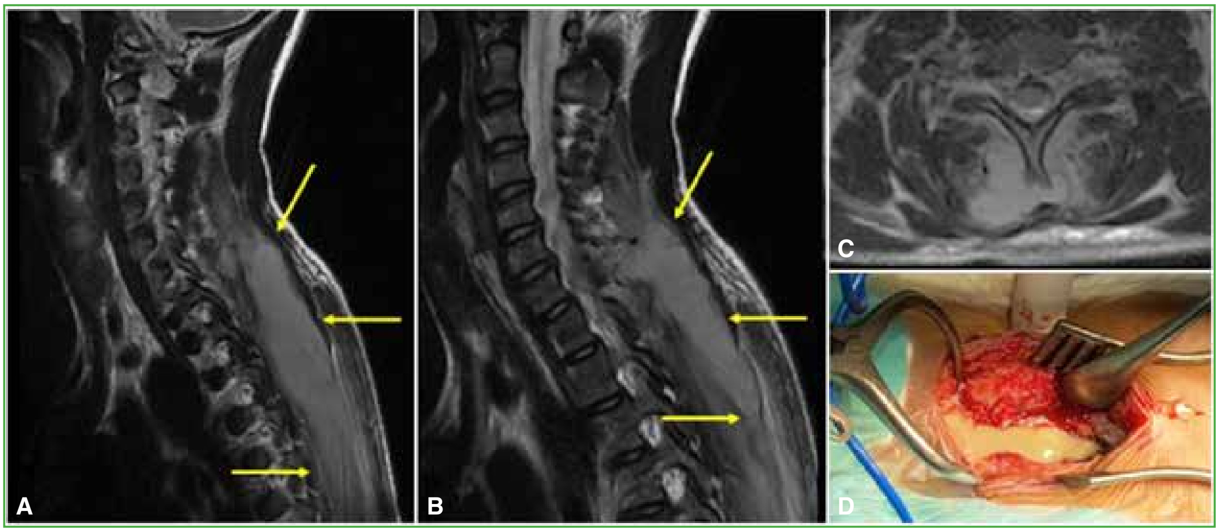

Figure 6. 14-year-old boy with fever and back pain, with elevated acute-phase reactants. **A and B**. Magnetic resonance imaging of the cervicothoracic spine, sagittal sections. Fluid collection extending from C6 to T4 (yellow arrows). **C**. Magnetic resonance imaging of the cervicothoracic spine, axial section. Posterior paraspinal abscess. **D**. Intraoperative image of posterior surgical approach showing evacuation of purulent material.

On computed tomography, bone lesions exhibited a lytic or mottled appearance, with asymmetric distribution and poorly defined margins. One patient developed angular kyphosis due to wedging of T11, which required delayed pedicle subtraction osteotomy (Figure 7).

Figure 7. 12-year-old girl with febrile syndrome, back pain, and functional limitation. Frankel grade E. Methicillin-resistant *Staphylococcus aureus* isolated from blood culture and bone biopsy. **A and B**. Computed tomography, axial slice at the T11 vertebra. Eccentric lytic, mottled-appearing lesion at T11 and a circumferential (360°) perivertebral abscess. **C**. Magnetic resonance imaging of the thoracic spine, coronal view. Abscess with preserved intervertebral disc integrity and an hourglass-shaped vertebral body. **D and E**. Same study, sagittal T2- and T1-weighted sequences. Angular kyphosis of 30° secondary to wedge collapse of the vertebral body.

Magnetic resonance imaging showed hypointense signal on T1-weighted sequences and hyperintense signal on T2-weighted and STIR sequences, with gadolinium enhancement. In patients with bone involvement and negative blood cultures, image-guided needle biopsies were performed: three percutaneous transpedicular biopsies, one transfacet biopsy, and one transoral biopsy. In two cases, no pathogen was identified; in two cases, *S. aureus* was isolated (1 MRSA and 2 MSSA). All specimens submitted for histopathological analysis were classified as acute osteomyelitis (Figures 8 and 9). According to protocol, all specimens were evaluated for tuberculosis (Figure 10).

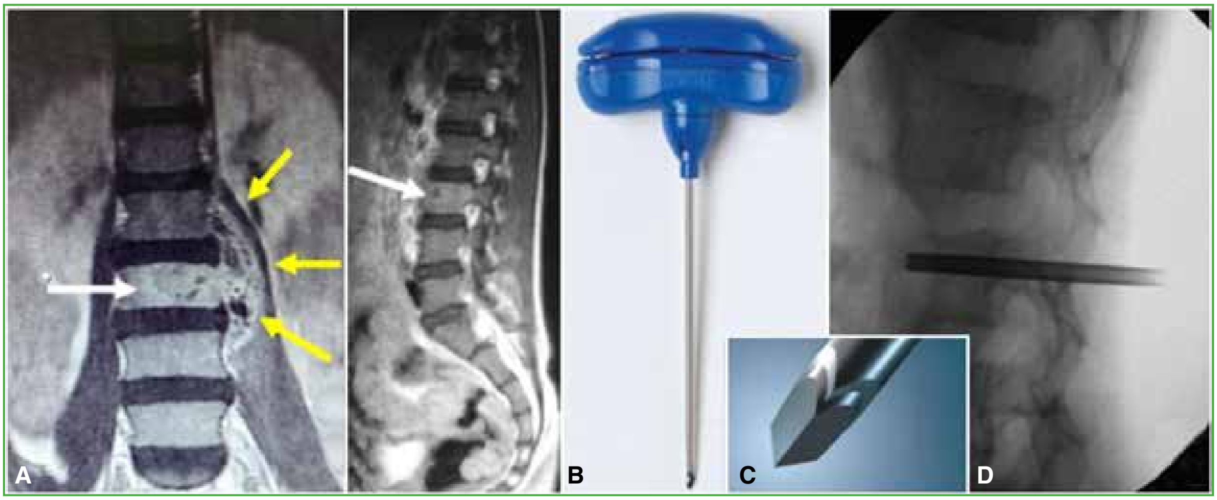

Figure 8. 10-year-old boy with low back pain and febrile syndrome. **A**. Magnetic resonance imaging of the lumbar spine, coronal and sagittal T1-weighted images. L3 spondylitis (white arrows) and a concomitant abscess of the left psoas muscle (yellow arrows). **B and C**. Jamshidi needle and its trocar. **D**. Percutaneous transpedicular biopsy performed under fluoroscopic guidance.

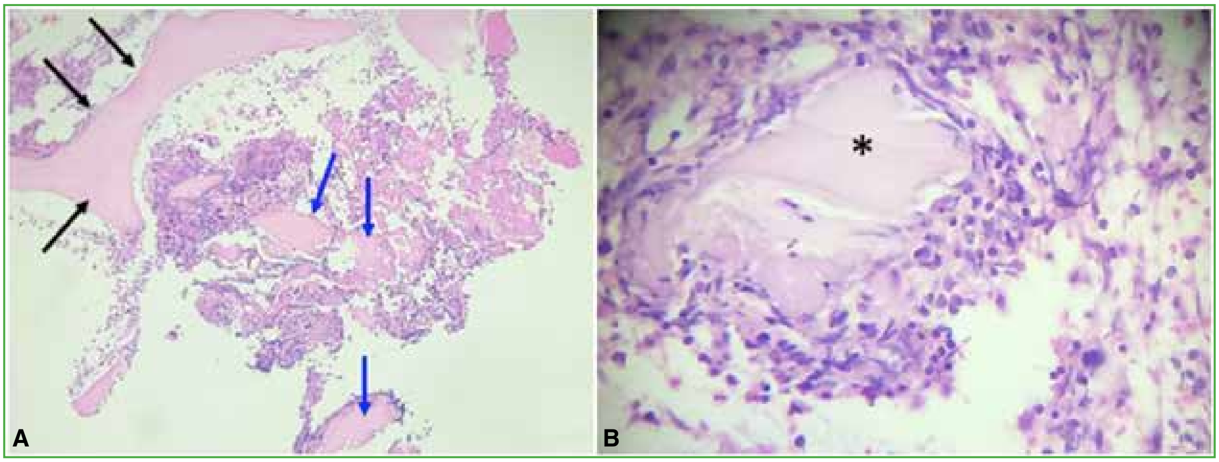

Figure 9. Bone specimen (hematoxylin–eosin stain), acute osteomyelitis. **A**. Centrally, islands of devitalized (acellular) bony trabeculae secondary to necrosis, surrounded by an intense polymorphonuclear inflammatory infiltrate (blue arrows); at the upper left margin, forming a C-shaped configuration, normal bone matrix is observed (black arrow). **B**. Higher-magnification image. Centrally, necrotic osteoid (black asterisk) with a marked peripheral leukocytic infiltrate.

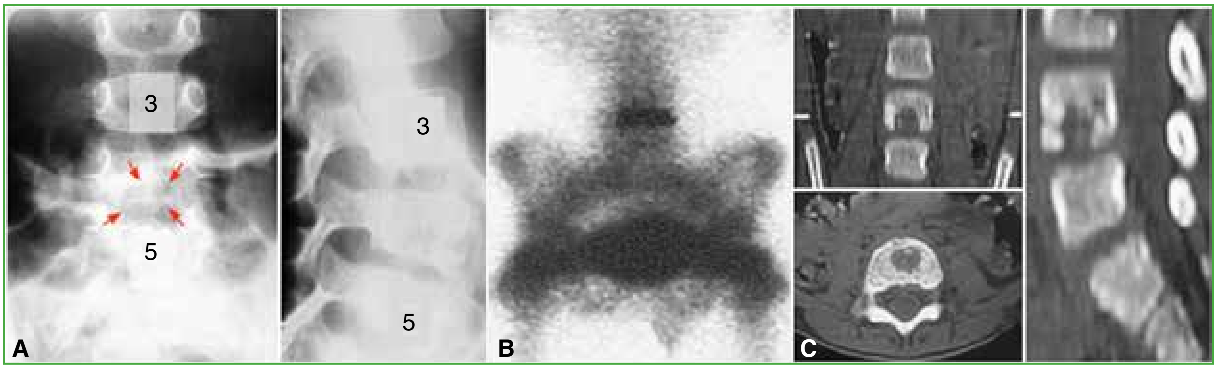

Figure 10. 5-year-old boy with insidious back pain and low-grade fever. Prolonged course. Family history suggestive of tuberculosis; PPD (+++). **A.** Computed tomography and radiograph of the lumbar region, coronal and sagittal views, respectively. Quiescent lacunar lesion in L4 (red arrows). **B.** Technetium-99m bone scintigraphy. Selective increased uptake in the L4 vertebral body. **C.** Computed tomography of the lumbar region, coronal, axial, and sagittal views. Lytic lesion with microcalcifications and preserved intervertebral disc integrity. Vertebral aspiration: frank caseous material. *Mycobacterium tuberculosis* was isolated. Medical treatment was initiated, with satisfactory clinical evolution.

Antibiotic therapy was guided by antibiogram results or administered empirically, according to local epidemiology. In general terms, the protocol included 2 to 3 weeks of intravenous antibiotics followed by 4 to 8 weeks of oral therapy. The most frequently administered antibiotics were clindamycin and vancomycin. Table 3 summarizes the most relevant variables. Overall, the cohort can be summarized into three main findings: (1) spondylitis, (2) facet joint arthritis, and (3) primary paraspinal abscesses or abscesses associated with the aforementioned bone infections.

Table 3. Differential diagnosis between nonspecific spondylitis and tuberculosis.

Characteristics of the infection	Pyogenic	Tuberculosis
Elective region	Thoracic or lumbar	Thoracic
Delay in diagnosis	+	+++
Clinical presentation	Eloquent	Overlapping
Biological data	+++	+
Pulmonary tuberculosis	No	Yes
Vertebral collapse CT/MRI >50%	+	+++
Bone fragments on CT	+	+++
Microcalcifications on CT scan	+	+++
Paraspinal abscess on MRI	+	+++
Length of abscess	+	+++
Mixed signal on T1-weighted gadolinium-enhanced MRI	+	+++
Mixed signal on T2-weighted MRI	+	+++
Peripheral enhancement on T1-weighted MRI with gadolinium	+	+++

CT = computed tomography; MRI = magnetic resonance imaging. Crosses indicate probability estimates: unlikely (+), highly likely (+++).

DISCUSSION

The vascular pattern appears to be the key differentiating factor in the pathogenesis of vertebral infection in children. In the first years of life, the metaphyseal vascular network facilitates bacterial inoculation, bone abscess formation, and disc involvement.[6] From the second stage of childhood onward, spinal blood supply, more prominent at the equator of the vertebral body, predisposes to osteomyelitis that spares the intervertebral disc.[2,7,8] Between the ages of 3 and 8 years, the prevalence of spondylodiscitis and spondylitis is similar, after which spondylitis becomes predominant. Reports on pyogenic spondylitis and facet joint arthritis in childhood are scarce.[6,8,9] In this study, five cases were identified over a 19-year period. The deleterious effect of *Staphylococcus aureus* is manifested by tissue necrosis, abscess formation, and recurrence.[10-14] The production of exotoxins, such as Panton–Valentine leukocidin, α-hemolysin, enterotoxins, and superantigens, may trigger a generalized inflammatory storm, leading to hemodynamic shock, multiple organ failure, and death.[11,12] According to the literature, deep abscesses, cellulitis, and furunculosis are caused by MRSA in 63% of cases and by MSSA in 15%.[14,15] In this cohort, the incidence of paraspinal abscesses was close to 90%, caused by both bacterial species (Table 3).

Drainage and saline irrigation of posterior septic collections appears to be a generally accepted procedure.[14] However, there are no standardized indications regarding anterior collections. In principle, provided that there is no alteration of spinal biomechanics, instability, or neurological compromise, initial management consists of antibiotic therapy.

Diagnostic confirmation by histopathology, bacteriology, or both methods allowed us to corroborate, albeit inversely, the usefulness of the algorithm proposed by Ju et al.[4] Other authors have reported disparate results, with a reliability of 91% at Boston Children's Hospital and 50% at Phoenix Children's Hospital.[4,11,15] Computed tomography has moderate sensitivity in infectious disease; it is useful for bone tissue analysis and 3D reconstructions. However, long-term carcinogenic effects related to radiation exposure in children have been reported.[16] Therefore, its indication should be selective, and whenever possible, biopsies should be performed using image-intensifier–assisted needle techniques with limited imaging sequences. Magnetic resonance imaging is the imaging modality of choice in patients with spinal infection, with a sensitivity of 96%, specificity of 94%, and accuracy of 92%.[1] Occasionally, on T2-weighted sequences, a "flare phenomenon" may be observed, which has also been described in stress fractures and neoplastic disease.[17] Granulomatous tissue formation may mimic a paraspinal abscess in hematological malignancies. The association of spondylitis and abscess should be considered tuberculosis until proven otherwise.[18-21] For this reason, we developed a comparative table with pyogenic infections based on the literature (Table 4).[19-21]

Table 4. Summary of main clinical variables and complementary studies.

Case	Age/Sex	Signs/ Symptoms	Reactive Infection	Blood culture	Site	Abscess	X-ray-CT scan	MRI	Ultra-sound	Bone biopsy/ Germ	Pathological anatomy	Sequela	Follow-up (months)
1	12 years F	Fever, Back pain, ↓ functional	Yes	(+) MRSA	T11	Yes 360 + epidural	Mixed Kyphosis	Classic		Yes/ MRSA	Osteomyelitis	Kyphosis	36
2	3 months M	Fever, Torticollis, opisthotonos	Yes	(-)	C2	Yes 360 + epidural	Lysis	Classic		Yes/ MRSA	Osteomyelitis	No	24
3	15 years M	Low back pain	No	(-)	L3	No	Lysis	Classic		Yes (-)	Osteomyelitis	No	12
4	10 years M	Low back pain	Yes	(-)	L3	Yes Psoas	No	Classic		Yes (-)	Osteomyelitis	No	12
5	13 years M	Back pain	Yes	(-)	Facet arthritis T9-T10	Yes Paraspinal Drainage	(-)	Classic		Yes/ MSSA	Osteomyelitis	No	16
6	6 years F	Fever, low back pain	Yes	(-)	Lumbosa-cral	Yes Paraspinal MRSA drainage	(-)	No	Yes	No	No	No	6
7	9 years F	Fever, back pain	Yes	(-)	Thoracic, lumbar	Yes Paraspinal Drainage. MRSA	(-)	No	Yes	No	No	No	6
8	13 years M	Fever, Torticollis	Yes	(-)	Cervical	Yes Paraspinal Drainage MRSA	Yes Abscess	Abscess	No	No	No	No	18
9	14 years M	Fever, back pain	Yes	(+) MSSA	Cervical, thoracic	Yes Paraspinal Drainage MSSA	No	Abscess	No	No	No	No	6

F = female; M = male; MRSA = methicillin-resistant *Staphylococcus aureus*; MSSA = methicillin-sensitive *Staphylococcus aureus*; CT = computed tomography; MRI = magnetic resonance imaging. Classic MRI refers to the pattern of infection detailed in the text.

Unlike spondylodiscitis, in which the indication for needle aspiration remains controversial, we believe that in patients with bone lesions and negative blood cultures, biopsy is essential because of its bacteriological relevance and histopathological diagnostic certainty, particularly in view of the broad differential diagnosis.

The main limitations of this study are its retrospective design and the size of the cohort; however, the latter is relative, as this analysis addresses rare forms of spinal infection in children.

CONCLUSIONS

Pyogenic vertebral osteomyelitis without disc involvement is common in late childhood and adolescence, as is the concomitant presence of paraspinal abscesses and the etiological predominance of *S. aureus*. We recommend the application of Ju's algorithm and, in cases of negative blood cultures, bone biopsy for bacteriological and histopathological diagnosis, surgical drainage of soft tissue abscesses, and targeted antibiotic therapy.

With inferential statistics, the variables were analyzed using the Wilcoxon nonparametric rank test and the Pearson correlation coefficient. For bone infection and abscesses, all variables were statistically significant when compared with the final definitive diagnosis (bacteriological or histological), $p < 0.002$.

Conflict of interest: The authors declare no conflicts of interest.

M. E. Moreiro Varela ORCID ID: https://orcid.org/0009-0000-5590-9738
M. G. Miranda ORCID ID: https://orcid.org/0000-0003-4949-9407
M. A. López Friera ORCID ID: https://orcid.org/0009.0006-3788-2133

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