

# Chronic Osteomyelitis Secondary to Paenibacillus azoreducens after a Pencil Penetrating Injury in a Previously Healthy Child

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## Abstract

Paenibacillus azoreducens is a bacterium found in soil and industrial water, known for its ability to reduce complex synthetic dyes. Paenibacillus species infections are rare, opportunistic, often seen in immunocompromised patients. We present the first case report of *P. azoreducens* infection in a previously healthy pediatric patient following a lower back penetrating injury with a pencil. She subsequently developed a chronic draining wound site complicated by chronic osteomyelitis, that required multiple incision and drainage procedures and a prolonged antimicrobial therapy course. A pencil piece was retrieved and P. azoreducens was isolated from the sample via Matrix-assisted laser desorption ionization-time of flight (MALDI-TOF), sensitivity testing guided antibiotic treatment. This case contributes to the knowledge gap among infections in immunocompetent pediatric patients as Paenibacillus has not been reported in immunocompetent patients. It is important for clinicians to maintain a high index of suspicion of rare pathogens associated with chronic infections as early identification allows targeted antimicrobial therapy. Awareness will contribute to understanding of management in unusual infections in the pediatric population.

Keywords: Paenibacillus; Osteomyelitis; Penetrating injury; Rare infection

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#### 1. Introduction

*Paenibacillus azoreducens* is a spore-forming, motile, facultative anaerobic, gram-positive rod found in soil and industrial wastewater [1,2]. *Paenibacillus* are well-known for the promotion of plant growth, utilization as biofertilizer, and its antimicrobial properties in medicine [1,3]. Several *Paenibacillus* species have been implicated in human infections in immunocompromised settings including chronic kidney disease, sickle cell disease, Whipple's disease, chronic interstitial nephropathy, and acute lymphoblastic leukemia [1]. Other species of *Paenibacillus* have been isolated from wound infections in the post-traumatic setting [4] and in other multiple clinical settings in pediatric and adult patients [5,6]. *P. azoreducens* has not been reported as a source of human infection in the past to our knowledge. We present the first reported case of *P. azoreducens* infection in a previously healthy pediatric patient following a penetrating lower back injury with a pencil.

#### 2. Case Description

A 9-year-old female with no significant past medical history fell and impaled her lower back with a pencil while doing acrobatics at home; an initial lower back X ray at her primary care provider office did not show a foreign body, or signs of infection and she was sent home on oral cephalexin for 10 days. Four months later, a "knot" appeared near the injury site. An incision and drainage (I&D) was performed from a collection noted at the site of the injury but no sample was sent for microbiological identification. She was sent home on a 10-day course of amoxicillin/clavulanic acid.

Over the next four months, she continued to have intermittent drainage from the injury site, only one an ultrasound was done showing a 2 cm complex fluid collection that was drained but no sample was sent for microbiologic identification. Subsequent I& D procedures with discarded samples followed. Therefore, she received multiple courses of antimicrobials including amoxicillin and trimethoprim sulfamethoxazole over several months with only partial resolution of symptoms.

Nine months after her initial injury, a magnetic resonance imaging (MRI) of lumbosacral plexus with and without contrast showed a retained foreign body positioned along the dorsal aspect of the right fifth lumbar lamina (L5) and projecting medially into the L4-L5 interspinous ligament (FIG. 1-5). Multifocal chronic osteomyelitis with suspected early involucrum formation involving the right L5 vertebral body, a 0.7 cm  $\times$  0.8 cm  $\times$  0.8 cm peripherally enhancing fluid collection inferolateral to the right transverse process of L5, and an adjacent small soft tissue abscess were seen. The patient was admitted to our institution for further management.

On admission, vital signs included temperature  $36.2^{\circ}$ C, heart rate 75 bpm, blood pressure 114/77, and respiratory rate 20 breaths/min. Physical examination was unremarkable except for evidence of pain to palpation in the sacral area with a small 3 cm x 2 cm scar in process of healing without evident purulent discharge. Of note, her neurological exam showed normal cranial nerves examination from II-XII, normal motor exam with strength 5/5, no pronator drift, and intact sensory exam.

Laboratory results included a white blood cell count (WBC) of 13,700 c/mm3 (reference range (RR): 4.5 - 11.0 thous/mm<sup>3</sup>), neutrophils 95% (RR 20%-55%), lymphocytes 11% (RR 30%-65%), hemoglobin 10.8 g/dL (RR 11-16 g/dL). Erythrocyte sedimentation rate (ESR) 36 mm/hr, (RR 0-19 mm/hr) and C-reactive protein (CRP) 0.541 mg/dL (RR 0.00-0.50 mg/dL). Basic Metabolic Panel showed blood urea nitrogen of 7 mg/dL (RR 9-23 mg/dL), creatinine of 0.36 mg/dL (RR 0.6-1.0 mg/dL),

aspartate transaminase (AST) of 28 U/L (RR: 11-35 U/L), alanine transaminase (ALT) of 40 U/L (RR 10-49 U/L), total bilirubin of 0.2 mg/dL (RR 0.3-1.2 mg/dL) Methicillin-resistant staphylococcus aureus (MRSA) and methicillin-sensitive staphylococcus aureus (MSSA) polymerase chain reaction (PCR) from nares were negative on admission.



FIG. 1. Post contrast axial T1, fat saturated. Multifocal chronic osteomyelitis involving the right L5 vertebral body. Involvement of the right greater than left L5 and L5 posterior elements.



FIG. 2. Post contrast axial T1 fat saturated. Retained foreign body positioned along the dorsal aspect of the right L5 lamina and projecting medially into the L4-L5 interspinous ligament. Additional small discrete focus of susceptibility just inferolateral to the right transverse process of L5 with adjacent peripherally enhancing fluid collection, measuring 0.7 cm × 0.8 cm × 0.8 cm, concerning for additional small focus of foreign body and adjacent small soft tissue abscess.



FIG. 3. Axial T2 with pencil fragment transitioning between the spinous processes of L4 and L5. Mixed signal intensity elongated conical structure, with central core of hypointense susceptibility signal, located at the L4-L5 interspinous region and projecting along the dorsal aspect of the L5 lamina, measuring approximately 3.3 cm × 0.8 cm

 $\times$  5.3 cm.



FIG. 4. Sagittal post contrast T1 fat saturated demonstrating epidural enhancement of infectious process ascending to approximately the L3 L4 disc level, most consistent with epidural phlegmon. Abnormal enhancement of the L5 vertebral body secondary to osteomyelitis.



FIG. 5. T1 post contrast fat saturated coronal plane showing L5 osteomyelitis.



FIG. 6. Sagittal post contrast T1 showing decreased phlegmon and resolved sinus tract over time from right to left. Posteriorly projecting cutaneous sinus tract extending posteriorly to the left para midline soft tissues as well as sinus tract projecting anteriorly to the L5 vertebral body (Figure 6c).

Patient underwent a lumbar abscess incision and drainage with removal of the foreign body and resection of the L4-5 spinous processes. A pencil fragment found within the L4-5 interspinous space was removed entirely (Figure 7). Samples collected from the abscess drainage in the operating room as well as the pencil fragment removed were sent to the microbiology laboratory for identification. The surgical procedure was performed without any complications, and she was started on cefepime and vancomycin intravenously (IV) awaiting organism identification and sensitivity report.

On post operative day two, a peripherally inserted central catheter (PICC) was positioned. She was afebrile with down trending CRP. Vancomycin was stopped and the patient was sent home on day 4 with IV ceftriaxone to manage focal chronic osteomyelitis with an unknown organism; a sample taken from the I&D procedure did not grow any organism, so a decision

was made to submit the pencil piece retrieved during the surgical procedure to the microbiology lab for aerobic/anaerobic bacterial cultures.



FIG. 7. Piece of pencil removed during surgical procedure sent for final microbiological identification.

On day four of culture, growth of a gram-positive bacilli was reported on aerobic culture media, and the organism was further identified by Matrix-assisted laser desorption ionization–time of flight (MALDI-TOF) mass spectrometry as *P. azoreducens*. Sensitivity testing was performed at Mayo reference laboratory and reported for clindamycin with minimal inhibitory concentration (MIC) of 2, interpreted as intermediate (I), Trimethoprim/sulfamethoxazole (TMP) MIC  $\leq 0.5/9.5$  interpreted as Susceptible (S) and vancomycin MIC of 4 also interpreted as (S). The sensitivity report coincided with a patient visit to the Emergency Department with tenderness to deep palpation of the upper quadrant and an evaluation with a CT scan of the abdomen showing multiple small stones in the gallbladder extending to the level of the cystic duct and small calcifications 2-3 mm in the distal common bile duct without associated obstruction. HerAST level increased to 160 U/L, ALT increased to 441 U/L, and CRP of 0.501 mg/dL.

These changes were interpreted as possible toxicity from the use of Ceftriaxone, this medication was discontinued, and the patient was transitioned to oral TMP-SMX based on sensitivity reports. One week later, the AST and ALT have normalized to 26 U/L, and 53 U/L respectively and her CRP was <0.1 mg/dL; the patient reported no prominent side effects from TMP-SMX. A repeated Lumbar spine MRI three months after initial admission reported interval improvement in changes of osteomyelitis, interval decreased size of remnant peripherally enhancing fluid collection adjacent to the L5 right transverse process, and interval decreased epidural phlegmon, mildly decreased right L4-L5 zygapophyseal infectious synovitis (FIG. 6). Her last MRI was done seven months after the initial admission showing reported as continued improvement of osteomyelitis and soft tissue inflammatory changes, resolution of peripherally enhancing fluid collection inferolateral to the right L5 transverse process, no residual epidural phlegmon and resolution of right L4-L5 zygapophyseal infectious synovitis. Patient received TMP/SMX for a total of 6 months with good tolerance and compliance.

### 3. Discussion

This case highlights the isolation of a rare species, *P. azoreducens*, secondary to a penetrating trauma. It adds to the knowledge gap regarding this infection in an immunocompetent pediatric patient as most infections are seen in immunocompromised individuals. *Paenibacillus turicensis* has previously been reported following a type II open fracture secondary to a traumatic

accident in an adult patient [7]; *Paenibacillus thiaminolyticus, Paenibacillus alvei,* and *Paenibacillus dendritiformis* were reported as sources of neonatal sepsis and meningitis [6]; *P. thiaminolyticus* was reported in the settings of cytomegalovirus coinfection [8] and post-operative hematoma [9]. However, *P. azoreducens* has not been implicated in any of these cases.

Due to the limited cases reported, treatment recommendations for *Paenibacillus* infections are not well-established. In this case, successful management was achieved following both surgical removal of the foreign body and prolonged antibiotic therapy after susceptibility testing. Our patient's isolated organism exhibited vancomycin and trimethoprim-sulfamethoxazole sensitivity but clindamycin resistance. The antimicrobial susceptibility profile for this organism has shown a wide range of resistance to ampicillin, cotrimoxazole, cefotaxime, vancomycin, rifampicin, and erythromycin [4]. This susceptibility profile further differs based on the specific species of the genus *Paenibacillus*. Due to significant variability in susceptibility response to antimicrobials used to treat these infections, empiric treatment may not provide adequate coverage.

It is important for clinicians to consider other organisms in the differential diagnosis for chronic osteomyelitis, particularly in penetrating injuries with organic materials. Having a high index of suspicion increases the likelihood of earlier thorough evaluation of a non-healing wound site. Our patient experienced a penetrating trauma that progressed to chronic osteomyelitis. However, earlier advanced imaging and microbiological testing could have delayed this progression, and could have contributed to timely diagnosis and treatment, reducing patient morbidity

# 4. Conclusion

Penetrating injuries with retained foreign bodies can lead to chronic infections with uncommon organisms, even in immunocompetent patients. This case highlights the critical importance of a thorough initial evaluation, advanced imaging, and microbiological sampling during surgical interventions. Clinicians should maintain a high index of suspicion with rare pathogens in these scenarios to attain early identification of the causative organism. This facilitates early targeted antimicrobial therapy and surgical interventions.

## 5. Authorship Contribution Statement

Alisha Patel: writing – original draft, writing – review and editing, Ali Abolhassani: writing – original draft, writing – review and editing, Srilatha Neshangi: writing – review and editing, Justin Nguyen: writing – review and editing, Stephen Schaffner: writing – review and editing, Nirupma Sharma: writing – review and editing, Ingrid Camelo: writing – review and editing.

## 6. Conflict of Interest

The authors declare no potential conflict of interest.

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