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Delayed Staphylococcus Epidermidis Infection Presenting as Chronic Low Back Pain after Percutaneous Vertebroplasty: A Case Report and Literature Review

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Abstract: *Percutaneous vertebroplasty (PVP) is a established minimally invasive technique for treating osteoporotic vertebral compression fractures, offering advantages such as minimal trauma and rapid recovery. However, delayed postoperative infection, though rare (incidence 0.1% - 2.5%), remains a significant clinical challenge due to its insidious symptoms and the diagnostic interference caused by bone cement artifacts, which often lead to misdiagnosis as nonunion or spinal tumors. While antibiotic-loaded bone cement (ABC) is widely used to prevent implant-related infections, "breakthrough infections" have emerged as a new clinical hurdle . We report a case of a 76-year-old female with type 2 diabetes who developed a delayed Staphylococcus epidermidis infection 6 months post-PVP, in which antibiotic-loaded bone cement was not used. Initial infectious signs were missed, leading to disease progression. Diagnosis was confirmed through MRI, vertebral puncture biopsy, and bacterial culture. A comprehensive strategy comprising surgical debridement, 0.35% povidone-iodine irrigation, sequential sensitive antibiotic therapy (intravenous vancomycin followed by oral moxifloxacin for 6 weeks), anti-osteoporosis treatment, and standardized blood glucose management led to significant pain relief (VAS score decreased from 8 to 2 at 4 weeks postoperatively), normalization of inflammatory markers (ESR, CRP), and no recurrence at the 3-month follow-up. Drawing on relevant literature, this article systematically discusses the clinical features and key differential diagnoses of delayed PVP infection caused by S. epidermidis. We specifically analyze the prophylactic value of ABC, the mechanisms of "breakthrough infections," and the efficacy of our combined treatment strategy, aiming to enhance clinical awareness and improve management of this condition.*

Keywords: *Percutaneous vertebroplasty(PVP); Delayed postoperative infection; Staphylococcus epidermidis*

1. Introduction

Osteoporotic vertebral compression fractures are common in the elderly. Percutaneous vertebroplasty (PVP), which involves injecting bone cement into the fractured vertebra to rapidly restore stability and alleviate pain, has become a preferred minimally invasive treatment [5,13,27,28]. Despite its advantages, complications such as infection, cement leakage, and adjacent vertebral fractures can occur [2,8,24]. Postoperative infections are categorized as acute (within 1 month) or delayed (more than 1 month post-surgery), with the latter accounting for approximately 30% of cases and presenting significantly greater diagnostic and therapeutic challenges compared to acute infections. Delayed infections often lack typical acute signs like fever or local erythema, with chronic low back pain frequently being the sole clinical symptom. This can easily be mistaken for residual postoperative pain, cement loosening, Kummell's disease (vertebral nonunion), or spinal tumors [7]. Furthermore, high-density artifacts from bone cement can obscure infectious signals on conventional imaging, increasing diagnostic difficulty [6]. Staphylococcus epidermidis, a common skin commensal, is a frequent pathogen in delayed PVP infections [1]. It can contaminate the surgical tract during the procedure, colonize the cement-bone interface, and form biofilms, evading host immune clearance and causing chronic infection [4]. Failure to diagnose and treat such infections promptly can lead to progressive vertebral destruction, spread of infection, and may necessitate open surgical debridement, severely impacting patient prognosis [12]. Antibiotic-loaded bone cement (ABC) is designed to release antibiotics locally over time, creating a high-concentration microenvironment that inhibits bacteria introduced during surgery, thereby reducing

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postoperative infection risk [22]. This is particularly beneficial for high-risk patients, such as the elderly, diabetics, or immunocompromised individuals [14]. However, the prophylactic effect of ABC is not absolute, and the occurrence of "breakthrough infections" presents a new clinical hurdle [16]. Therefore, by presenting a typical case and reviewing related literature, this article aims to explore the differential diagnosis, treatment strategies, and rational use of ABC in delayed S. epidermidis infections post-PVP, thereby enhancing clinical awareness and management proficiency.

2. Case Report

2.1. General Information

A 76-year-old female presented in March 2025 with "persistent low back pain for 6 months following PVP." Her medical history included type 2 diabetes mellitus for over 20 years with suboptimal glycemic control (fasting blood glucose 8-10 mmol/L). In October 2024, she underwent PVP for an L1 vertebral compression fracture at a local hospital. Initial postoperative pain relief was significant (VAS score 2), but pain gradually worsened starting one month after surgery, reaching a VAS score of 8. The pain was predominantly nocturnal, without significant exacerbation upon activity, and no associated lower limb radicular pain, numbness, or bowel/bladder dysfunction.

2.2. Diagnostic Workup

The patient was admitted to our hospital for further evaluation of the worsening pain.

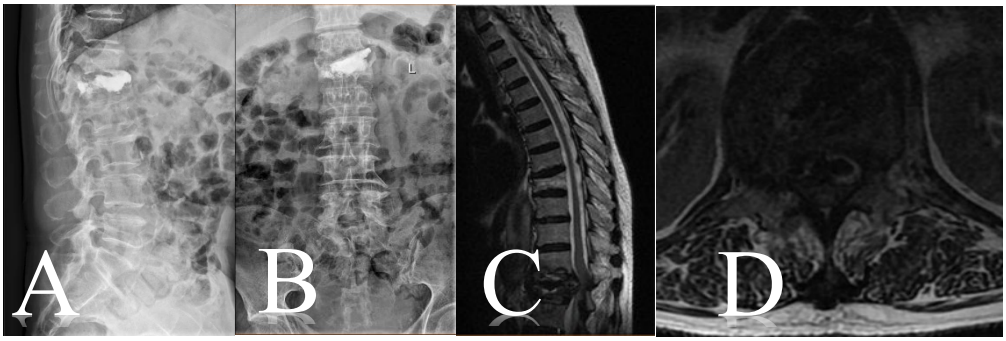
2.3. Physical Examination

Temperature 36.5°C, heart rate 92 bpm, respiratory rate 16 bpm, blood pressure 158/85 mmHg. Normal spinal curvature. Tenderness and percussion pain were elicited over the L1 spinous process and paravertebral muscles, without local erythema or increased warmth. Lower limb sensation, motor function, and pathologic reflexes were normal.

2.4. Auxiliary Examinations

2.4.1. Imaging

As shown in Figure 1A and 1B, lumbar spine X-ray showed post-PVP changes at L1 with uniform cement distribution; spotty calcifications were noted along the abdominal aorta. Figures 1C and 1D (thoracic spine MR) revealed morphological abnormality of the L1 vertebra with heterogeneous internal signals and hypointense areas, spinal canal stenosis at the L1 level, and Figures 1E, 1F, and 1G (lumbar spine CT) further demonstrated compression of the conus medullaris, and slightly tortuous cauda equina. Subsequent bone densitometry revealed a T-score of -2.2 at the lumbar spine and proximal femur, consistent with osteopenia (WHO criteria).



A-B: The lumbar spine DR shows intravertebral canal leakage of cement at the L1 level in the shape of a long bar.

C-D: The thoracic spine MR shows infection with paraspinal abscess formation, stenosis of the corresponding segment, and compression and degeneration of the spinal cord after L1 vertebroplasty .

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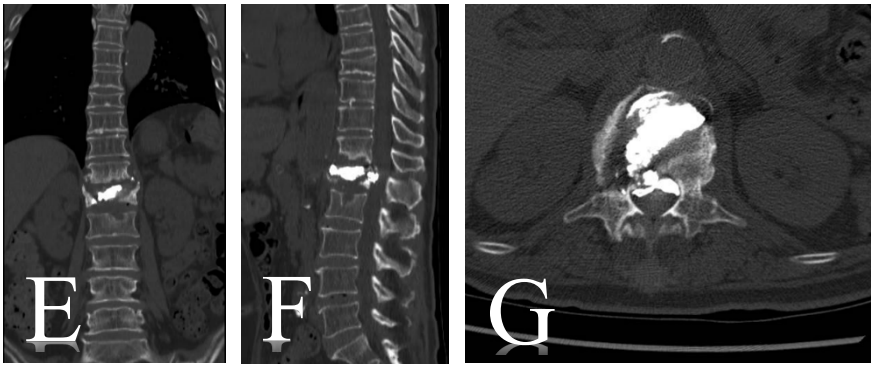

E-G: the lumbar spine CT shows intravertebral canal occupation and compression of the spinal canal.

Figure 1: DR, MR, CT scan showing cemented intravertebral

2.4.2. Laboratory Tests

Complete blood count: WBC 8.68×10^9/L, neutrophils 60.0%. ESR 101 mm/h, CRP 19.2 mg/L, Procalcitonin (PCT) 0.076 ng/mL. Mycobacterium tuberculosis antibody test was positive, but T-SPOT.TB test was negative, effectively ruling out tuberculous infection.

2.4.3. Microbiology

CT-guided percutaneous needle biopsy of the L1 vertebra was performed. Histopathology showed chronic inflammatory cell infiltration with fibrous tissue hyperplasia. Bacterial culture grew Staphylococcus epidermidis (methicillin-sensitive strain). Antimicrobial susceptibility testing indicated sensitivity to moxifloxacin, vancomycin, and rifampicin.

2.5. Diagnosis and Treatment

2.5.1. Diagnosis

Based on the history of PVP, long-standing diabetes, chronic low back pain (nocturnal predominance), imaging findings (characteristic ring enhancement on fat-suppressed contrast-enhanced MRI, locally increased metabolism on PET-CT), and positive bacterial culture, the final diagnosis was "delayed vertebral infection (Staphylococcus epidermidis) following percutaneous vertebroplasty."

2.5.2. Treatment Strategy

A combined modality approach was adopted:

1) Antimicrobial Therapy: Based on susceptibility results, intravenous vancomycin (1g q12h) was initiated. After 2 weeks, therapy was switched to oral moxifloxacin for a total course of 6 weeks. Renal and hepatic function, along with drug levels, were monitored regularly.

2) Surgical Debridement: Following preoperative localization, a layered approach was used to expose the L1 vertebra. Significant purulent granulation tissue was observed, with part of the bone cement protruding into the spinal canal and compressing the cord. The diseased vertebral tissue and displaced cement were piecemeal removed. The lesion was thoroughly irrigated with 0.35% povidone-iodine (PVP-I) solution to eliminate necrotic tissue and infection. Autologous bone graft from the left anterior superior iliac spine was used for reconstruction to restore vertebral height and stability. After confirming absence of residual cement and satisfactory graft position, a drain was placed for 24 hours.

2.5.3. Treatment Outcome

One week post-surgery, the patient's VAS score decreased to 4, with significant pain relief. Postoperative CT (Figure 2) shows that the decompression of the posterior lamina of L1 is complete, with no compression of the posterior aspect of the spinal canal, and improved paravertebral abscesses. At 4 weeks, VAS score was 2, and ESR/CRP levels normalized. At 6 weeks, follow-up MRI showed resolution of vertebral inflammation, and bacterial cultures were negative. At the 3-month follow-up, the patient remained pain-free with no signs of infection recurrence and was able to perform daily activities independently.

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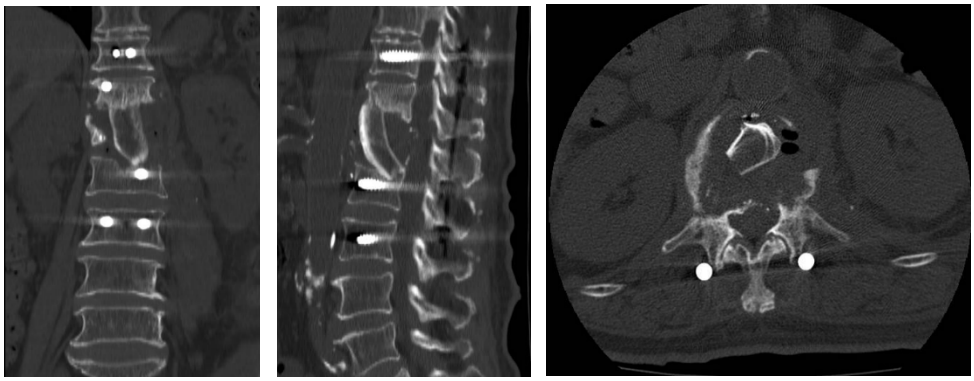

CT shows that the decompression of the posterior lamina of L1 is complete, and there is no compression of the posterior aspect of the spinal canal.

Figure 2: Postoperative imaging suggests no spinal cord compression and improved paravertebral abscesses

3. Discussion

3.1. Differential Diagnosis: Distinguishing Infection from Nonunion and Tumor

3.1.1. Distinction from Kummell's Disease

Kummell's disease is characterized by intravertebral vacuum cleft, progressive collapse, and pain typically exacerbated by activity and relieved by rest. Inflammatory markers (ESR, CRP) are usually normal, and MRI typically shows signal changes confined around the fracture line [7]. In contrast, infectious pain often presents as nocturnal pain at rest, unrelated to position, accompanied by elevated ESR and CRP. Fat-suppressed contrast-enhanced MRI typically reveals diffuse bone marrow edema and ring enhancement [11]. Importantly, in cases of "breakthrough infection" following ABC implantation, the elevation in inflammatory markers may be less pronounced than in infections without ABC, potentially complicating differentiation [23].

3.1.2. Distinction from Spinal Tumors

Spinal tumors often present with systemic symptoms like weight loss, anemia, and progressively worsening nocturnal pain. PET-CT typically shows a hypermetabolic focus and possible distant metastases. Puncture biopsy reveals tumor cells [11]. Infectious lesions usually show relatively milder metabolic activity without systemic metastases. Biopsy reveals chronic inflammatory cell infiltration, and bacterial culture identifies the causative organism [3]. In suspected "breakthrough infection" cases with ABC where PET-CT findings are atypical, definitive diagnosis relies on bacterial culture and histopathology [19]. Puncture biopsy has >95% accuracy in ruling out spinal tumors and remains the gold standard for differentiation[11].

3.1.3. Optimizing Imaging Strategies

Bone cement artifacts are a major cause of missed infections. Both antibiotic-loaded and plain bone cement share similar high-density characteristics that can obscure infectious signs on conventional imaging [6]. A multi-modal imaging approach enhances diagnostic accuracy:

Fat-suppressed contrast-enhanced MRI can penetrate cement artifacts, clearly visualizing bone marrow edema, soft tissue inflammation, and ring enhancement indicative of infection [6].

3.2. Prophylactic Role of Antibiotic-Loaded Cement and Mechanisms of "Breakthrough Infection"

3.2.1. Preventive Value of Antibiotic-Loaded Cement

Antibiotic-loaded bone cement (ABC) releases antibiotics locally over time, creating a high-concentration environment that inhibits contaminating bacteria during surgery, thus reducing early postoperative infection risk [22]. Studies suggest that using ABC in minimally invasive spine surgery can reduce infection rates by 30%-50% [9], particularly benefiting high-risk patients (e.g., elderly, diabetics, immunocompromised) [14]. Commonly used antibiotics include vancomycin and gentamicin, with spectra covering typical PVP pathogens like S. epidermidis and S. aureus[22]. However, ABC's preventive effect

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is not absolute, and "breakthrough infections" pose a clinical challenge [16].

3.2.2. Mechanisms of "Breakthrough Infection"

Bacterial Biofilm Formation: S. epidermidis can contaminate the surgical site, colonize the ABC-bone interface, and form biofilms composed of extracellular polysaccharides . Biofilms protect bacteria from antibiotics and host immune cells; even antibiotics released from ABC may fail to penetrate the biofilm effectively, leading to chronic, indolent infection [1,4]. This is a core mechanism of "breakthrough infection."Antimicrobial Resistance: Prolonged use of ABC containing a single antibiotic may induce bacterial resistance [16]. For instance, long-term use of vancomycin-loaded cement could select for vancomycin-resistant strains, rendering the prophylaxis ineffective [1]Altered Antibiotic Elution Kinetics: Antibiotic elution from ABC is highest early after implantation, declining progressively, often falling below effective concentrations within weeks[22]. For delayed infections occurring months later, as in this case, the local antibiotic levels are likely sub-inhibitory, creating a window for "breakthrough infection."

3.3. Rationale and Efficacy of the Treatment Strategy

The successful outcome using "surgical debridement + povidone-iodine irrigation + sequential sensitive antibiotics" in this case supports its applicability, even for "breakthrough infections" involving ABC. The rationale includes:

0.35% PVP-I can disrupt S. epidermidis biofilms, possesses broad-spectrum activity, and has a low propensity for inducing resistance, offering advantages over traditional saline irrigation [3,4,15,18] .PVP-I acts by slowly releasing free iodine, exerting microbicidal effects while effectively penetrating and disrupting biofilms [4,17]. This is particularly relevant for overcoming biofilm-mediated resistance in "breakthrough infections." Additionally, PVP-I exhibits good tissue biocompatibility at low concentrations (0.35%-1.0%) and is suitable for intraoperative irrigation [10,17].

3.4. Preventive Strategies: Optimizing ABC Use and Infection Control

3.4.1. Rational Use of Antibiotic-Loaded Cement

1) Strict Indications: Reserve ABC primarily for high-risk patients (elderly, diabetics, immunocompromised, chronic steroid users) [14]. Routine use in low-risk patients is discouraged to avoid unnecessary antibiotic exposure and resistance development [16].

2) Appropriate Antibiotic Selection: Choose antibiotics based on local resistance patterns. Consider using combination therapy (e.g., vancomycin + gentamicin) to broaden antimicrobial coverage and reduce resistance risk, rather than single antibiotics[22].

3.4.2. Enhanced Intraoperative Infection Control

1) Employ alcohol-based povidone-iodine skin antisepsis. Irrigate the puncture tract with 0.35% PVP-I before cement injection to effectively reduce contamination by skin flora [3,20,21]. Studies show that intraoperative PVP-I irrigation can reduce postoperative infection rates by over 50% [14]and may enhance preventive effects when combined with ABC. While chlorhexidine-based preparations have shown advantages in certain settings such as nasal decolonization, alcohol-based povidone-iodine remains a reliable choice for percutaneous spinal procedures [25,26].

2) Maintain strict aseptic technique, minimize the number of puncture attempts, and avoid enlarging the puncture tract to reduce bacterial ingress [6]. Higher aseptic standards are necessary when implanting ABC to prevent contamination leading to "breakthrough infection."

3) Shorten operative time and minimize cement exposure to air to decrease contamination probability [9].

4. Conclusion

Delayed postoperative infection caused by Staphylococcus epidermidis following PVP is a rare but insidious complication. While antibiotic-loaded bone cement (ABC) reduces early infection risk, "breakthrough infections" pose an emerging clinical challenge, primarily driven by biofilm formation, antibiotic resistance, and elution kinetics. These infections are easily mistaken for nonunion or tumors, necessitating a combination of fat-suppressed contrast-enhanced MRI, PET-CT, and puncture biopsy for accurate diagnosis [11,19]. The strategy of "surgical debridement + povidone-iodine irrigation + sequential

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sensitive antibiotics" is effective for managing both plain cement infections and ABC-associated "breakthrough infections." Clinicians should rationally utilize ABC ,optimize perioperative infection control and postoperative surveillance , and enhance awareness of "breakthrough infections" to minimize misdiagnosis , improve patient outcomes, and refine preventive approaches.

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