

Rare Emphysematous Osteomyelitis of the Femoral Head: A Case Report and Literature Review

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Abstract: Emphysematous osteomyelitis (EO) is a perilous infection of the femoral head. In this case, we present a 66-year-old male patient of Han ethnicity, who had lumbar disc herniation and type 2 diabetes mellitus. The patient reported severe pain in his lower back and right lower limb, which had worsened over the past 20 days. Despite undergoing invasive procedures such as regional anesthetic blocks and other traditional Chinese medical methods such as acupuncture and acupotomy, his condition deteriorated. Pain in the lumbar region was not relieved, and there was a new onset of pain in the right hip, groin, and thighs. Preliminary medical evaluation revealed normal body temperature but elevated levels of the inflammatory marker high-sensitivity C-reactive protein (hsCRP). In the imaging tests, computed tomography revealed air bubbles within the right femoral head, corresponding to the EO. Diabetes mellitus and malignant neoplasms have been well-established as predominant risk factors for EO, while iatrogenic interventions may serve as potential precipitating factors in disease pathogenesis. Our report underlines the critical role of radiologists in identifying EO through distinctive imaging features, such as the “pumice stone” sign. This highlights the need for further research to enhance our understanding, diagnosis, and management of EO.

Keywords: emphysematous osteomyelitis, MRI, CT, acupotomy, diabetes

Introduction

Emphysematous osteomyelitis (EO) is a fatal infection triggered by gas-producing bacteria and is particularly rare in the femoral head.^{1,2} Improving the prognosis depends crucially on early diagnosis and intervention. EO is caused by anaerobic bacteria or members of the *Enterobacteriaceae* family.^{3,4} Infection may arise from haematogenous dissemination originating from an intra-abdominal source, as well as from cutaneous or soft tissue infections.^{5–7} Traditional Chinese medicine, which utilizes acupuncture and acupotomy, may increase the risk of the haematogenous spread of this infection. The treatment of EO typically includes a combination of broad-spectrum intravenous antibiotics, surgical drainage or debridement, and supportive care.^{8,9} Herein, we report the case of a patient with EO, diabetes, and hypertension. After undergoing invasive procedures for lumbar disc herniation, the patient exhibited worsening symptoms and developed a systemic infection. A typical “pumice stone” sign was observed on the Computed Tomography images. Previous research has rarely mentioned EO from iatrogenic injuries using traditional Chinese medicine methods. Our case emphasizes the caution in using traditional Chinese medicine treatment for patients at risk of EO, and early diagnosis and intervention for EO.

Case Presentation

A 66-year-old male presented to our hospital with intermittent lumbar and right lower-limb pain that had persisted for 13 years. Initially diagnosed with lumbar disc herniation, his symptoms progressively worsened over the previous three months. The patient self-administered regional anesthetic blocks multiple times. Despite undergoing treatments such as

acupuncture and acupotomy approximately 20 days prior to presentation, his symptoms worsened. His lumbosacral pain escalated and radiated to his right hip, groin, and thigh. This worsening pain coupled with numbness in his right calf disrupted his sleep. His pre-existing hypertension was controlled with 2.5mg of Amlodipine Besylate (QD), and he reported good blood pressure management.

The neurologic exam yielded normal results. Further tests revealed hyperglycemia (8.3 mmol/L), elevated glycated hemoglobin (HbA1c, 7.4%), leukocytosis ($16.9 \times 10^9/L$ with 76.3% neutrophils), increased high-sensitivity C-reactive protein (CRP, 41.49 mg/L), and elevated erythrocyte sedimentation rate (ESR, 82.6 mm/h). Upon re-examination, the patient's fasting blood glucose was 7.8 mmol/L, and HbA1c was 7.4%. The two-hour postprandial glucose level was 7.9 mmol/L, indicating type 2 diabetes. It is recommended that the patient follow the dietary principles for diabetes and be provided with low glycemic index, complete nutrients while monitoring blood glucose levels. Since subsequent blood glucose levels remained stable, pharmacological treatment has been temporarily deferred, and the patient will continue with dietary management. Urinalysis, urine cytometry, and blood cultures all fell within normal ranges.

Radiography showed no notable osteolytic changes or abnormal densities in the femur, except for insufficient concavity of the right femoral neck (Figure 1A). Computed Tomography (CT) revealed multiple intraosseous gases with diameters ranging from 1 to 3 mm in the right femoral head (white arrows). This finding aligns with the typical EO “pumice stone” sign. Additionally, effusion was observed in the surrounding joint cavity (Figure 1B and C). Axial fat-saturation T2WI Magnetic Resonance Imaging (MRI) of the bilateral hip revealed extensive edema in the right hip (white arrows), accompanied by soft tissue swelling and edema in the left femoral head and neck (arrowhead) (Figure 2A and B). Contrast-enhanced T1WI MRI images showed ring-enhancing lesions in the soft tissue (black arrows), in keeping with abscess (Figure 2C).

To further identify the infecting microorganisms, the patient underwent a CT-guided puncture and aspiration of the right hip joint. Pathological diagnosis showed fibrous adipose tissue and granulation tissue, many acute and chronic inflammatory cells infiltrating the stroma (Figure 3A), and local necrosis (Figure 3B).

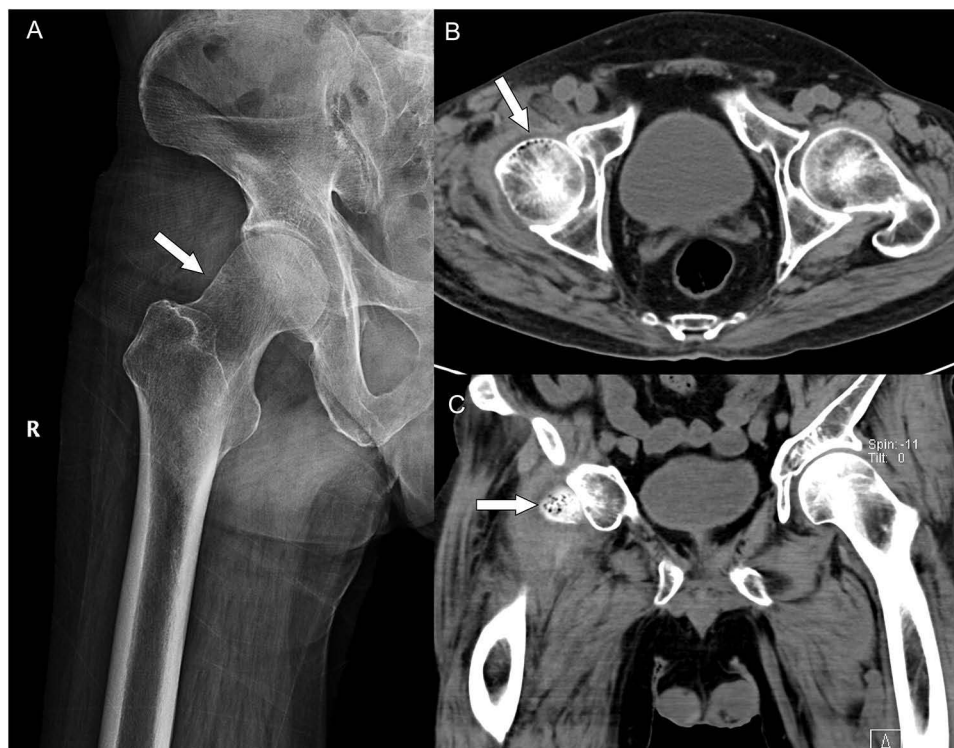


Figure 1 X-ray and CT images of the Hip. The anteroposterior radiograph of the right hip (A) shows no notable osteolytic changes or abnormal densities in the femur, except for a reduced concavity of the right femoral neck. Axial (B) and coronal (C) CT images of both hips reveal multiple intraosseous gas bubbles, ranging from 1 to 3 mm in diameter, within the right femoral head (white arrows), as well as effusion in the surrounding joint cavity.

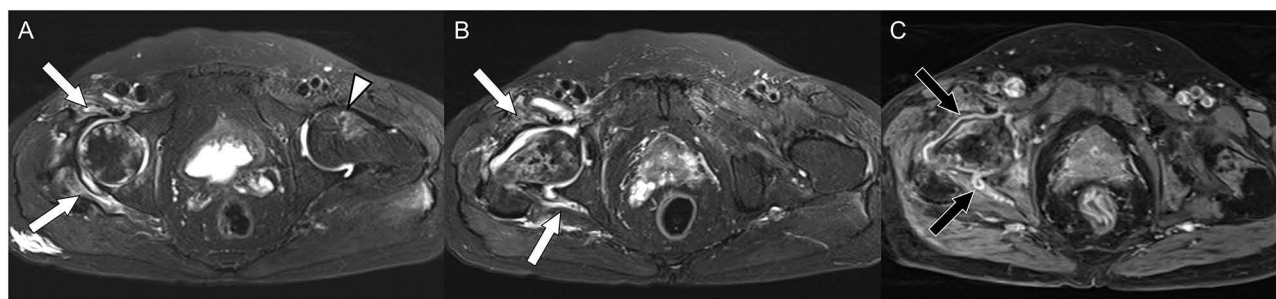


Figure 2 MRI images of the bilateral Hip. Axial fat-saturation T2WI images (**A** and **B**) show extensive edema and surrounding soft tissue swelling in the right hip joint (white arrows), with additional edema observed in the left femoral head and neck (arrowhead). Contrast-enhanced T1WI images (**C**) reveal ring-enhancing lesions in the soft tissue, consistent with an abscess (black arrows).

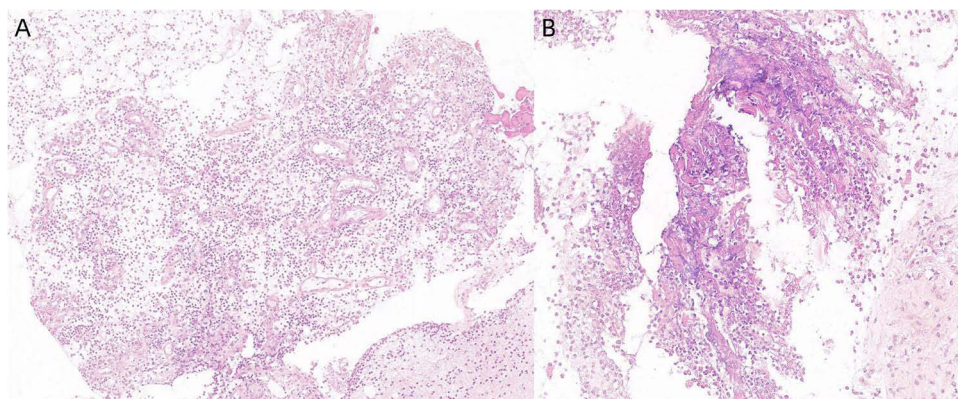


Figure 3 Microphotograph of histopathology findings (H&E stain) obtained during puncture and aspiration of the right Hip joint. (**A**) Granulation tissue composed by fibroblasts, capillaries and a certain number of inflammatory cells (magnification, $\times 50$). (**B**) Necrotic tissue (magnification, $\times 100$).

Owing to the patient's long-term misuse of steroid hormones, both his blood culture and puncture results were negative. The patient reported having self-administered more than 30 regional anesthetic blocks, each containing 10mg of dexamethasone (specific treatment details unclear). Chronic use of corticosteroids can suppress the immune response, which may impair the body's ability to mount an adequate defense, potentially leading to negative culture results. As a result, standard microbiological tests, such as blood cultures and puncture testing, may fail to identify the causative pathogens. Empiric antibiotic therapy targeting anaerobes and *Enterobacteriaceae* was initiated, comprising 0.6g of intravenous clindamycin phosphate and 3g of intravenous cefoxitin sodium every 12 hours. This resulted in the alleviation of his symptoms and gradual normalization of inflammatory markers, consequently leading to his discharge one week after post-admission.

Discussion

This report underscores the importance of closely monitoring patients with potential risk factors for emphysematous osteomyelitis (EO), such as diabetes and hypertension, to prevent complications from invasive procedures. We present the case of a patient diagnosed with diabetes upon admission, with a history of hypertension, who developed iatrogenic EO following traditional Chinese medicine (TCM) treatments, including acupuncture and acupotomy. The imaging findings for EO are distinct, which allows for early detection and timely empirical antibacterial intervention, thereby reducing the disease's lethality. Therefore, the patient was started on empirical antibiotic therapy prior to pathogen culture and puncture, resulting in rapid symptom relief.

Ram et al initially identified intraosseous gas as an osteomyelitis indication in 1981.¹⁰ Since then, a limited number of EO cases have been reported. EO is considered a specific osteomyelitis type, typically associated with chronic infections in patients with concomitant pathologies. Common causative organisms of EO mirror other gas-forming infections, including *Escherichia coli*, *Klebsiella pneumoniae*, *Fusobacterium necrophorum*, and various *Salmonella species*.^{3,6} Recent literature often finds members of the *Enterobacteriaceae* family in EO cultures, with monomicrobial infections being more prevalent.³ Conversely,

osteomyelitis is a bone infection caused by spread of inflammation in adjacent, bone trauma and hematogenous spread from systemic bacteremia.¹¹ Common pathogens causing osteomyelitis include *Staphylococcus aureus*, *Hemolytic streptococcus*, *Pneumococcus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and others.¹² Among these, *Staphylococcus aureus*, a bacterium commonly associated with skin infections, pneumonia, and sepsis, stands as the most prevalent and devastating causative pathogen.¹¹ Hence, different causative agents in EO and common osteomyelitis may result in varied imaging features and therapeutic approaches. Notably, the pathogens commonly cited in the literature as causes of EO were not identified in our patient's cultures or puncture results. We suspect that this could be attributed to the patient's long-term misuse of steroid hormones, which may have suppressed the immune response and hindered the identification of typical pathogens. Corticosteroid therapy is known to impair immune function, which could have compromised the body's ability to mount an effective defense against infections, thereby influencing the culture outcomes. This highlights the importance of considering a patient's medication history, particularly long-term steroid use, when diagnosing and treating complex infections such as EO.

The most common predisposing risk factors for EO are congenital or acquired immunodeficiency conditions, mainly due to uncontrolled diabetes, current or recently treated neoplasms, and postoperative states.^{3,13} Hyperglycemia can augment pro-inflammatory cells by modifying the differentiation of endothelial progenitor cells, emphasizing diabetes' impact on inflammation's immunological process.¹⁴ Berbudi et al proposed that deficiency in the innate immune response (including neutrophils and macrophages dysfunction) and dysfunction in the adaptive immune response (including T cells) lead to a weakened immune system.¹⁵ Additional predisposing factors encompass a spectrum of clinical conditions and therapeutic interventions, including but not limited to: intravenous substance abuse, corticosteroid administration, chemotherapeutic regimens, pelvic radiotherapy, chronic alcohol dependency, inflammatory bowel disorders, sickle cell disease, and various malignant processes.^{1-3,16,17} The synergistic effect of these comorbid conditions induces profound immunosuppression, consequently elevating the risk of opportunistic pathogen colonization and subsequent infection, with heightened susceptibility to both anaerobic microorganisms and *Enterobacteriaceae* species.

EO can develop through multiple pathogenic pathways, with common primary infection sources including genitourinary tract infections, post-surgical complications following abdominal or spinal procedures, and secondary dissemination from cutaneous or soft tissue infections.⁵⁻⁷ In our case, regional anesthetic blocks and acupotomy may have contributed to the development of EO. Acupotomy is an invasive approach that deploys a knife after an advanced needle to dislodge adhesions, resolve lesions, elevate lumbar function, and suppress inflammation, thereby relieving disease-related symptoms. However, this method can inadvertently damage blood vessels, nerves, and healthy tissues, potentially exacerbating the condition and complicating treatment.¹⁸ One reported case involved a 56-year-old Chinese male who underwent repeated acupotomy therapy and joint corticosteroid injections, resulting in recurring pain and swelling in his right knee.¹⁹ Ultimately, the patient received a diagnosis of recurrent arthritis. Consequently, invasive medical interventions inherently carry the risk of iatrogenic microbial inoculation, potentially serving as a nidus for systemic infection and subsequent complications.

In our case, the patient's condition worsened primarily due to prolonged steroid use, compounded by invasive TCM treatments. Steroids are known to weaken the immune system, making the patient more vulnerable to infections, especially from anaerobic and enteric pathogens. Invasive TCM procedures like acupuncture and acupotomy may have further compromised local immune defenses, creating an environment favorable for infection. This combination of steroids and invasive treatments highlights the importance of careful management in patients with conditions like diabetes. Controlling blood glucose levels, maintaining sterile conditions during procedures, and limiting invasive treatments are essential to reduce the risk of complications like EO. Therefore, effective management of diabetes is essential given that uncontrolled diabetes boosts EO-related mortality rates.³ For diabetic patients, strict adherence to aseptic techniques and judicious limitation of invasive interventions are essential components of comprehensive care management.

Characteristic imaging manifestations of EO typically demonstrate multiple irregularly sized foci of intraosseous gas, pathognomically referred to as the "pumice stone" sign,¹ which exhibits a diagnostic prevalence of approximately 96%. This sign, in conjunction with the absence of cortical destruction and the presence of a sclerotic rim, constitutes a distinctive diagnostic triad for EO identification.^{1,20} Imaging plays a critical role in accurate diagnosis. Radiographs, primarily for screening, depict intraosseous gas as radiolucent areas, but they may miss minor or early cases. CT is the most sensitive modality for diagnosing EO, offering clear visualization of the intraosseous gas distribution type and related soft tissue involvement. While

MRI excels at examining bone edema and soft tissues, it cannot independently validate EO. Intraosseous gases may indicate conditions such as vacuum phenomena, subchondral cysts, injury, chasmic necrosis, bone lymphangiomatosis, substantial negative pressure development, neoplasms, and osteomyelitis due to gas-forming bacteria may be indicated by the presence of intraosseous gas.^{20–22} Given that intraosseous gas is often caused by non-infectious conditions, it is crucial for radiologists to recognize EO promptly to ensure timely intervention. Furthermore, soft tissue emphysema is seen in 79% of EO cases, typically as a complication driven by inflammation and bacterial toxins.¹ However, dense bone and marrow structures often shield soft tissues from direct infection. Bone immune responses, particularly through OsteoMacs (macrophages embedded within bone tissue), play a significant role in managing bacterial invasion.²³ Furthermore, to aid the bone's natural defense mechanisms against bacterial invasions, bone and immune cells employ numerous same pathways and precursors.²⁴ In summary, the protective defense mechanisms of bone tissue prevent bacterial invasion, thereby limiting the occurrence of soft tissue emphysema in most EO cases. In our case, CT revealed irregular intraosseous gas ranging from 1 to 3 mm in the right femoral head, without signs of soft tissue emphysema or cortical bone destruction, aligning with findings reported in the literature.

While traditional CT can detect gas bubbles in EO, spectral CT provides superior visualization of gas formation, which is crucial for diagnosing infections caused by gas-forming bacteria.²⁵ Additional indicators, such as bone marrow edema, cortical destruction, abnormal contrast enhancement, and surrounding fluid collections, further assist in diagnosing infections and informing treatment decisions.² Spectral CT imaging has emerged as a pivotal diagnostic modality for both early detection and comprehensive evaluation of osteomyelitis, offering superior diagnostic capabilities compared to conventional imaging techniques. Conventional imaging techniques like X-rays may fail to detect early bone marrow changes in osteomyelitis until the infection has progressed. In contrast, spectral CT, using three-material decomposition, is more sensitive in detecting bone marrow edema, a critical sign of osteomyelitis. Its tissue differentiation capability allows it to detect subtle changes in bone marrow even before structural damage becomes visible on traditional CT scans. Therefore, spectral CT not only enhances EO diagnosis but also provides more accurate detection of bone marrow edema and gas formation in osteomyelitis, aiding in the assessment of infection presence and severity.

In cases of acute EO, prompt diagnosis, and timely antibiotic treatment are crucial for effectively managing this complex infectious disease.²⁶ Early identification of the causative pathogen and its antibiotic sensitivity is key, with blood culture and puncture offering significant information. If the pathogen remains unknown, empiric antibiotics that act against anaerobes and *Enterobacteriaceae* should be instantly given.²⁷ There appears to be a correlation between surgical debridement and survival rate, as 66.7% survival rate among those who received surgical intervention, compared to the 43% of deceased patients underwent surgery.³ Current data reveals an overall mortality rate of 30.4% in cases with documented outcomes, with at least one surgical intervention was needed in 63% of the reported cases.³ However, the indications for surgery are still unclear. In our case, the patient showed significant improvement after receiving one week of empirical antibacterial treatment targeting anaerobes and *Enterobacteriaceae*. In conclusion, prompt identification of the infection's source and antibiotic susceptibility, specifically in high-risk patients, is life-saving.

In this case, the patient developed iatrogenic EO following TCM treatments, consistent with previous reports in the literature, which were promptly diagnosed and managed. This case underscores key lessons for clinical practice. First, diabetic patients must rigorously control their blood glucose levels to prevent immune dysfunction and avoid hormone treatments that could further compromise immunity. For high-risk patients, such as those with diabetes or immune deficiencies, antibiotics targeting anaerobic bacteria and *Enterobacteriaceae* are essential for reducing infection severity and improving recovery. Early empirical antibiotic therapy is particularly critical in acute EO cases to reduce mortality. Finally, while TCM treatments, including acupuncture and acupotomy, are commonly used for symptom relief, they can lead to complications, including infections. Consequently, in patients with diabetes mellitus or immunocompromised status, a conservative approach toward invasive interventions is strongly recommended, with complete avoidance being preferable in most clinical scenarios. The implementation of rigorous surveillance protocols for early detection of potential infectious processes is paramount in mitigating the risk of severe complications.

Although the report offers valuable insights for future clinical practice, several limitations must be acknowledged. First, the study is based on a single case, lacking large-scale data, which limits the generalizability of its findings. The treatment plan was specifically tailored to the patient's comorbidities, including diabetes mellitus and immunocompromised status, may limit its generalizability to all cases, particularly in immunocompetent individuals. While the report suggests that TCM treatments, such as acupuncture and acupotomy, could contribute to the development of EO, the

absence of a control group or randomized trials makes it difficult to establish a clear causal relationship. Furthermore, although empirical antibiotic therapy is emphasized for acute EO, the report does not compare different antibiotic regimens, highlighting the need for further research to identify the optimal treatment. Lastly, while imaging modalities like CT play a crucial role in the initial identification of EO, they may miss subtle changes in the disease's early stages, underscoring the need for a more comprehensive diagnostic approach.

Conclusion

In conclusion, emphysematous osteomyelitis (EO) is a rare, life-threatening disease. This condition predominantly manifests in immunocompromised individuals and patients with established risk factors for EO, particularly following recent invasive interventions or surgical procedures. Radiologists identifying key signs like the “pumice stone” sign is pivotal. Timely interventions such as empirical antibiotic therapy and potential surgical debridement significantly improve patient outcomes. Our case describes a patient with type 2 diabetes and hypertension who developed EO, highlighting the need for caution when administering invasive Traditional Chinese Medicine treatments to patients at risk for EO. After undergoing invasive treatment for lumbar disc herniation, the patient's symptoms worsened and progressed to a systemic infection. Computed tomography revealed the characteristic “pumice stone” sign. Following empirical antibiotic therapy, the patient's symptoms improved rapidly. We recommend that invasive treatments be used with caution in patients at risk for EO, with close monitoring of their condition. Early identification of the infection source and assessment of antibiotic sensitivity are crucial for effective management. Our case underscores the need for radiologists' thorough understanding of EO to enhance clinical handling and patient prognosis. It's hoped that further research will offer insights into EO and guide its treatment.

Abbreviations

EO, emphysematous osteomyelitis; TCM, traditional Chinese medicine; CT, computed tomography; MRI, magnetic resonance imaging.

Ethics Approval and Informed Consent

This study was approved by the ethics committee of The First People's Hospital of Zunyi (The Third Affiliated Hospital of Zunyi Medical University). Institutional approval was not required for the publication of this case report as it does not involve sensitive patient information. All procedures performed in studies involving human participants were per the ethical standards of the institutional and/or national research committee and with the 1964 helsinki Declaration and its later amendments or comparable ethical standards. The patient has provided written informed consent to have the case details and accompanying images published.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. Consent for publication. The patient has provided written informed consent to have the case details and accompanying images published.

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Disclosure

The authors report no conflicts of interest in this work.

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