JOURNAL OF NEUROSURGERY:
Case Lessons

J Neurosurg Case Lessons 1(9):CASE20164, 2021
DOI: 10.3171/CASE20164

A minimally invasive lateral approach with CT navigation for open biopsy and diagnosis of *Nocardia nova* L4–5 discitis osteomyelitis: illustrative case

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BACKGROUND Lumbar spine osteomyelitis can be refractory to conventional techniques for identifying a causal organism. In cases in which a protracted antibiotic regimen is indicated, obtaining a conclusive yield on biopsy is particularly important. Although lateral transpsoas approaches and intraoperative computed tomography (CT) navigation are well documented as techniques used for spinal arthrodesis, their utility in vertebral biopsy has yet to be reported in any capacity.

OBSERVATIONS In a 44-year-old male patient with a history of *Nocardia* bacteremia, CT-guided biopsy failed to confirm the microbiology of an L4–5 discitis osteomyelitis. The patient underwent a minimally invasive open biopsy in which a lateral approach with intraoperative guidance was used to access the infected disc space retroperitoneally. A thin film was obtained and cultured *Nocardia nova*, and the patient was treated accordingly with a long course of trimethoprim-sulfamethoxazole.

LESSONS The combination of a lateral transpsoas approach with intraoperative navigation is a valuable technique for obtaining positive yield in cases of discitis osteomyelitis of the lumbar spine refractory to CT-guided biopsy.

https://thejns.org/doi/abs/10.3171/CASE20164

KEYWORDS discitis osteomyelitis; image-guided biopsy; minimally invasive surgery; neuronavigation; *Nocardia*

Osteomyelitis of the lumbar vertebrae can be a cause of low back pain and most often requires antibiotics and conservative measures for pain control. However, late recognition and treatment can lead to hospital mortality rates ranging from 2% to 17%.[1–3] Vertebral osteomyelitis, also referred to as "discitis osteomyelitis" or "spondylodiscitis," is caused via hematogenous spread from a distant focus.[4] *Staphylococcus aureus* is known to be the most common causal pathogen accounting for about half of nontuberculosis cases.[5,6]

Magnetic resonance imaging (MRI) is commonly accepted as the radiological modality of choice for diagnosis and characterizing the extent of involvement.[2,7,8] Computed tomography (CT) of the lumbar spine can be used to provide detailed visualization of bone involvement and is often used for guidance during biopsy. Blood cultures and bone biopsy have equal ability to isolate a causal organism, although blood cultures are obtained in almost all patients as a first diagnostic test owing to the relative ease and reduced risk of the procedure.[9] CT-guided biopsy (CTGB) is usually performed when other studies lack the ability to yield a pathogen and there is a targetable lesion on MRI. However, even CTGB has been shown to offer modest yield, with the diagnostic power dependent on various clinical features.[10–12] As an alternative, minimally invasive options for open biopsy offer novel ways to obtain microbiological yield from suspected vertebral infections in patients who had prior negative CTGBs.[13,14]

Although the role of intraoperative navigation for biopsy is poorly defined, it can be used as a powerful adjunct to traditional mini-open or tubular minimally invasive surgery (MIS).[15] We present a case report of an MIS retroperitoneal transpsoas approach in the lateral decubitus position with the use of neuronavigation for open biopsy of an L4–5 vertebral osteomyelitis/discitis infection. The patient was a 44-year-old male with prior pulmonary nocardiosis and initial nondiagnostic CTGB. There have been prior reports of *Nocardia* spp. as causes of vertebral osteomyelitis but none using our technique.[16,17] Of note, the *Nocardia* spp. are frequently intractable to positive biopsy by traditional means.[18,19] In the literature, both CTGB and the few alternative MIS

ABBREVIATIONS CT = computed tomography; CTGB = computed tomography–guided biopsy; IV = intravenous; MIS = minimally invasive surgery; MRI = magnetic resonance imaging; PICC = peripherally inserted central catheter.

INCLUDE WHEN CITING Published March 1, 2021; DOI: 10.3171/CASE20164.
SUBMITTED December 22, 2020. **ACCEPTED** January 6, 2021.

biopsy techniques have been attempted through a posterior or posterolateral approach. We believe that this is the first reported lateral MIS approach to address this scenario, utilizing both navigation and a tubular transpsoas technique to obtain a positive culture yield.

Illustrative Case

A 44-year-old male with a history of prior *Nocardia* bacteremia was admitted from the Emergency Department with the chief complaint of worsening lower back pain and a recent hospitalization for L4–5 osteodiscitis with paravertebral phlegmon. Nine months earlier the patient had been treated with a course of trimethoprim-sulfamethoxazole and imipenem at a separate facility for *Nocardia* bacteremia. A CTGB performed approximately 2 weeks prior to the index admission was nondiagnostic with no organisms and few neutrophils. Blood cultures were also found to be negative except for one set with coagulase-negative gram-positive cocci suggestive of *Staphylococcus* that was believed to be a likely contaminant. Nevertheless, the patient was treated with vancomycin and piperacillin-tazobactam. He was discharged and planned to follow up with the Infectious Disease Department.

Upon readmission, the patient was experiencing progressively worse back pain, as well as left hip pain, despite taking pain medications and his new antibiotics. His neurological examination revealed normal motor function and sensation in the lower extremities. Initial laboratory results were all normal, including a set of negative blood cultures. An MRI study of the lumbar spine showed stable discitis or osteomyelitis from the MRI 2 weeks prior (Fig. 1). The infectious disease team consulted interventional radiology for another CTGB, but the patient was deemed a poor candidate given the prior negative result. We were eventually consulted and asked if any open approach could be undertaken to help obtain a positive yield. The infectious disease team wanted confirmation of presumed recurrent *Nocardia* infection before prescribing an additional trimethoprim-sulfamethoxazole regimen, which would require longer than 9 months of treatment and a more deleterious side-effect profile than alternatives for other diagnoses.

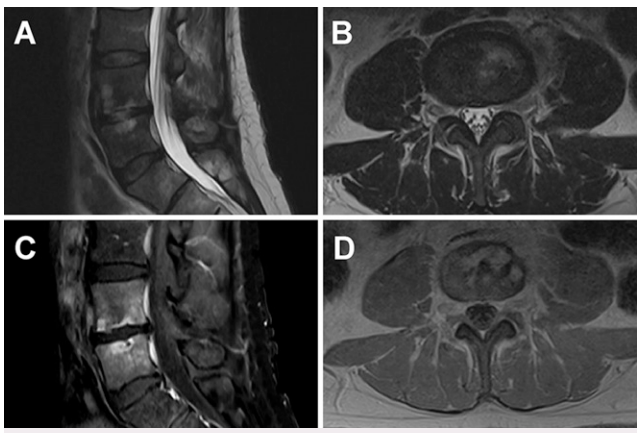

FIG. 1. MRI sequences of known L4–5 discitis osteomyelitis. **A** and **B:** T2 hyperintensity of the L4 and L5 vertebral bodies from sagittal and axial views were overall stable compared with MRI from earlier in the initial hospital course. **C:** Postgadolinium T1-weighted sagittal view demonstrated adjacent involvement of the inferior L4 and superior L5 endplates. **D:** Axial slice of the inferior L4 endplate demonstrating contrast enhancement.

Given the location of the L4–5 osteomyelitis/discitis involving the outer lateral aspect of the adjacent vertebral body, we believed the lesion could be amenable to open biopsy via a lateral retroperitoneal transpsoas approach with real-time navigation. This approach would enable direct visual access to the lesion instead of a "blind" approach reliant on navigation alone or imaging from a posterior approach.

Procedure Description

The patient was brought into the operating room and intubated, then secured in the right lateral decubitus position. Fluoroscopy was brought into the room, and the L4–5 disc space was localized, as were the anterior and posterior margins of the L4–5 vertebral bodies. A 3-cm incision was marked spanning the disc space level. The site was prepped in a sterile fashion. An iliac reference array was mounted to the left iliac crest, and an intraoperative CT scan was obtained (Fig. 2, AIRO AG, BrainLAB). A retroperitoneal transpsoas approach was performed, and the disc space was serially dilated with electrophysiological monitoring. Retractors (NuVasive) were placed, expanded, and electrically monitored for lumbar plexus irritation. Once expanded, the disc space and lesion were directly visualized and the level confirmed with navigation. At the inferior aspect of the L4 vertebral body was a "punched-out" lytic lesion with a thin yellow film. We verified that the visualized lesion correlated to the intraoperative CT that was being used for navigation in real time (Fig. 2C and D). Of note, no pus was encountered in the psoas muscle, vertebral body, or disc space. The thin film in the punched-out lytic part of the vertebral body was curetted off and sent to microbiology. Retractors used to expand the psoas muscle were withdrawn, and the incision was closed in layers. Total retraction time was only 12 minutes, and there were no immediate complications or changes in neuromonitoring throughout the procedure. The patient woke up at his neurological baseline, notably without left thigh numbness or other evidence of postoperative plexopathy.

Surgical Pathology

The patient was discharged 3 days after the open biopsy with some mild incisional pain and good leg strength bilaterally. Antibiotics were withheld pending surgical pathology results, which returned as *Nocardia* spp 1 day after the patient's discharge. Isolate was also sent to the Mycobacteria/Nocardia Laboratory (University of Texas Health Center at Tyler) for further confirmation and matched 99.80% to *Nocardia nova* strains by 16S rRNA gene sequencing.

The Infectious Disease Department notified the patient and requested he return to the inpatient service for a peripherally inserted central catheter (PICC) line and the recommended antibiotics. He began a dual course of intravenous (IV) trimethoprim-sulfamethoxazole and imipenem/cilastatin administered every 6 hours. After 6 weeks, the patient's PICC line was removed and he was transitioned to oral trimethoprim-sulfamethoxazole (480 mg, twice daily) for suppressive therapy with a plan to continue this for at least 1 year depending on his toleration. Upon the most recent follow-up, he reported significant improvement in his low back pain.

Discussion

Observations

A minimally invasive lateral retroperitoneal transpsoas approach to open biopsy using intraoperative CT for direct navigation successfully identified *N. nova* in a case of CTGB-refractory L4–5 discitis osteomyelitis. Our technique shows the success of this approach and also demonstrates that it should be a consideration for cases yielding no

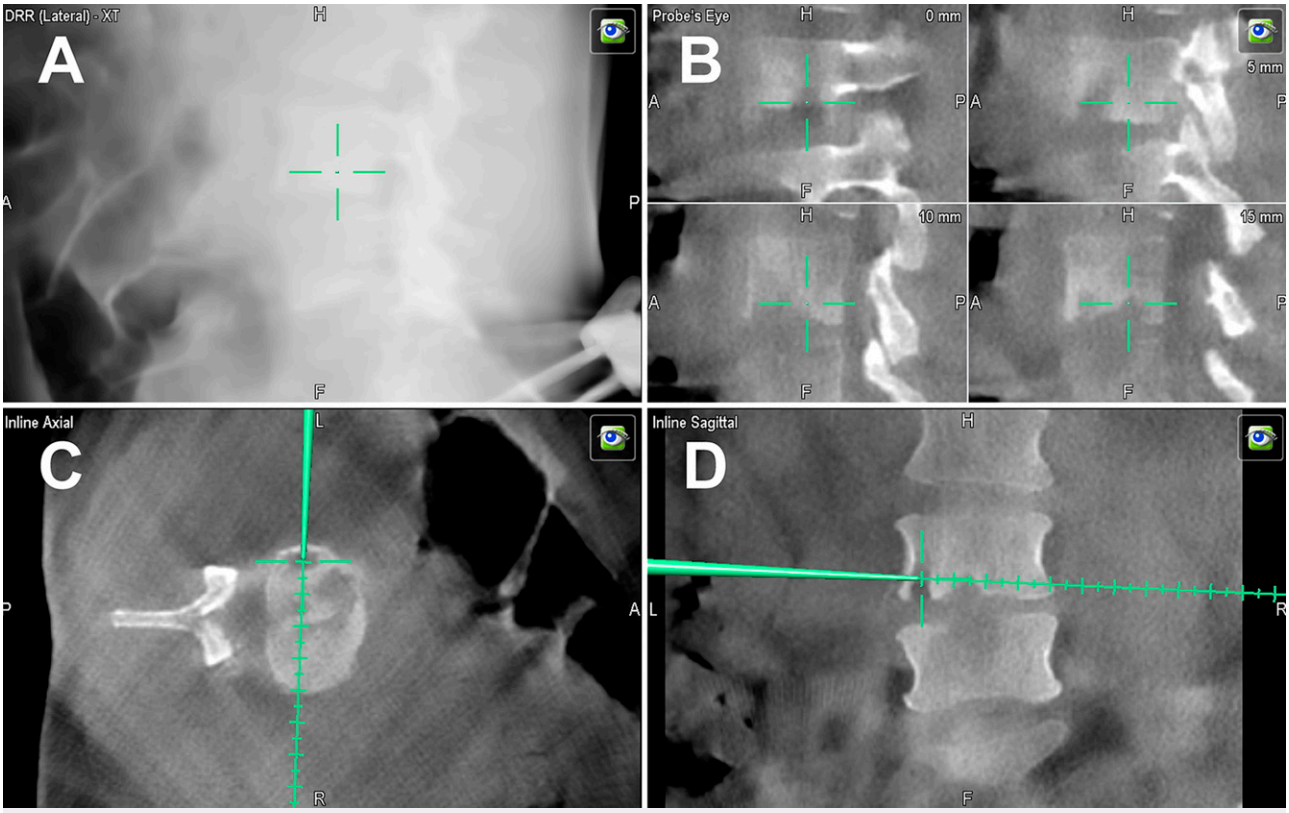

FIG. 2. Intraoperative image workflow used for direct guidance during lateral biopsy. **A** and **B:** After placement of our iliac pin for registration and obtaining our intraoperative CT (AIRO, BrainLAB), offset was used to ensure our incision correlated with our fluoroscopy to target the L4–5 disc space. **C** and **D:** After performing our retroperitoneal transpsoas approach with serial dilation of the disc space, our navigation wand showed our location and target of the lytic lesion.

result through CTGB or even as a first approach for diagnostic biopsy when difficult-to-biopsy pathogens are suspected.

This patient's lumbar spine infection was also caused by *Nocardia*, a genus known to be difficult to culture. In this case, an MIS lateral retroperitoneal transpsoas approach with navigation proved to be a viable option after failed CTGB. Our approach allowed for successful diagnosis and confirmed the need for treatment with specific antibiotics, helping both the infectious disease team and, more importantly, our patient.

Lessons

Although MIS of the spine encompasses various types of procedures, a common goal is to preserve the surrounding tissue and musculature in order to decrease the morbidity associated with open approaches, such as blood loss, and to facilitate improved functional recovery.[20] Moreover, MIS avoids muscular and ligamentous disruption, which may lead to spinal instability.[21] Originally described by Ozgur et al., the lateral transpsoas approach has become a proven and popular method for gaining access to the lumbar spine, particularly for indirect decompression, correction of deformity, and lumbar arthrodesis.[22] This approach is increasingly preferred for access to intervertebral discs due to the minimization of blood loss, vascular injury, dural tear, postoperative pain, and hospital length of stay compared to those with anterior and posterior open techniques.[23–26] This approach does increase the procedural risk of transient and permanent lumbar plexopathies, which can induce various lower extremity symptoms, including anterior thigh/groin pain, numbness, and weakness.[27] Recently, the MIS lateral retroperitoneal transpsoas approach has become a mainstay of spine surgery; however, it has rarely been used for diagnosing or treating spinal infections.

Real-time image guidance has become a powerful adjunct to MIS for spinal procedures. Although intraoperative fluoroscopy is traditionally used to visualize target anatomy, intraoperative CT navigation has been demonstrated across multiple studies and meta-analyses to provide greater surgical precision, enhanced orientation to patient 3-dimensional anatomy, and decreased intraoperative complication rates.[28–30] Additionally, the use of intraoperative CT guidance has been shown to reduce radiation exposure to the surgeon and operating room staff compared with traditional fluoroscopy. With regard to limitations, the cost-effectiveness of image-guided surgery is not yet well described.[31,32] There can also be a steep learning curve for surgeons learning to incorporate this technology into their MIS practice. However, there is no doubt that combining MIS and spinal navigation offers a powerful intraoperative toolkit for optimizing outcomes in some of our most challenging cases.

The applications of MIS approaches have been expanded to treat multiple spinal pathologies, including discitis or osteomyelitis, especially for patients with significant comorbidities that increase operative risk.[33] For example, Yang et al. found favorable bacterial yields using percutaneous endoscopic biopsy, a technique similar to that used in this report in that it was originally used for treatment of other lumbar disc pathologies rather than biopsy.[14] Still, there is a dearth of

studies demonstrating the role and efficacy of the lateral retroperitoneal transpsoas approach for decompression and debridement of refractory discitis.[34–36] Most reports of MIS techniques for spinal infections have focused on percutaneous CT-guided or fluoroscopy-guided needle biopsy, which can be more accessible and cost-effective but at times produce unreliable results for certain subsets of lesions.[37]

Reasons for the relatively low microbiological yield of CTGB in the setting of infection may include the lack of precise visualization of the target lesion, variable expertise of those performing the biopsy, indolent nature of the pathogen, and/or lesion size and composition. In most cases, if the traditional CTGB is nondiagnostic, no other biopsy options are typically offered, and the patient is treated empirically with broad-spectrum antibiotics. Less targeted antibiotic treatment can be ineffective, have deleterious patient side effects, and lead to antibiotic resistance. Thus, MIS approaches have really expanded the armamentarium for lesions that are difficult to biopsy without direct visualization. In this case, we utilized a new approach: a direct lateral retroperitoneal transpsoas approach similar to that used in lateral lumbar interbody fusion, using intraoperative CT for direct real-time guidance. Our case shows that this is a viable option and should be considered in patients with discitis or osteomyelitis that has yielded inconclusive results from CTGB and lesions that are not targetable or difficult to target through traditional CTGB. Additionally, a transpsoas approach was chosen primarily because of its ease and familiarity to the institution but may not necessarily be optimal for all similar cases. Performing an MIS biopsy via a prepsoas approach could also be a reasonable option, particularly when navigation is used. Further studies that directly compare the reliability of these techniques with CTGB would be necessary to quantify benefits more clearly and to compare complication profiles.

Nocardia spp. are also notoriously slow growing and therefore difficult to culture.[19] There is scant literature on *Nocardia* osteomyelitis in the vertebrae, with only one other case of *N. nova* spondylodiscitis reported by Hamdad et al. in 2007.[16] This patient's infection differs in that there was no voluminous psoas abscess that could have easily drained purulence to yield the causative organism. Imipenem has been shown to be effective for the treatment of all *N. nova* strains, among other *Nocardia* spp.[38,39] Because imipenem/cilastatin often requires a protracted regimen with mandatory IV administration and significant adverse side effects, it was particularly important to confirm the suspected microbiology in this patient, who had a recent history of *Nocardia* bacteremia.[40]

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Disclosures

Dr. Oyelese is a consultant for BrainLab and Depuy-Synthes.

Author Contributions

Conception and design: Abdulrazeq, Gokaslan, Fridley, Camara-Quintana. Acquisition of data: Abdulrazeq. Analysis and interpretation of data: Abdulrazeq. Drafting the article: Zheng, Abdulrazeq, Leary, Fridley. Critically revising the article: Zheng, Abdulrazeq, Leary, Oyelese, Fridley, Camara-Quintana. Reviewed submitted version of manuscript: Zheng, Abdulrazeq, Leary, Gokaslan, Camara-Quintana. Approved the final version of the manuscript on behalf of all authors: Zheng. Study supervision: Camara-Quintana.

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