Pediatric brainstem abscess successfully treated with stereotactic aspiration: illustrative case

Nahom Teferi, MD,1 Ajmain Chowdhury, BSc,2 Sarah Lee, BSc,1 Meron Challa, MD,2 Lukasz Weiner, MD,3 Sarah Auerbach, DO,3 Mahil Rao, MD, PhD,4 and Brian J. Dlouhy, MD1,2,5

1Department of Neurosurgery, University of Iowa, Iowa City, Iowa; 2University of Iowa, Carver College of Medicine, Iowa City, Iowa; 3Department of Pediatrics, Division of Infectious Disease, University of Iowa, Iowa City, Iowa; and 4Department of Pediatrics, Division of Critical Care Medicine, University of Iowa, Iowa City, Iowa; and 5Iowa Neuroscience Institute, Iowa City, Iowa

BACKGROUND Pediatric brainstem abscesses are rare entities that account for 1% of all brain abscesses and, when diagnosed, constitute a neurosurgical emergency.

OBSERVATIONS A previously healthy 11-year-old male presented with several days of worsening headache, confusion, and ataxia. Brain magnetic resonance imaging (MRI) revealed a midbrain and pons lesion. The patient subsequently had a rapid neurological decline with loss of consciousness and brainstem function. Follow-up MRI revealed significant enlargement of the brainstem lesion with extension into the pons, midbrain, and thalamus, with greater concerns for an abscess rather than a tumor or an inflammatory process. He was taken for an emergent stereotactic aspiration of the abscess, and broad-spectrum antibiotics were initiated. He had neurological improvement, which subsequently declined 5 days later with brain MRI revealing an increase in the brainstem abscess, which required a second stereotactic aspiration. After rehabilitation, he made a significant neurological recovery.

LESSONS Pediatric brainstem abscesses are rare pathologies, and a high index of suspicion is needed in patients presenting with a brainstem lesion mimicking tumor but with rapid neurological decline despite no other evidence of infection or infectious/inflammatory markers. Stereotactic aspiration is required for large lesions to target the antibiotic treatment and as an adjunct to broad-spectrum antibiotics.

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KEYWORDS brainstem abscess; stereotactic aspiration; polymicrobial infection; broad-spectrum antibiotics; cranial nerve palsy

Pediatric brainstem abscesses are rare entities that occur from pyogenic necrosis of brain parenchyma, most often from local or systemic infection and rarely from trauma or iatrogenic causes.1,2 They account for 1% of all brain abscesses and are most common in the pons (75%), followed by the midbrain and medulla oblongata.3 Similar to other forms of brain abscesses, these lesions are often polymicrobial in nature and are commonly due to the contiguous spread of local infections of the head and neck, such as otitis media, mastoiditis, or sinus infections, or hematogenous spread in the setting of pulmonary arteriovenous fistula, systemic infections, congenital cyanotic heart disease, or endocarditis.4

Here, we describe an 11-year-old male who presented with an isolated brainstem abscess without fever, other infectious symptoms, or markers of systemic inflammation. The brainstem abscess was aggressive but was treated successfully with repeated stereotactic aspiration, broad-spectrum antibiotics, and steroids. This case is the 25th isolated pediatric brainstem abscess reported in the literature.

Illustrative Case

A previously healthy 11-year-old male presented initially to an outside hospital (OSH) emergency department with several days of
progressively worsening headache, nausea, vomiting, confusion, and ataxia. There was no evidence of recent bacterial infection or sinusitis, cellulitis, blood infection, or ear infection. Lumbar puncture showed minimally decreased protein, increased glucose, mild pleocytosis, negative culture, and cerebrospinal fluid (CSF) multiplex polymerase chain reaction. Brain magnetic resonance imaging (MRI) demonstrated a ring-enhancing lesion within the brainstem (Fig. 1) with areas of hemorrhage on brain computed tomography (CT). The initial concern at the OSH was for a brainstem tumor (diffuse midline glioma), and he was transferred to the pediatric intensive care unit at the University of Iowa Stead Family Children’s Hospital (SFCH).

Upon initial evaluation at SFCH, the patient was drowsy with increased spasticity and ataxia involving the right upper and lower extremities. Over the next 36 hours, he was noted to exhibit rapid neurological decline with loss of speech and increased drowsiness. This quickly progressed to minimal brainstem function and loss of spontaneous movement, with only flexion on examination. Repeat brain MRI (Fig. 2) revealed worsening of the pontine enhancing mass with increased central areas of diffusion restriction, concerning for abscess. At this stage, the decision was made to proceed with frameless stereotaxy-guided aspiration of the abscess, and he was taken emergently to the operating room. With the aid of Stealth navigation guidance (Medtronic Inc.), a left retrosigmoid approach traversing through the middle cerebellar peduncle and targeting the lateral margin of the pontine abscess cavity was planned. Tractography with diffusion tensor imaging was not utilized, because the abscess cavity involved the entire lateral pons and presented to the medial margin of the middle cerebellar peduncle. Intraoperatively, the patient was positioned supine with shoulder bump and his head turned 110 to 120 degrees to the right. His head was fixed in Mayfield head holder, and following Stealth registration, a Vertek biopsy solution (Medtronic Inc.) was used to target and drain approximately 3 mL of thick purulent material. Intraoperative gram stain revealed gram-positive cocci and many neutrophils, prompting broad-spectrum antibiotic coverage of vancomycin, ceftriaxone, and metronidazole postoperatively.

There was minimal neurological improvement after stereotactic aspiration. Despite antibiotics, neurological examination revealed further worsening with decerebrate posturing to noxious stimuli in the extremities. Repeat brain MRI revealed an enlarging abscess cavity and evolving ventricular enlargement (Fig. 3). Because of worsening neurological examination findings and radiological evidence of abscess progression despite broad-spectrum antibiotic coverage, the patient was taken back to surgery and underwent a second frameless stereotactic aspiration of the abscess through the prior burr hole and trajectory along with ventriculostomy drain placement for CSF. Approximately 10 mL of purulent fluid was evacuated.

Postoperatively, neurological examination showed gradual improvement, and follow-up brain MRI showed a progressive decrease of the abscess cavity (Fig. 4). The antibiotic regimen was narrowed to ceftriaxone and metronidazole after finalization of the culture results, which revealed a polymicrobial infection with Strep-tococcus anginosus and Aggregatibacter aphrophilus. This occurred despite no recent sinus infection, dental procedures, or evidence of oral or sinopulmonary infection on imaging. His last dental procedure was 6 months earlier. He had been diagnosed with coronavirus disease 2019 (COVID-19) 4 months earlier, which led to a gradually worsening cough and concern for pneumonia, which was treated with azithromycin.

The ventriculostomy drain could not be successfully weaned, and the patient later underwent right-sided ventriculoperitoneal shunt placement after infectious disease clearance. He was later discharged to acute rehabilitation in stable condition on postoperative day 40. On discharge, he was noted to be awake at times with residual right-sided hemiparesis but able to intermittently follow simple commands with the left upper and lower extremities. He was minimally verbal and could communicate yes and no with his fingers at times. He had a waxing and waning clinical course afterward because of perilesional edema, which required long-term dexamethasone treatment in addition to the broad-spectrum antibiotic coverage of ceftriaxone and metronidazole for 8 weeks. A longer antibiotic course was prescribed because of incomplete source control due to the location of the abscess.

At the 6-week follow-up appointment, he was awake, alert, and oriented but continued to have residual hemiparesis on the right side, needing assistance to stand from the wheelchair and walk to
the examination bed. Brain MRI showed near-complete resolution of the abscess (Fig. 5). At the 4-month follow-up, he had made significant neurological improvement and was back to neurological baseline except for left third cranial nerve palsy.

**Patient Informed Consent**

The necessary patient informed consent was obtained in this study.

**Discussion**

Pediatric brainstem abscesses are an exceedingly rare condition that occurs from the necrosis of brain parenchyma, most often from infection but also rarely from trauma or iatrogenic causes.\textsuperscript{1,2} Although rare in presentation, they are associated with significant rates of morbidity, especially in the pediatric population, and early diagnosis is paramount.\textsuperscript{5} Similar to other forms of brain abscess, these lesions are due to either spread from infection of contiguous structures or hematogenous spread from distant sources. Commonly associated risk factors include local infections, such as otitis media, mastoiditis, or sinus infections, or hematogenous spread in the setting of pulmonary arteriovenous fistula, systemic infections, congenital cyanotic heart disease, or endocarditis.\textsuperscript{4} These lesions are often polymicrobial in etiology, and the most commonly reported organisms include streptococci, *Staphylococcus aureus*, *Bacteroides*, *Actinobacillus*, and *Enterobacteriaceae*.\textsuperscript{6}

Symptoms of brainstem abscesses include the typical triad of fever, headache, and focal neurological deficits, which are found in 9%–28% of pediatric brain abscess patients.\textsuperscript{7,8} Given the abscess’ predisposition to the pons, patients can often present with cranial nerve (CN) palsies primarily involving CN VI and VII,\textsuperscript{9,10} which tend to occur during the latter course of the disease. Hemiparesis due to involvement of the descending corticospinal tract occurs in up to 66% of patients,\textsuperscript{5} and approximately 40% of patients present with alteration of mental status.\textsuperscript{11}

Evaluation of the suspected brain abscess begins with routine infectious workup involving complete blood count, inflammatory markers, serological testing, blood cultures, lumbar puncture, and subsequent imaging including CT and MRI. A high index of suspicion is needed, as signs of infection may not be present in half of the patients, and CSF analysis may be unremarkable in up to 40% of cases.\textsuperscript{12,13} The CT and MRI features of the abscess depend on the infection phase and etiology, and it may not always be possible to differentiate an abscess from other lesions, including necrotic glioma, demyelination, lymphoma, and rare infections such as neurocysticercosis or tuberculoma.\textsuperscript{3,5}
In our patient, there was a report of a post–COVID-19 upper respiratory tract infection several months earlier that resolved spontaneously prior to the current presentation. There were no other identifiable risk factors that would predispose him to develop a brainstem abscess. This is not uncommon, as risk factors predisposing to brain abscess development were found in only 56%–86% of pediatric patients. Initial infectious workup including lumbar puncture revealed decreased protein, increased glucose, and negative cultures. This is not uncommon, as negative inflammatory parameters and CSF cultures in the setting of brain abscesses have been reported in 30%–40% of patients. Further testing with brain MRI showed a ring-enhancing pontine lesion with areas of hemorrhage and diffusion restriction; a differential diagnosis of cavernoma versus hemorrhagic brainstem glioma was considered. A high index of suspicion is needed, as a brainstem abscess can mimic different lesions on MRI. A recent review showed that combining diffusion-weighted imaging (DWI) sequence and magnetic resonance spectroscopy can improve the specificity and sensitivity of abscess diagnosis from 61% and 62%, respectively, to 100% for both parameters.

When diagnosed, brainstem abscesses constitute a neurosurgical emergency and urgent medical intervention is warranted. Given the rarity of these cases, there is no standard of care or treatment guideline for the management of brainstem abscesses; however, broad-spectrum antibiotics are considered the mainstay of treatment. Medical management has traditionally been recommended for abscesses smaller than 2.5 cm, a Glasgow Coma Scale score >12, multiple abscesses, or microbiological tests of CSF/blood revealing the etiological microorganism. However, given the risks associated with surgical evacuation/aspiration of a brainstem abscess, even larger lesions (>2.5 cm), several authors have recommended medical management for children in a stable clinical condition and where serial radiological surveillance is available. Surgical intervention with stereotactic aspiration or aspiration via craniotomy has been traditionally reserved for patients whose condition fails to respond to medical management or who show clinical deterioration despite maximal medical therapy. The main risks associated with stereotactic biopsy of a brainstem lesion include hemorrhage with significant neurological deficit ranging from diplopia, hemianesthesia, and hemiparesis to quadriplegia and locked-in syndrome and vascular injury.

After an initial stereotactic biopsy for microbiological diagnosis and abscess aspiration, our patient was initiated on broad-spectrum antibiotics but continued to undergo clinical deterioration, with serial radiological imaging showing continued abscess progression. At this stage, the decision was made to proceed with repeat stereotactic aspiration of the brainstem abscess, and 10 mL of purulent fluid was evacuated. Advantages to surgical drainage include obtaining tissue for microbiological diagnosis and reducing mass effect. Stereotactic aspiration is ideal for deep-seated abscesses that do not present to the cortical surface, as the procedure is minimally invasive and carries minimal morbidity and mortality compared to drainage via craniotomy. In addition to surgical drainage and broad-spectrum antibiotics, our patient also required long-term treatment with systemic steroids (Decadron) given a waxing and waning clinical course due to perilesional edema throughout his rehabilitation. The role of steroids in managing cerebral edema in brain abscess patients has been extensively reported; however, this would be the first report on the role of steroids in improving neurological outcome in brainstem abscess patients.

In conclusion, advances in neurosurgical techniques and procedures along with early detection due to improved imaging modalities and antibiotic therapy have all led to significant improvement in the prognosis of this disease.
Observations

Clinicians should have a high index of suspicion for brainstorm abscesses in children with an alteration of mental status, headache, rapid neurological decline, or possible regional or distant sources of infection even if the infectious and imaging workup is equivocal. Early biopsy for diagnosis is key and improves functional outcome. Broad-spectrum antibiotics should be considered first-line treatment, but surgical evacuation with a stereotactic approach or craniotomy is a safe option in patients in whom medical treatment has failed. With the emergence of advanced surgical and imaging techniques, early detection and initiation of treatment have led to significant improvement in the prognosis of this disease.

Lessons

A multidisciplinary team consisting of neurosurgeons, intensivists, and infectious disease specialists should be established when brainstorm abscesses are encountered in children. A high index of suspicion is key, as early detection improves functional outcome. Medical management with broad-spectrum antibiotics should be considered first-line treatment, but stereotactic abscess evacuation is a safe therapeutic option when medical management fails.

References


Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Teferi, Chowdhury, Lee, Challa, Weiner. Acquisition of data: Teferi, Chowdhury, Lee, Rao. Analysis and interpretation of data: Dlouhy, Teferi, Chowdhury, Lee, Weiner. Drafting the article: Teferi, Chowdhury, Lee, Challa, Weiner. Critically revising the article: Dlouhy, Teferi, Chowdhury, Challa, Weiner. Auerbach, Rao. Reviewed submitted version of manuscript: Dlouhy, Teferi, Chowdhury, Auerbach, Rao. Approved the final version of the manuscript on behalf of all authors: Dlouhy. Study supervision: Dlouhy.

Correspondence

Brian J. Dlouhy: University of Iowa, Iowa City, IA. brian-dlouhy@uiowa.edu.