Sinusitis complicated by intracranial abscess in 3 patients with coronavirus disease 2019: illustrative cases

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BACKGROUND The novel coronavirus disease 2019 (COVID-19) can be associated with various neurological manifestations, including cerebrovascular disease, seizures, peripheral nerve disease, and encephalitis. Intracranial abscess related to COVID-19 is rare but illustrates a serious complication in the studied cases.

OBSERVATIONS The authors report 3 cases of patients presenting with COVID-19 complicated by sinusitis with associated intracranial abscesses. Each patient underwent craniotomy with washout and sinus debridement during their hospital stay. All 3 patients improved to their baseline following treatment. Similar outcomes have been observed in other cases of intracranial abscess associated with COVID-19 infections.

LESSONS Patients achieved significant improvement following evacuation of the abscess and intravenous antibiotics. Further investigation is needed to determine treatment in relation to COVID-19, and the authors recommend following the standard treatment of intracranial abscess at this time.

KEYWORDS COVID-19; intracranial abscess; empyema

Coronavirus disease 2019 (COVID-19), a viral illness caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has had a profound impact around the world since the first reported case in December 2019.1 As of September 11, 2022, there have been over 605 million reported cases worldwide and 6.4 million deaths.2 The manifestations and complications of COVID-19 are still being investigated, with the typical presentation involving respiratory disease. Multiple neurological manifestations have been noted, including cerebrovascular disease, seizures, peripheral nerve disease, and encephalitis.3,4 In this report, we present 3 cases of intracranial abscess that developed shortly after a diagnosis of COVID-19. Intracranial abscesses related to COVID-19 are rare with few cases reported in the literature.5–8

Illustrative Cases

Case 1
A previously healthy 15-year-old male presented to the emergency department with headaches and altered mental status. He had been diagnosed with COVID-19 1 week prior to admission after being exposed to his father 2 weeks prior. He complained of headaches, fatigue, and neck pain at that time, then developed swelling over his left forehead. The finding of brain magnetic resonance imaging (MRI) performed at an outside hospital was reported as negative, but an ultrasound of his forehead showed a subgaleal abscess, so he was started on clindamycin. The day before presentation, the patient became progressively confused and was taken to the emergency department (ED). On initial evaluation, he was noted to be confused and somnolent with a temperature of 103°F. Laboratory evaluation findings were significant for leukocytosis (28,000/mm3) and elevated erythrocyte sedimentation rate (ESR; 90 mm/h) and C-reactive protein (CRP; 18.2 mg/dL). While in the ED, the patient had a witnessed generalized tonic-clonic seizure, which was aborted with Ativan. He remained unresponsive following the seizure, with a reported Glasgow Coma Scale (GCS) score of 6, so he was intubated for airway protection. Computed tomography (CT) of the patient’s head was concerning for a possible

ABBREVIATIONS COVID-19 = coronavirus disease 2019; CRP = C-reactive protein; CT = computed tomography; CVST = cerebral venous sinus thrombosis; ED = emergency department; ENT = ear, nose, and throat; ESR = erythrocyte sedimentation rate; GCS = Glasgow Coma Scale; MRI = magnetic resonance imaging; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2; VP = ventriculoperitoneal.

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subdural empyema and intracranial abscess, so Decadron and vancomycin were administered, then the patient was transferred to our hospital for further care. On arrival, the patient had a GCS score of 7T. His pupils were equal and reactive, with positive corneal reflexes and positive cough reflex, and he localized to stimulation on the right side and extended the left upper extremity. Review of the patient’s outpatient brain MRI from 4 days prior showed a right frontal epidural fluid collection. A CT angiogram and CT sinus were obtained, which showed subperiosteal, epidural, and subdural collections on the right side, as well as diffuse opacification of the frontal sinuses, left ethmoid sinus, and left maxillary sinus (Fig. 1). No evidence of intraparenchymal abscess was noted. The patient was taken emergently to the operating room for a right craniotomy for evacuation of the subperiosteal, epidural, and subdural empyemas, and intraoperative findings were significant for purulent collections and cerebritis. Following our procedure, a left maxillary antrostomy, left ethmoidectomy, and left sphenoidectomy were performed by an ear, nose, and throat (ENT) specialist, and intraoperative findings were significant for mucopurulent collections and mucosal inflammation. Postoperatively, the patient remained intubated but was following commands on both sides with mild left-sided weakness. A postoperative MRI scan showed evacuation of the epidural and subdural empyemas, with a small residual subdural collection along the floor of the right middle fossa (Fig. 1). An area of right frontotemporal cortical infarction, which correlated with the right frontal hypodensity seen on the preoperative head CT, was also noted. Parenteral vancomycin, ceftriaxone, and Flagyl were started postoperatively, and intraoperative cultures eventually grew pan-susceptible Streptococcus intermedius. Final fungal culture findings were negative. At the 2-week postoperative follow-up, the patient’s left-sided weakness had completely resolved.

Case 2
A previously healthy 28-year-old male initially presented to an outside hospital with altered mental status and fevers 4 days prior to admission to our facility. The patient was noted to be febrile to 103.1°F, and laboratory evaluation findings were significant for leukocytosis (20.5 × 10^9/L) with a left shift and a positive SARS-CoV-2 test result. A lumbar puncture was performed, which revealed a white blood cell count of 370/μL, a red blood cell count of 10.8/μL, a glucose level of 39 mg/dL, and a protein level of 177 mg/dL. Further meningitis/encephalitis panel results were negative. A head CT scan revealed a mixed-density subdural collection along the left side of the falx, as well as severe sinus disease in the left maxillary and ethmoid sinuses. The parafalcine subdural collection seen on CT enhanced with central diffusion restriction on brain MRI, raising concern for a subdural empyema (Fig. 2). Upon arrival at our facility, the patient was noted to be confused and aphasic, with a right facial droop and right-sided hemiplegia. He was taken emergently to the operating room for a left decompressive craniectomy and evacuation of the subdural empyema. A large purulent collection was encountered within the interhemispheric fissure and drained. A subdural drain was inserted into the interhemispheric fissure, and a Jackson-Pratt drain was left in the subgaleal space. Following our procedure, ENT personnel performed a left maxillary antrostomy, left ethmoidectomy, left sphenoidectomy, left frontal sinusotomy, right maxillary antrostomy, and right anterior ethmoidectomy, with intraoperative findings significant for purulence and thickened mucosa. Parenteral vancomycin, ceftriaxone, and metronidazole were started postoperatively, and the patient’s aphasia, right facial weakness, and right-sided hemiplegia slowly improved. Intraoperative cultures from the subdural collection and sinus eventually grew Parvimonas micra, Prevotella buccae, and Prevotella species. Final fungal culture findings were negative. MRI of the brain 6 days after surgery showed evacuation of the interhemispheric subdural empyema, a small residual subdural collection along the left tentorial leaflet, and unchanged left frontal lobe cerebritis. At the 1.5-month follow-up visit, the patient’s aphasia and right facial droop had resolved, with mild residual right-sided weakness.

Case 3
A 14-year-old male with a history of spastic diplegic cerebral palsy, seizure disorder, and posthemorrhagic hydrocephalus status after ventriculoperitoneal (VP) shunt placement presented to an outside hospital with altered mental status, headaches, fever, nausea, and vomiting. He had been diagnosed with COVID-19 eleven days prior to admission. A head CT at the outside hospital showed significant sinus disease but no evidence of shunt dysfunction. The patient was started on intravenous antibiotics and transferred to our facility for further work-up. On initial examination, he was somnolent and noted to be febrile to 102.1°F with a GCS score of 13. Laboratory evaluation findings were significant for leukocytosis (47.7 × 10^9/L), lactic acidosis (3.4 mmol/L), elevated ESR (96 mm/h), and an elevated CRP (14.0 mg/dL). A CT shunt series at our facility revealed normal ventricular size but severe bilateral sphenoid sinus opacification and thinning of the posterosuperior wall of the left sphenoid sinus. Subsequent MRI was concerning for meningitis with subarachnoid abscess formation on the left side, left-sided cerebellitis, and subarachnoid hemorrhage. An area of right frontal epidural and subdural spaces, concerning for abscess formation. A: Preoperative MRI showing fluid collections in the right frontal epidural and subdural spaces, concerning for abscess formation. B: Preoperative head CT with contrast showing right frontal hypodensity concerning for cortical infarction under the empyema. C: Postoperative MRI showing resection of empyema with no definite residual collections while maintaining enhancement over right frontal cortex concerning for meningitis and cerebritis with associated cortical infarction. D: Intraoperative view of subdural empyema.
small left anteromedial thalamic infarct, and opacification of the sphenoid sinus (Fig. 3). A shunt tap was performed and revealed a white blood cell count of 3,746/μL, a red blood cell count of 2,000/μL, a glucose level of 5 mg/dL, and a protein level of 463 mg/dL. The patient was started on intravenous ceftriaxone, vancomycin, and metronidazole. He was taken to the operating room the next day for removal of his VP shunt and placement of an external ventricular drain with neurosurgery. Following our procedure, an ENT specialist performed bilateral maxillary antrostomy, ethmoidectomy, bilateral sphenoidectomy, and septoplasty with significant findings of copious, purulent fluid in the bilateral sphenoid sinuses and posterior ethmoid sinuses. The patient was continued on his preoperative antibiotics. Intraoperative cultures and cerebrospinal fluid from his initial shunt tap grew Streptococcus pneumoniae. His hospital course was further complicated by rupture of a 2- to 3-mm mycotic basilar artery aneurysm requiring cerebral angiogram and coil embolization. MRI 19 days after his initial procedure revealed persistent collection of purulent fluid in the left lateral ventricle, worsening of the purulent fluid collection in the basal cisterns, and increasing ventricular dilation. The patient was taken back to the operating room for endoscopic exploration, lavage of the left lateral ventricle, and placement of an additional extraventricular drain. Findings during the operation were significant for a noncommunicating abscess in the tip of the left occipital horn. Following surgery, he was started on a 7-day course of intrathecal antibiotics and 4 weeks of intravenous antibiotics. The patient required external ventricular catheter revision during his hospital course, which was replaced with VP shunts 2 months after his initial procedure. He was ultimately discharged to a pediatric bridge hospital for further care. He has since returned to baseline with resolution of intracranial and sinus purulent fluid collections on imaging.

Discussion

Observations

These 3 cases illustrate intracranial abscesses concurrent with COVID-19 infection. To our knowledge, there are only 7 other reported cases of sinusitis and associated intracranial abscess in the setting of COVID-19 (Table 1).5–8 Of the known cases, only 1 occurred in a patient with a history of chronic sinusitis. Although intracranial abscesses are known to occur because of contiguous spread in the setting of chronic

![FIG. 2. Case 2. A: Preoperative head CT without contrast showing a mixed-density hypodense subdural fluid collection along the left parasagittal cerebral hemisphere convexity and left tentorium. B: Outside MRI showing diffusion restriction consistent with subdural empyema. C: Postoperative CT showing removal of the subdural empyema with the resolution of mass effect.](image)

![FIG. 3. Case 3. A: Preoperative MRI showing fluid collections in the suprasellar cistern and the left sylvian fissure with associated leptomeningeal thickening concerning for abscess formation. B: Preoperative MRI with contrast showing a persistent fluid collection of the left occipital horn. C: Follow-up MRI showing resolution of the occipital horn abscess, with a persistent extra-axial fluid collection and T2 elongation of periventricular white matter.](image)
sinusitis, the absence of chronic sinusitis in the remaining cases suggests that SARS-CoV-2 could have contributed to the pathogenesis.\textsuperscript{9,12} We suggest that upper respiratory congestion secondary to COVID-19 infection may have led to sinus obstruction, bacterial sinusitis, and contiguous intracranial spread. Of note, 2 of the presented cases occurred during a surge of the SARS-CoV-2 Delta variant within the region. The Delta variant has been associated with higher viral loads and increased rates of hospitalization in adolescents and young adults.\textsuperscript{13,14}

With the exception of 2 previous cases and our third case with preexisting risk factors,\textsuperscript{6,7} all other reported cases occurred in young, previously healthy patients. Most cases were treated with craniotomy for abscess evacuation followed by parenteral antibiotics. One patient with cerebritis was treated with parenteral antibiotics alone after refusing sinus debridement.\textsuperscript{7} Two patients with associated orbital cellulitis underwent orbitotomy or sinus debridement combined with parenteral antibiotics but did not undergo open treatment of their intracranial disease.\textsuperscript{5} Neurological outcomes were largely favorable following treatment, except for one case complicated by concomitant cerebral venous sinus thrombosis (CVST).\textsuperscript{5}

It has been argued that forgoing neurosurgical operative intervention in favor of antibiotic treatment or antibiotic treatment and sinus debridement may be adequate to treat small intracranial abscesses without signs of neurological impairment or midline shift in high-risk patients.\textsuperscript{9,15,16} However, newer studies suggest that forgoing neurosurgical operative intervention is associated with a significant increase in mortality rate and inferior neurological outcomes.\textsuperscript{17} Because the pathology of intracranial abscess related to COVID-19 is unknown, we recommend that bacterial subdural empyemas and epidural abscesses be treated with evacuation via craniotomy and broad-spectrum antibiotics.\textsuperscript{9,10} Operative evacuation may help prevent the development of worsening neurological deficits and sequelae such as CVST, whereas intraoperative cultures can guide targeted antibiotic therapy. The addition of sinus debridement for source control can be considered separately in consultation with ENT specialists. Additionally, cases complicated by ventriculitis in patients with a ventricular shunt, as reported in case 3, should undergo complete removal of shunt hardware with placement of an external drain or externalization of shunt hardware in addition to the above management.\textsuperscript{18,19} Replacement of the shunt should be performed once infection has cleared, because this management minimizes the nidus for infection and results in the highest likelihood of infection resolution.\textsuperscript{18,19}

A variety of organisms were responsible for intracranial disease in these cases, with half of the cases involving a strain of Streptococcus. This is similar to findings for non–COVID-19-associated intracranial empyema and abscess, because anaerobic and microaerophilic Streptococci

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### TABLE 1. Literature review summary for reported cases of patients with intracranial abscess associated with COVID-19

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Age (yrs)/Sex</th>
<th>Significant Past Medical Hx</th>
<th>Intracranial Infection Location</th>
<th>Sinus Debridement</th>
<th>Craniotomy for Washout</th>
<th>Additional Interventions</th>
<th>Intraoperative Cultures</th>
<th>Neurological Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbin et al., 2020\textsuperscript{8}</td>
<td>12/M</td>
<td>N</td>
<td>Dural thickening</td>
<td>N</td>
<td>N</td>
<td>Orbitotomy, IV antibiotics</td>
<td>Orbital—negative</td>
<td>Baseline</td>
</tr>
<tr>
<td>Turbin et al., 2020\textsuperscript{8}</td>
<td>15/M</td>
<td>N</td>
<td>Epidural abscess</td>
<td>Y</td>
<td>N</td>
<td>IV antibiotics</td>
<td>Sinus—negative</td>
<td>Baseline</td>
</tr>
<tr>
<td>Shahab et al., 2021\textsuperscript{7}</td>
<td>49/M</td>
<td>Y—uncontrolled diabetes</td>
<td>Cerebritis</td>
<td>N</td>
<td>N</td>
<td>IV antibiotics</td>
<td>NA</td>
<td>Baseline</td>
</tr>
<tr>
<td>Charlton et al., 2021\textsuperscript{6}</td>
<td>65/M</td>
<td>Y—chronic sinusitis</td>
<td>Subdural empyema</td>
<td>N</td>
<td>Y</td>
<td>IV antibiotics</td>
<td>Streptococcus milleri</td>
<td>Not reported</td>
</tr>
<tr>
<td>Blitz et al., 2022\textsuperscript{5}</td>
<td>A/M</td>
<td>N</td>
<td>Subdural empyema</td>
<td>Y</td>
<td>Y—multiple</td>
<td>IV antibiotics</td>
<td>Persistent cognitive impairment</td>
<td></td>
</tr>
<tr>
<td>Blitz et al., 2022\textsuperscript{5}</td>
<td>A/F</td>
<td>N</td>
<td>Epidural abscess, subdural empyema, IP abscess</td>
<td>Y</td>
<td>Y</td>
<td>IV antibiotics</td>
<td>Fusobacterium necrophorum, MSSA</td>
<td>Baseline</td>
</tr>
<tr>
<td>Blitz et al., 2022\textsuperscript{5}</td>
<td>A/M</td>
<td>N</td>
<td>Subdural empyema</td>
<td>Y</td>
<td>Y—multiple</td>
<td>IV antibiotics</td>
<td>Streptococcus intermedius, Parvimonas</td>
<td>Baseline</td>
</tr>
<tr>
<td>Present study</td>
<td>15/M</td>
<td>N</td>
<td>Epidural abscess, Subdural empyema</td>
<td>Y</td>
<td>Y</td>
<td>IV antibiotics</td>
<td>Streptococcus intermedius</td>
<td>Baseline</td>
</tr>
<tr>
<td>Present study</td>
<td>28/M</td>
<td>N</td>
<td>Subdural empyema</td>
<td>Y</td>
<td>Y</td>
<td>IV antibiotics</td>
<td>Parvimonas mica, Prevotella buccae</td>
<td>Mild rt-sided weakness</td>
</tr>
<tr>
<td>Present study</td>
<td>14/M</td>
<td>Y</td>
<td>Subarachnoid abscess, ventriculitis</td>
<td>Y</td>
<td>Y—delayed</td>
<td>VP shunt removal, IV antibiotics</td>
<td>Streptococcus pneumoniae</td>
<td>Baseline</td>
</tr>
</tbody>
</table>

\textsuperscript{A} = adolescent (age not specified); \textsuperscript{Hx} = history; \textsuperscript{IP} = intraparenchymal; \textsuperscript{IV} = intravenous; \textsuperscript{MSSA} = methicillin-sensitive \textsuperscript{Staphylococcus aureus}; \textsuperscript{N} = no; \textsuperscript{NA} = not available; \textsuperscript{Y} = yes.
are responsible for a majority of cases.20,21 This should be considered when selecting antibiotics for these patients and further suggests that standard treatment plans for intracranial infections ought to be followed.

Lessons
In the cases we present, patients achieved significant improvement following evacuation of the abscess and administration of intravenous antibiotics. Further investigation is needed to determine the association of COVID-19 with neurological manifestations, diagnosis, and management. At this time, standard management for intracranial abscesses should be followed. Relation to various strains of COVID-19 and change over time should be considered.

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.

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Conception and design: Cleary, Prim, Musgrave, Coppens, Kemp. Acquisition of data: Cleary, Musgrave, Kemp. Analysis and interpretation of data: Musgrave, Kemp. Drafting the article: Griffin, Prim, Musgrave. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Griffin. Administrative/technical/material support: Griffin, Prim, Kemp. Study supervision: Coppens, Kemp.

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