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Case Report

Pyogenic Ventriculitis After Anterior Skull Base Surgery Treated With Endoscopic Ventricular Irrigation And Reconstruction Using a Vascularized Flap

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Ventriculitis is a rare, serious complication of neurosurgery. A 59-year-old man who had undergone a craniotomy for a paranasal adenocarcinoma, developed a right frontal cystic lesion. We performed a bifrontal craniotomy to remove the lesion. The dura was repaired with non-vascularized free fascia lata in watertight fashion. Ventriculitis occurred 3 days postoperatively. Ventricular drainage, craniectomy, and endoscopic irrigation were undertaken to remove an abscess. The dura and the resection cavity were reconstructed using a vascularized anterolateral thigh adipofascial flap. His symptoms disappeared, indicating that endoscopic irrigation and reconstruction can effectively address ventriculitis even in patients in critical clinical condition.

Key words: ventriculitis, surgical site infection, intraventricular antimicrobial therapy, anterior skull base surgery

Ventriculitis and meningitis are known complications in patients who have undergone neurosurgery. It has been reported that the infection rate is 2-5% when a paranasal sinus is in the surgical field [1-3]. Once present, ventriculitis often results in a critical course [4] because early recognition of infectious ventriculitis is difficult [5]. We report a case of ventriculitis that became obvious shortly after anterior skull base surgery for an intracerebral lesion in the right frontal lobe. The decision to address the lesion with surgical intervention, medication, and rehabilitation, despite the patient's critical condition, dramatically improved his course.

Case Presentation

A 59-year-old man had first been seen in the Department of Otorhinolaryngology for a nasal cavity lesion 15 years earlier. As the tumor invaded the right frontal skull base, he underwent an extended resection via bifrontal craniotomy. Both frontal sinuses were cranialized, and a pericranial flap was used to reconstruct the anterior skull base. Histological examination indicated well-differentiated adenocarcinoma, and he underwent adjuvant chemotherapy and irradiation (30 Gy in three fractions) of the right frontal lobe.

At the present admission to our department, he complained of intractable headache. He had no apparent signs of infection or neurological deficits. Magnetic

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resonance imaging (MRI) showed an intracerebral cystic lesion with brain edema in the right frontal lobe (Fig. 1A). The lesion was attached to the frontal base of the lobe (Fig. 1B). As it was suspected to be an intracranial recurrence of the adenocarcinoma, radical resection of the lesion and the attached dura was planned.

Using an optical navigation system and 2 fence posts, bifrontal craniotomy was performed to remove the right frontal lesion and the attached dura (Fig. 1C). The liquid in the cyst was transparent and had a reddish color. Intraoperative laboratory evaluation reported no apparent malignant cells or infectious changes. We closed the right lateral ventricle by placing an absorbable hemostatic agent (Surgicel Absorbable Hemostat; Ethicon Inc., Somerville, NJ) at its orifice after removing the lesion. The dura was then reconstructed with non-vascularized free fascia lata in watertight fashion (Fig. 1D). The orifice toward the nasal cavity that had been opened to remove the lesion was then closed using an anterolateral thigh adipofascial flap, anastomosing the graft to the right superficial temporal artery and vein to fill the extradural space and the orifice without sutures (Fig. 1E). Histological examination of the resected tissue indicated the presence of radiation necrosis.

Cefazolin was administered postoperatively as a prophylactic antibiotic. There was no apparent evidence of cerebrospinal fluid rhinorrhea, and the glucose oxidase test-tape did not indicate cerebrospinal fluid leakage. The patient was extubated on postoperative day (POD) 1. A high fever appeared on POD 3, and the antibiotic was switched to ceftriaxone. On POD 4, however, he became disoriented and lethargic. On POD 3, sequential computed tomography (CT) — which had commenced on POD 1 and had shown what was thought to be a hematoma — now revealed it to be a large intraventricular, iso-density lesion. On POD 5, CT showed dramatic increases in the sizes of both lateral ventricles and the resection cavity, the latter of which contained an enlarged fluid-like lesion (Fig. 2A). Additionally, on POD 5, diffusion-weighted MRI showed hyperintensity of the resection cavity, suggesting an abscess (Fig. 2B). Brain edema was visible around the abscess (Fig. 2C). Addition of gadolinium enhanced the intensity of the walls of the resection cavity and the ventricles (Fig. 2D). On POD 6, we placed extradural drains (SILASCON®; Kaneka Medix Corp., Osaka, Japan) in

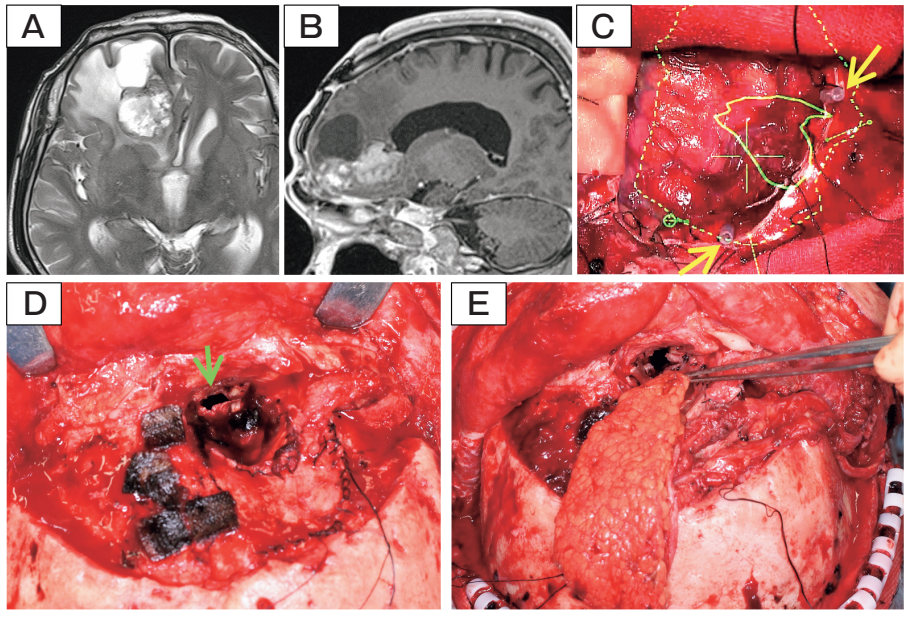

Fig. 1 Surgical treatment for the cystic lesion. MRI T2-weighted images of the cystic lesion (**A**) and gadolinium-enhanced T1-weighted sagittal view (**B**) before craniotomy show heterogeneous signal intensity; **C**, Microscopic view of the lesion after incising the dura. Two fence posts were inserted at the margin of the lesion (yellow arrows); **D**, Photograph of the frontal skull base after dural reconstruction. The orifice toward the nasal cavity is opened (green arrow); **E**, Photograph of the right frontal base being filled with the vascularized anterolateral thigh adipofascial flap; MRI, magnetic resonance imaging.

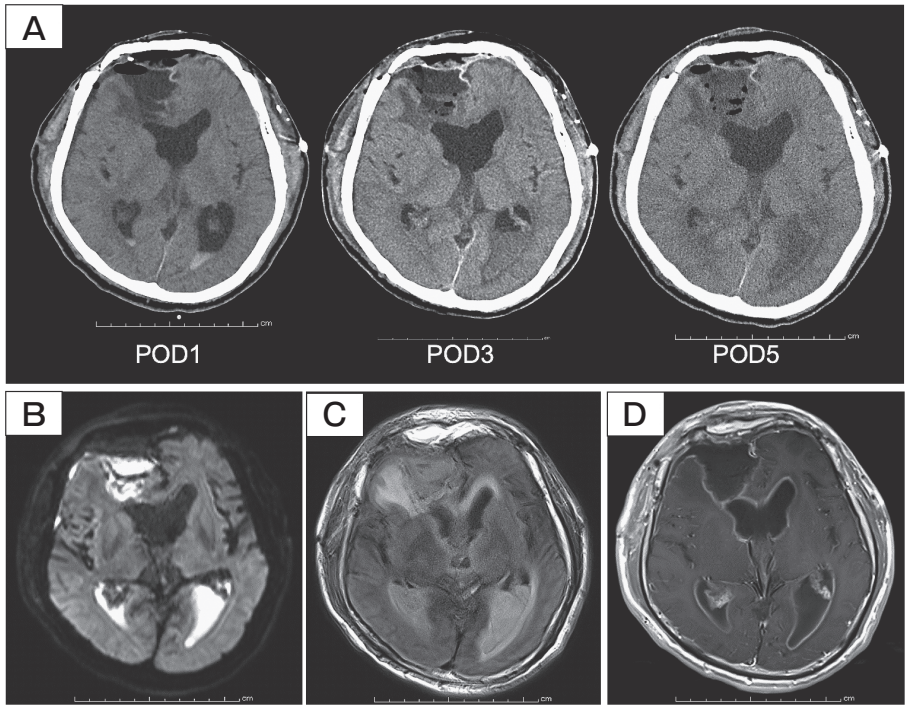

Fig. 2 Radiological images after craniotomy. **A**, Sequential CT images after the craniotomy on POD 1, POD 3, and POD 5. Fluid in the bilateral posterior horns of the lateral ventricles increased sequentially. The resection cavity was filled with a fluid-like lesion on POD 5; **B**, A diffusion-weighted image on POD 5 shows hyperintensity of the fluid, implying the existence of an abscess; **C**, Fluid-attenuated inversion recovery MRI shows brain edema surrounding the resection cavity and subventricular zone; **D**, Gadolinium-enhanced T1-weighted MRI. The resection cavity rim and ventricular wall are enhanced. POD, postoperative day; CT, computed tomography; MRI, magnetic resonance imaging.

the bilateral posterior ventricular horns. Cultured blood and aspirated cerebrospinal fluid showed the presence of *Serratia marcescens* and methicillin-resistant *Staphylococcus aureus*. Hence, the intravenous antibiotic regimen was changed to vancomycin and meropenem. We also irrigated the lateral ventricles with gentamicin (5 mg, twice a day) and vancomycin (5 mg, twice a day) for the next week. Although his fever resolved, repeat MRI showed an increased abscess volume in the resection cavity.

On POD 12, we performed a craniectomy, which revealed pus on the reconstructed dura, and the abscess had filled the subdural resection cavity (Fig. 3A). The constructed dura was dissected, the pus on the brain surface was removed, and the subdural surgical area was irrigated. The previously placed Surgicel was found at the orifice of the lateral ventricle, without apparent abscess formation. Using a flexible endoscope, we subsequently removed the abscesses from both lateral ventricles through the orifice between the resection cavity and the ventricle. The abscess appeared whiteish and adhered tightly to the ventricular wall. After removing as much of the abscess as possible with biopsy forceps, the ventricles were irrigated with gentamicin-infused saline (Fig. 3B). Because blood flow to the previously transplanted adipofascial flap from the anterolateral thigh was intact, the flap was used to repair the dura mater and fill the dead space in the brain parenchyma (Fig. 3C). We then harvested a tensor fascia lata musculocutaneous flap with attached vastus lateralis muscle and anastomosed it to the left superficial temporal artery and vein. Thus, the vastus lateralis muscle filled the bone defect in the anterior skull base, and the flap with skin removed was placed in the bone defect in the frontal region (Fig. 3D).

Following the craniectomy and abscess irrigation, we irrigated the lateral ventricles with gentamicin and vancomycin for 1 week (Fig. 4). The intravenous antibiotics, including meropenem, were discontinued after 6 weeks. The abscess disappeared, leaving vascularized

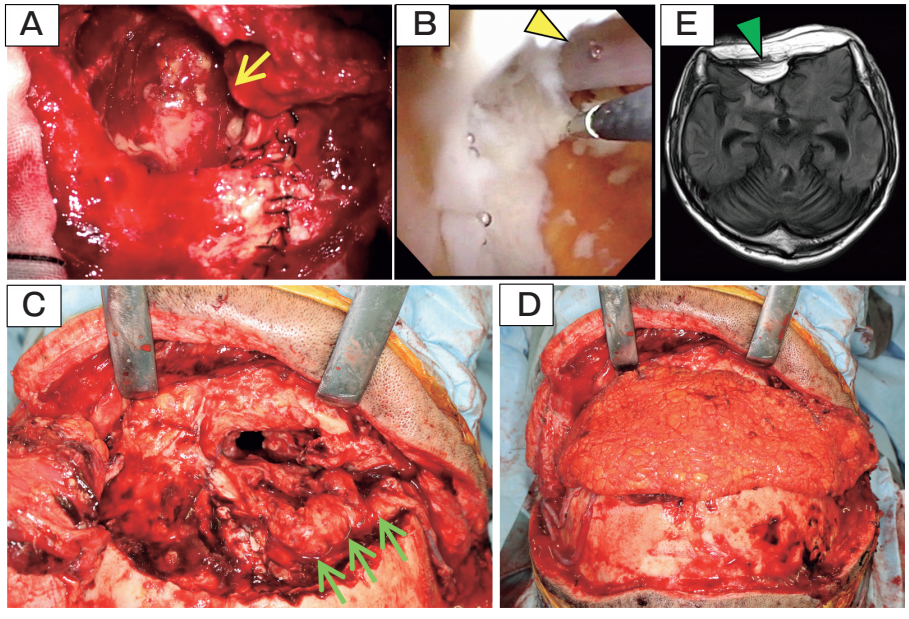

Fig. 3 Surgery for ventriculitis. **A**, Microscopic view after incising the dura. The cavity was filled with an abscess (yellow arrow); **B**, Endoscopic view in the right lateral ventricle. Ventricular drainage is visible (yellow arrowhead). The abscess was removed with endoscopic forceps; **C**, Macroscopic view after dural reconstruction with a vascularized anterolateral thigh adipofascial flap (green arrows); **D**, Macroscopic view after reconstruction of the bone defect with a tensor fascia lata musculocutaneous flap with vastus lateralis muscle; **E**, Postoperative diffusion-weighted MRI after craniectomy. The abscess has disappeared, and vascularized tissue remains in the resection cavity (green arrowhead). MRI, magnetic resonance imaging.

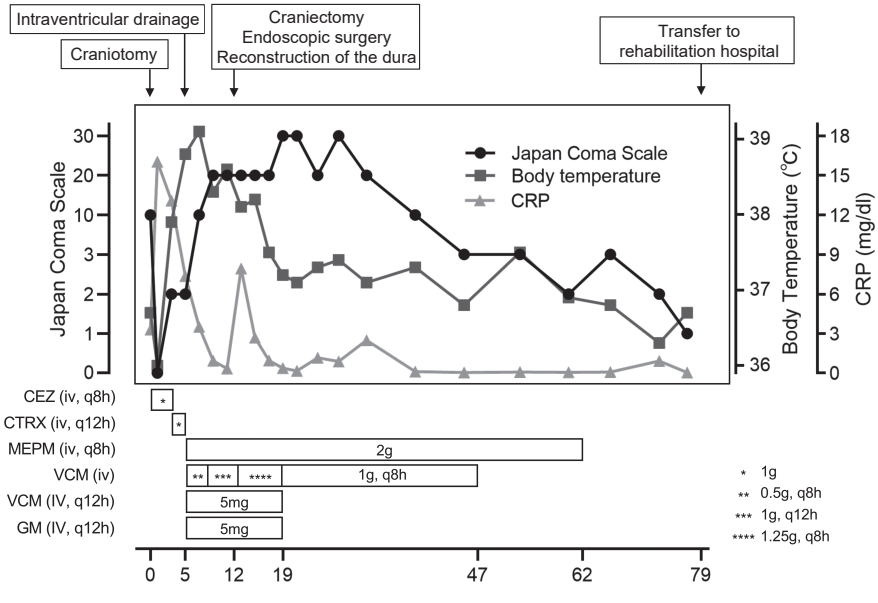

Fig. 4 Clinical course after the diagnosis of ventriculitis. The patient was administered meropenem for 8 weeks and vancomycin for 6 weeks. Also, the lateral ventricles were irrigated with vancomycin and gentamicin via ventricular drainages for 2 weeks. Craniectomy, endoscopic surgery and reconstruction of the dura were performed 1 week after the diagnosis. The patient's fever then declined, and his consciousness level started to improve beginning 14 days after craniectomy. CEZ, cefazolin; CTRX, ceftriaxone; MEPM, meropenem; VCM, vancomycin; GM, gentamicin; iv, intravenous; IV, intraventricular; CRP, C-reactive protein.

tissue in the resection cavity (Fig. 3E). The patient's consciousness level began to improve starting 14 days after the craniectomy. He was transferred to a rehabilitation hospital 67 days after the final surgery. Cranioplasty and scalp reconstruction with a vascularized skin flap were performed successfully 6 months later, after his rehabilitation was completed.

Discussion

Case summary. In this rare case, a 59-year-old man developed radiation necrosis of the right frontal skull base after a neurosurgical procedure. After ascertaining the diagnosis, we removed the necrotic area completely and reconstructed the anterior cranial skull base. Unfortunately, ventriculitis developed at several days postoperatively. In addition to intravenous and intraventricular antibiotic therapies, we irrigated both lateral ventricles using the endoscope and reconstructed the dura of the anterior cranial skull base using a vascularized flap, which dramatically ameliorated the patient's critical condition.

Mechanism of early onset of postoperative ventriculitis. Risk factors for post-neurosurgical intracranial infection include cerebrospinal fluid leakage and clean-contaminated craniotomy [6]. Generally, the symptoms of intracranial infection due to cerebrospinal fluid leakage present 1 week after neurosurgery. Huang *et al.* reviewed the literature regarding meningitis after neurotraumatic injury or neurosurgery and found only one case that had occurred earlier (8 h after intrathecal injection of contaminated skin disinfectant) [7, 8]. In our case, the patient's clinical condition deteriorated rapidly, although with no evident infectious finding and no apparent cerebrospinal fluid leakage — implying that the infection was caused by intraoperative contamination rather than postoperative cerebrospinal fluid leakage.

Surgicel is an absorbable hemostatic agent with a long history of safe, effective use in neurosurgery. Only one published report — a retrospective epidemiological analysis — showed that an absorbable hemostatic agent could cause postneurosurgical infection [9]. Our patient exhibited pus emerging from both lateral ventricles and the surgical cavity even though the surgical field seemed to be isolated from the right lateral ventricle with an absorbable hemostatic agent (Surgicel), implying that this absorbable hemostatic agent allowed infectious changes. However, the bactericidal effects of Surgicel have been attributed to its low pH [10], and implantation of Surgicel has been shown to markedly improve the survival of animals with infected spleens [11]. Therefore, our patient's lateral ventricles were probably infected with the bacteria via the orifice between the surgical field and the lateral ventricles, because the orifice might not have been completely closed, allowing the contamination.

Treatment of ventriculitis after anterior skull base surgery. Appropriate treatments for ventriculitis (*e.g.*, antibiotics, surgical excision) are required because intracranial infection after neurosurgical intervention is associated with a high mortality rate [12]. A combination of vancomycin and an anti-pseudomonal β-lactam antibiotic is recommended as systemic treatment for health care-associated ventriculitis [5]. Vancomycin is widely used to treat infectious disease due to methicillin-resistant *Staphylococcus aureus* (*e.g.*, meningitis, ventriculitis). The anti-pseudomonal β-lactam antibiotic meropenem is preferred for *Serratia marcescens* infection, such as in our patient, because it hyperproduces β-lactamases. Although intraventricular antimicrobials have not been approved by the U.S. Food and Drug Administration, the guidelines propose the use of intraventricular irrigation with antimicrobials, including gentamicin and vancomycin, when ventriculitis does not respond to systemic antibiotic therapy [5]. In addition, surgical removal of any pus present increases the therapeutic effects, especially when there is a large amount of pus in the cerebrospinal fluid [13, 14]. Recent reports have described treating ventriculitis with endoscopic irrigation of the ventricles. Endoscopy is also highly effective for visualizing and removing the pus from everywhere on the ventricles [14, 15]. Although the clinical course of the ventriculitis can be rapid, as in our patient who experienced a rapid critical decline, intensive treatments that include removing the pus and applying endoscopic irrigation can successfully address it, as they did in the present case.

Reconstruction of the infectious sites, including the dura, is also important when treating an intracranial infection [16, 17]. In our case, endoscopic surgery alone could have been undertaken to remove the pus through the surgical tract via the external drainages. The dura, however, should have been reconstructed with a vascularized flap because the initially reconstructed dura proved to be intensely affected by the

abscess, and intraventricular antibiotics were ineffective in the resection cavity prior to craniectomy. Repeated reconstruction procedures could be performed as in our case, although harvesting tissue from the donor site for the flap is invasive, as is anastomosing the vessels. Moreover, it is unique and important that the previously transplanted vascularized flap was used both to close the dura and to fill the resection cavity, as this increased the therapeutic effect of the antibiotics attempting to reach the resection cavity without vascular anastomosis.

Conclusion

We described a rare case of ventriculitis that appeared a few days after surgery for radiation necrosis of the right frontal lobe. Intracranial infection that occurs shortly after skull base surgery is usually attributable to a surgical field contaminated with bacteria derived from intraoperative exposure to the nasal cavity. Endoscopic ventricular irrigation with antibiotics and reconstruction of the surgical sites, including the dura, with a vascularized flap is an effective treatment for ventriculitis even in patients whose clinical condition is deemed critical.

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