Brain edema after cranioplasty

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Some authors have reported a rare unexplained complication of sudden death in association with massive brain edema immediately after cranioplasty.

Causes of cerebral edema and hemorrhage immediately after cranioplasty include reperfusion, reduction of automatic adjustment function, sinking skin flap syndrome, negative pressure due to s.c. drain, venous stasis, vascular damage following restoration of midline shift, and allergic reaction [1].

Once the computed tomography scan shows malignant cerebral swelling, the patient is expected to have a poor prognosis [2] [3].

It is hypothesized that intracranial hypotension (IH) caused stagnation of venous flow. Neurosurgeons should be aware that fatal venous congestion induced by IH may occur after cranioplasty. To avoid this, tight dural closure should be obtained, and avoidance of the use of subcutaneous drains should be considered [4].

Case reports

2023

A 45-year-old man underwent decompression craniectomy due to traumatic brain injury. At 3 months after the decompression craniectomy, the patient developed refractory subdural hydrogen and received ipsilateral refractory subdural effusion capsule resection, but no significant relief was seen. Therefore, the cranioplasty was decided to treat subdural hydrogen and restore the normal appearance of the skull. After the successful cranioplasty surgery and the expected anesthesia recovery period, the pupils of the patients continued to be dilated and fixed, without light reflection and spontaneous breathing. The Computed Tomography of the patient 1 hour after surgery showed malignant cerebral edema.

Conclusions: Malignant cerebral edema is a rare and lethal complication after cranioplasty. Negative pressure drainage and deregulation of cerebral blood flow at the end of cranioplasty may partially explain the malignant cerebral after cranioplasty. In addition, patients with epileptic seizures, no spontaneous breathing, dilated pupils without reflection, and hypotension within a short period after cranioplasty may show the occurrence of malignant cerebral [5].

The first clinical cases using a novel dynamic craniotomy bone flap fixation system. The NeuroVention NuCrani reversibly expandable cranial bone flap fixation plates provide dynamic bone flap movement to accommodate changes in intracranial pressure (ICP) after a craniotomy.

The reversibly expandable cranial bone flap fixation plates were used for the management of cerebral swelling in a patient with a subdural hemorrhage after severe traumatic brain injury and another patient with a hemorrhagic stroke.

Results: Both cases had high ICP which normalized immediately after the dynamic craniotomy. Progressive postoperative cerebral swelling was noted which was compensated by progressive outward bone flap migration thereby maintaining a normal ICP, and with the resolution of the cerebral swelling, the plates retracted the bone flaps to an anatomic flush position.

Conclusion: The reversibly expandable plates provide an unhinged cranial bone flap outward migration with an increase in ICP and retract the bone flap after the resolution of brain swelling while also preventing the bone flap from sinking inside the skull [6].

2022

a 9-year-old boy who developed massive brain swelling following reduction cranioplasty for secondary turricephaly. His history included surgical repair of metopic-craniosynostosis at age 5.5 months, by means of an anterior cranial-vault reconstruction with front orbital advancement. After presenting to our clinic with a significant turricephalic skull deformity, he underwent cranial reduction cranioplasty. On postoperative day 1, mild neurological signs associated with increased intracranial pressure were noticed. As they worsened and massive brain swelling was identified, he was treated pharmacologically. On postoperative day 13, the patient was operated for decompression. A literature review yielded 4 articles related to massive brain swelling for post-traumatic craniectomies. None described elevated intracranial pressure or massive brain swelling following cranial reduction for secondary craniosynostosis. The main dilemma regarding our patient was the necessity and timing of a second operation. The literature did not reveal relevant recommendations regarding treatment timing or preventative measures. The authors recommend presurgical neuro-ophthalmological and imaging evaluation, for comparisons and management during the immediate and short-term follow-ups. The authors suggest that for a patient presenting with signs and symptoms of cerebral edema or high intracranial pressure following reduction-cranioplasty, pharmacological treatment should be initiated promptly, and careful drainage and eventual surgical-treatment should be considered if no improvement is shown in the subsequent days [7].

2019

Zhang et al. reported one fatal case and analyze the possible mechanism of this complication.

The patient was a 40-year-old man who had a severe right basal ganglia hemorrhage and underwent DC ~ 2 months before. One day before the scheduled cranioplasty, a External lumbar cerebrospinal fluid drainage was placed. The cranioplasty itself was uneventful. However, he gradually fell into a coma, and his right pupil was moderately dilated 20 hours after the surgery. A brain computed tomography (CT) scan indicated massive right cerebral edema with compressed right midbrain. The patient did not regain consciousness, and he remained quadriplegic.

It is necessary to increase awareness of complications of cranioplasty in high-risk patients. The lessons learned from this case include avoiding excessive drainage of cerebrospinal fluid. Patients with low-density lesions in the brain need to be treated with caution. Once the CT scan shows massive cerebral swelling, the patient has a poor prognosis [8].

2018

A 51-year-old man who was a victim of traumatic brain injury underwent emergency clot removal and decompression craniectomy. His neurologic condition improved with subsequent rehabilitation therapy, and he had left sinking skin flap syndrome where the skull was defective. Six months after the initial surgery, he underwent a cranioplasty; however, he did not recover from the uneventful anesthesia. A vacuum suction drain showed 300 mL of flow outflow had drained when his pupils dilated and fixed. An immediate computed tomography scan showed ipsilateral diffuse cerebral swelling with diffuse cerebral hemorrhage. Despite all approaches that were considered, the cerebral swelling continued to worsen until death [9].

2017

Two cases of critical brain swelling after otherwise uneventful cranioplasty. Both cases had subarachnoid hemorrhage and extremely similar clinical courses. They underwent decompressive craniotomy and clipping in the acute phase and had cranioplasty in the chronic phase, resulting in serious cerebral swelling and death. Deep venous sinus thrombosis was revealed in the autopsy for one case. Although no venous occlusion was identified in the other case, radiological findings suggested venous congestion. In both cases, intraoperative cerebrospinal fluid leakage was massive and was prolonged by a drain [10].

A 64-year-old man was admitted with the diagnosis of cerebral hemorrhage, and emergency surgery for hemorrhage removal and decompressive craniotomy were performed. One month after surgery, cranioplasty was performed using a titanium mesh plate. Sixteen hours after the surgery, the patient became comatose with bilateral dilated pupils followed by blood pressure lowering. Computed tomography of the brain showed bilateral massive cerebral edema. The titanium mesh plate was immediately removed, however, the patient's neurological condition did not recover and he died 7 days after the surgery. We speculated that the negative pressure difference and increase in cerebral blood flow after cranioplasty may have attributed to the fatal cerebral swelling [11].

A 84-year-old man with subarachnoid hemorrhage underwent craniotomy and clipping with external decompression. Perfusion magnetic resonance imaging showed subclinical sinking skin flap syndrome,

and he underwent cranioplasty on postoperative day 58. No problems occurred during the operation, but cerebral edema and hemorrhage were recognized on immediate postoperative computed tomography. Edema continued to progress, but edema and bleeding eventually improved without additional surgery.

Neurological symptoms improved to presurgical baseline and stabilized [12].

2015

A 50-year-old female was admitted with sudden onset of stuporous consciousness. A brain computed tomography (CT) revealed a subarachnoid hemorrhage with intracranial hemorrhage and subdural hematoma. Emergency decompressive craniectomy and aneurysmal neck clipping were performed. Following recovery, the decision was made to proceed with an autologous cranioplasty. The cranioplasty procedure was free of complications. An epidural drain was placed and connected to a suction system during skin closure to avoid epidural blood accumulation. However, following the procedure, the patient had a seizure in the recovery room. An emergency brain CT scan revealed widespread cerebral edema, and the catheter drain was clamped. The increased intracranial pressure and cerebral edema were controlled with osmotic diuretics, corticosteroids, and antiepileptic drugs. The edema slowly subsided, but new low-density areas were noted in the brain on follow-up CT 1 week later. They speculated that placing the epidural drain on active suction may have caused an acute decrease in intracranial pressure and subsequent rapid expansion of the brain, which impaired autoregulation and led to reperfusion injury [13].

Sviri reported on 4 patients who underwent cranioplasty after DC between January 2005 and August 2010 and died because of massive cerebral edema immediately after uneventful surgery and anesthesia. All 4 of the new cases reported involved young male patients who underwent decompressive hemicraniectomy after traumatic brain injury. They developed massive cerebral swelling immediately after uneventful cranioplasty (3 patients) or after removal of an epidural hematoma several hours after surgery (1 patient). All 4 patients had a large skull defect and significantly sunken craniotomy site, and all were treated with a closed vacuum suction system that was placed under the scalp and kept open at the end of the cranioplasty procedure. After surgery, the patients' pupils became fixed and dilated, and brain CT scans showed massive brain edema. Despite emergency DC, the patients did not recover, and all 4 died. A MEDLINE search showed 8 similar cases that were reported previously. Fatal cerebral swelling after uneventful cranioplasty is a distinct clinical entity, although it is unpredictable. It is postulated that a negative pressure difference from the elimination of atmospheric pressure that had been chronically applied on the injured sinking brain in combination with the negative pressure applied by the closed subgaleal suction drain may lead to a massive brain shift toward the cranioplasty site and initiate a fatal vasomotor reaction [14].

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