RESOLUTION OF INTRACRANIAL HYPERTENSION AFTER ELEVATION OF DEPRESSED CRANIAL FRACTURE OVER THE SUPERIOR SAGITTAL SINUS: CASE REPORT

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OBJECTIVE AND IMPORTANCE: It is common neurosurgical wisdom that depressed cranial fractures (DCFs) over the superior sagittal sinus (SSS) should not be elevated because of the risk of fatal venous hemorrhage.

CLINICAL PRESENTATION: A 34-year-old man presented with severe headache and diplopia after a motor vehicle accident. Clinical examination demonstrated severe papilledema and bilateral abducens palsy. Imaging findings demonstrated a DCF over the posterior third of the SSS and absent flow distal to the fracture with dilated cortical venous drainage.

INTERVENTION: Conservative treatment with acetazolamide only partially alleviated the patient’s headache and diplopia. Definitive surgical treatment via elevation of the DCF was discussed and decided upon. Twelve days after injury, the patient underwent midline parieto-occipital craniotomy with successful elevation of the DCF off the posterior third of the SSS. Postoperative magnetic resonance venograms revealed restoration of patency in the SSS with reduced tortuosity of cortical veins. The patient’s headache resolved, and his papilledema and diplopia resolved gradually.

CONCLUSION: Elevation of DCF over the SSS can be attempted in cases in which favorable bone anatomy and the patient’s clinical condition warrant. This may result in rapid and dramatic resolution of signs and symptoms of secondary intracranial hypertension.

KEY WORDS: Depressed cranial fracture, Intracranial hypertension, Papilledema, Superior sagittal sinus

Midline depressed cranial fractures (DCFs) occasionally lead to occlusion of the superior sagittal sinus (SSS), resulting in secondary intracranial hypertension and neurological deficit (6, 23). Conventional neurosurgical wisdom dictates that the fracture should not be elevated because of the risk of fatal hemorrhage (1, 7, 8). However, some published cases document safe fracture elevation over the SSS with clinical and radiographic resolution (4, 6, 14, 22). In support, we report the case of a patient with DCF over the posterior third of the SSS leading to signs and symptoms of secondary intracranial hypertension, which resolved after fracture elevation. In addition, we review the literature regarding operative intervention in cases of DCF over major cranial venous sinuses.

CASE REPORT

A 34-year-old restrained driver was involved in a motor vehicle accident and sustained a closed head injury with brief loss of consciousness and memory to the event. Thereafter, he was alert and oriented and was determined to have a large occipital scalp laceration. A nonenhanced head computed tomographic (CT) scan revealed a DCF of the posterior midline parietal bone with a 1.2-cm depression (Fig. 1A). A brain magnetic resonance venogram (MRV) revealed a midline parietal DCF (3.1 × 2.5 cm) obliterating flow in the subjacent SSS (Fig. 2A) and prominent scalp veins. Initially, the patient was treated conservatively with intravenous narcotics followed by progressive mobilization. On the 4th hospital day, the patient reported severe headache and diplopia and was determined to have bilateral abducens and trochlear palsies with esodeviation and papilledema. The patient was managed conservatively for several more days, but his symptoms intensified and were complicated by the development of bilateral aural “hum.” A repeat MRV (1 wk after
the first MRV) revealed even slower flow in the SSS (Fig. 2B). Further ophthalmological evaluation included Humphrey visual fields, which demonstrated enlarged blind spots and early peripheral depression. Marked, acute papilledema and hemorrhages were now observed bilaterally. The patient was administered acetazolamide (Diamox; Wyeth Pharmaceuticals, Collegeville, PA), which led to mild improvement but incomplete resolution of his diplopia and aural hum. Given that the patient continued to have persistent bilateral abduction palsies and worsening vision, the decision to proceed with operative fracture elevation was made.

Twelve days after presentation, the patient underwent a biparietal craniotomy with elevation of DCF and decompression of the SSS. Intraoperatively, elevated venous pressures were noted in the subcutaneous tissues over the parietal midline. Bone bleeding was encountered, indicating increased pressure in the diploic space of the cranium. Multiple burr holes were used with a significant margin from the DCF to allow optimum visualization and gentle elevation. No dural laceration or SSS tear was observed. Inspection of the bone fragment revealed a comminuted compound fracture of the inner table (Fig. 3A), which was removed successfully separately from the outer table (Fig. 3B). Postoperatively, the patient’s diplopia improved and the aural hum resolved. Ophthalmoscopic examination demonstrated preserved visual acuity with persistent papilledema. A CT scan obtained on the 1st postoperative day revealed adequate fracture reduction (Fig. 1B), and an MRV revealed improved flow in the SSS with some residual SSS stenosis (Fig. 2C). Subsequently, the patient’s condition continued to improve, and by the time of discharge to home on the 2nd postoperative day, his diplopia had almost completely resolved. An MRV obtained 2 months postoperatively revealed entirely restored patency in the SSS (Fig. 2D), and the patient has not experienced recurrence of symptoms of intracranial hypertension.

**DISCUSSION**

**History**

In 1901, Wharton (25) reviewed 70 cases of “wounds of the great venous sinuses of the brain” and reported high operative mortality associated with elevation of fractures compressing the SSS. In 1915, Holmes and Sargent (9) described severe neurological deficits associated with obstruction of the parietal (postrolandic) portion of the SSS. In 1939, Carlucci (3) reported a case of DCF over the SSS, in which there was...
significant operative hemorrhage at fracture elevation controlled with packing to avoid exsanguination. In 1947, Kaplan (12) described two patients with compound DCFs involving the SSS, both of whom were treated effectively by operative fracture elevation. In 1953, Caudill et al. (4) were the first to measure CSF pressures pre- and post-SSS decompression via lumbar puncture to document the efficacy of sinus decompression at ameliorating intracranial hypertension.

Available case series of DCFs suggest that location over major venous sinuses is uncommon. In a study of 104 patients with compound cranial fractures, Pickles (18) documented no case of SSS injury. Munro (16) documented one case of SSS involvement in 215 cases of compound cranial fractures. In 1968, Miller and Jennett (15) documented 400 consecutive patients with civilian DCFs; 11% involved a major venous sinus.

Clinical Presentation and Diagnosis

In addition to local pain and tenderness associated with the traumatic insult, a variety of neurological deficits have been associated with SSS obstruction from a DCF, including obtundation, papilledema, altered visual acuity, nausea and vomiting, and sensorimotor dysfunction (6, 13, 14, 20, 22, 23); these findings are commonly observed in patients with secondary intracranial hypertension (2, 5, 10). In our patient, persistent headache accompanied by abducens and trochlear palsies, aural hum, and severe papilledema were noted.

As part of a standard trauma evaluation, a noncontrast head CT scan should reveal the DCF. Sinus patency can be evaluated by magnetic resonance imaging (13, 14, 22, 23). Magnetic resonance venography, in particular, provides detailed information regarding the site of obstruction, indirect indications of the degree of flow, and the presence or absence of thrombus (17, 19, 22, 23), and it can be used to observe the development of collateral circulation after a prolonged period of venous occlusion (23). Conventional sinus venography can be used if the magnetic resonance imaging scan/MRV is ambiguous (13).

Treatment

Factors justifying surgical treatment for DCF include presence of CSF leak suggesting dural tear, open fracture suggesting infection risk, significant mass effect on underlying parenchyma, and marked cosmetic disfigurement (1, 6, 7, 24). In such cases, operative debridement with or without elevation of fracture fragments and primary dural closure where appropriate can prevent associated sequelae (6, 21, 23); however, it is not clear that fracture elevation aids in prevention of post-traumatic epilepsy (11).

In a patient with DCFs overlying intracranial venous sinuses, conventional wisdom dictates extreme caution (1, 7, 8). However, several published reports document safe fracture elevation after failed conservative management. In a patient with traumatic DCF leading to total SSS obstruction, elevation of the bony fragments led to resolution of headache and obtundation (4). More recently, another patient with an open parietal DCF and partial SSS obstruction underwent fracture elevation, leading to immediate intraoperative ICP reduction (6). In a patient with homonymous hemianopsia and bilateral papilledema caused by a parietal DCF, surgical elevation led to prompt resolution of symptoms (22). Elevation of an occipital DCF in a 13-year-old boy with headache, emesis, and hyponatremia (14) led to complete resolution of symptoms within 7 days, and follow-up imaging verified SSS recanalization at 6 months (14).

Nonsurgical treatment of occlusive lesions over the posterior SSS also has been attempted. In a patient with parietal contusion and SSS occlusion who presented with acute cortical blindness and right leg monoplegia, conservative treatment with intravenously administered dexamethasone led to gradual restoration of sinus patency, but the visual deficits persisted (13). In a patient with headache, inferior quadrantanopsia, and papilledema caused by a partially obstructed SSS, serial lumbar punctures were used to reduce intracranial pressure, which ultimately led to resolution of symptoms (23).

Although all patients deserve individual consideration, progressive loss of visual acuity refractory to medical intervention seems an appropriate criterion for surgical intervention. In our patient, obliteration of the posterior third of the SSS, together with refractory and worsening symptoms, led us to surgical intervention. In addition, the appearance of the bony anatomy on preoperative CT scans suggested sinus compression rather than laceration or transection (Fig. 1A). Surgical exposure led to safe decompression followed by resolution of all neurological findings attributable to secondary intracranial hypertension.

CONCLUSION

The choice of whether to pursue surgical elevation of a DCF is contingent on the severity and evolution of the associated symptomatology. Our case report demonstrates that elevation of DCFs over the SSS can be attempted in cases in which favorable bone anatomy and the patient’s clinical condition warrant. This may result in rapid and dramatic reversal of signs and symptoms of secondary intracranial hypertension and prevent irreversible visual loss.

REFERENCES

ELEVATION OF DEPRESSED CRANIAL FRACTURE

The authors describe their surgical management of a patient with a depressed cranial fracture associated with occlusion of the posterior segment of the superior sagittal sinus. When medical treatment failed to relieve the patient’s symptoms and papilledema with hemorrhages and a decline in peripheral vision were documented, the patient was taken to surgery for elevation of the depressed fracture. This led to gradual resolution of the patients’ symptoms and restoration of normal flow through the superior sagittal sinus. In their very thorough review of the literature on this topic, the authors emphasize the risks involved with elevation of fractures over the superior sagittal sinus. It is important to note that before surgery, on the basis of a preoperative magnetic resonance venogram, they suspected that the superior sagittal sinus was compressed but not lacerated. Before surgery for elevation of such fractures, high-quality imaging studies must be performed to determine the integrity of the sinus. Often, the sinus is disrupted or lacerated, and this significantly complicates the surgery. In such cases, the surgeon must prepare for temporary shunting across the area of injury by widely exposing the sinus on either side of the site of injury before elevating the fracture. Even with this technique, significant brain swelling from an associated contusion or thrombosis of the proximal superior sagittal sinus can severely complicate repair of the damaged sinus. Thus, whenever possible, I would advocate medical management of these patients unless they have progressive neurological signs or symptoms.

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In this well-presented case report, the authors review the literature supporting and against operative intervention in patients with depressed fractures over the sagittal sinus. In the patient reported here, the presentation was chronic and characterized by features of raised intracranial pressure. More often, however, the presentation is much more acute, with fulminate intracranial pressure or massive bleeding in relation to sagittal sinus injury. In that event, the neurosurgeon may not have the luxury of the controlled circumstances reported here.

At the Medical College of Virginia, we have found that sagittal sinus pressure measurements may be of value and may easily be made by unroofing the sinus anterior to the depressed fracture and connecting a fluid column by means of a sharp needle to a manometer to measure the pressure. This also allows relatively safe temporary occlusion of the sagittal sinus during repair procedures. It cannot be emphasized too strongly, however, that the single most important factor in ensuring a successful outcome with sagittal sinus surgery in the trauma context is the head positioning of the patient.

Anesthesiologists should always prepare for the possibility of embolism with such patients, and the neurosurgeon needs to ensure that technical support, in the form of vascular clamps (a DeBakey “small-vessel” clamp is ideal) together with aneurysm clips, etc., is available. In addition, the head position should be slowly elevated to ensure a neutral pressure in the sagittal sinus so that there is also no risk of air entrapment during the procedure. These aspects should be attended to before the surgery is commenced. Frequent Val-salva maneuvers by the anesthesiologist may help to achieve this optimal positioning and minimize air entrapment.

There are numerous reports in the literature of dural patching techniques, muscle onlay, hemostatic patches, etc., that may be used, but in our experience, 6-0 Prolene continuous...
suture (Ethicon, Inc., Somerville, NJ) is often the most useful way to repair a torn sagittal sinus in the context of acute trauma. Usually, if there is a posterior third sinus injury or a torcular injury, the patient may need to be positioned prone and the repair facilitated by a temporary proximal clamp and continuous intracranial pressure monitoring, together with monitoring of the intrasagittal sinus pressure.

Ross Bullock
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This case report serves as a useful reminder of the potential danger from midline-convexity depressed cranial fractures and how symptomatic venous outflow obstruction from such an injury can occur in a delayed manner. Elevation of the fracture on postinjury Day 12 resulted in flow restoration through the sinus and resolution of intracranial hypertension. This case also demonstrates the usefulness of magnetic resonance angiography for diagnosing sinus flow abnormalities, obviating the need for conventional angiography. The authors have demonstrated excellent management of this patient.

Daniel F. Kelly
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During one of the first operations I assisted in, the bone was elevated over the confluens sinuum (torcula). I was advised never to lesion the sinus there, because “more than a liter of blood passes per minute.” Asked about what I should do if I lacerated it unintentionally, I was told: “Put your finger on it and call for help.” A couple of months later I performed one of my first epidural hematomas. The hematoma crossed the midline, and when I elevated the flap, blood spurted from a rupture of the sinus just above the confluens. I put my finger on it and asked the nurse to call the professor. With his help, the lesion was patched without problems.

In the present article, Binder et al. discuss a 34-year-old man with severe headache and diplopia after a motor vehicle accident. Computed tomography revealed a cranial fracture over the posterior sagittal sinus, and magnetic resonance venography revealed the absence of flow at the fracture site and dilated cortical veins. After conservative treatment had failed, the fractured area was repaired surgically, and the patient’s symptoms resolved.

The old masters told us that operations interfering with the sinus could have disastrous effects. The technical developments within our field, however, have made it possible to deal efficiently with most lesions of the sinus. Consequently, the threshold for elevating fractures crossing the sinus should be lowered. The present case report gives an eloquent example that it sometimes is necessary.

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