DURING the Vietnam conflict, 4% of 3000 penetrating craniocerebral injuries have involved a dural venous sinus. Military surgical experience demonstrates that such injuries require early definitive treatment. Cushing proposed in World War I that surgery could prevent the complications of acute hemorrhage, progressive venous thrombosis, cerebral edema, and infection associated with wounds involving the major venous channels. After World War II, Matson reviewed the principles of surgical treatment of dural sinus wounds. Meirowsky extensively analyzed the Korean War experience. At that time surgical treatment included debridement and thrombectomy followed by ligation of transected sinuses, or closure of lacerations by gelfoam packs or muscle stamps secured by dural sutures. Meirowsky concluded that there was no satisfactory technique for functional restoration of vascular continuity. Synthetic tubular grafts were used early in the Vietnam conflict, but all failed due to the associated problems of a foreign prosthesis in the venous system. A reappraisal of the surgical management of dural sinus wounds was then made and, by using current vascular surgical techniques, autogenous venorrhaphy was accomplished in 10 cases.

Operative Technique

When initial physical and radiographic examination of a patient indicated the possibility of a dural sinus injury, an organized aggressive plan for safe debridement and repair of the most extensive conceivable injury for that particular case was begun. While the necessary preparation and stabilization of the patient was being accomplished, hemorrhage was controlled by discrete external pressure either manually or by surgical dressing. Despite the potential hazard of air embolism, the preferred position with the head elevated for control of hemorrhage and optimal surgical approach was used, with an indwelling catheter in the superior vena cava for careful monitoring of the cardiovascular status.

Debridement and Thrombectomy

The standard principles for debridement of penetrating craniocerebral trauma were followed to the point of definitive repair of the sinus defect. During the debridement, the ensuing hemorrhage was frequently discouraging. However, adequate exposure, strategic digital pressure, careful placement of the cottonoid dams, and occluding clamps, as necessary, made repair possible.
Thrombectomy by digital expulsion and gentle suction was then accomplished. Intermittent release of controlled occlusion and copious irrigation with heparinized saline solution were used to preclude thrombosis and lessen the cerebral edema due to vascular stasis during the repair. Parenteral mannitol solution was used to gain exposure, particularly if the injury of the sinus was in apposition to the cortex. This regime appeared to lessen the edema from controlled occlusion during repair and in the postoperative period. With the same criteria used, steroids were empirically given in all cases.

**Simple Lacerations**

After debridement of the sinus wound and adjacent dura, an autogenous venorrhaphy was performed by using a pericranial patch graft or a saphenous vein section insert. Simple lacerations or single wall avulsions were repaired by placing the pericranial patch graft directly over the aperture. The graft was stabilized by digital pressure, secured with two stay sutures, and then sutured circumferentially with fine vascular suture (Fig. 1).

Total transection with loss of continuity of a sinus required insertion of an autogenous saphenous vein graft. After debridement of the sinus was accomplished, a length of graft just adequate to tautly span the defect was fashioned, beveling the ends as necessary to match circumferences. A polyethylene tube placed through the vein graft and inserted proximally and distally into the sinus stabilized the graft in position and served as a shunt to relieve venous stasis during the anastomosis. Encircling ligatures placed around the sinus proximally and distally secured the shunt and gained hemostasis. After two stay sutures had aligned the graft, an edge-to-edge anastomosis was performed (Fig. 2). Loupe magnification was used and the proximal anastomosis was accomplished first. Before the final superior portion of the distal anastomosis was closed, the polyethylene tube was removed and a repeat thrombectomy performed allowing the sinus and graft to flush clear. Heparinized saline was used to cover the aperture, preventing air embolism during this phase. All intact tributary cortical veins were protected and salvaged wherever possible to keep the ultimate loss of drainage to a minimum. Bleeding from the anastomosis was controlled by gentle cottonoid pressure over surgicel mesh or gelfoam. Flow dynamics and vascular techniques were applied throughout the procedures as in a peripheral vascular repair. Finally, the entire area was irrigated clean to preclude arachnoidal villi obstruction and the sequelae of hydrocephalus. Remaining dural defects were closed primarily or with a pericranial patch graft, taking care not to embarrass the venorrhaphy (Fig. 3).
Berkley L. Rish

FIG. 2. Vein graft in situ over shunt tube secured in sagittal sinus.

Donaghy has applied microsurgical vascular technique to accomplish similar venorrhaphy in dural sinus injuries. In one case, using the operating microscope and his “T” tube strut technique, he anastomosed a cortical tributary vein to a saphenous vein insert graft. This patient died due to extensive associated cortical injury. Postmortem examination revealed the venous restoration to be intact and patent.

Discussion

The 10 cases comprising this report include eight patch grafts and two vein inserts. Three fatalities occurred, all in the first 72-hour postoperative period. The anatomical distribution of the wounds included six in the middle third of the superior sagittal sinus, two in the posterior third and torcular area of the superior sagittal sinus, and two in the large transverse sinuses. Wounds of the anterior third of the superior sagittal sinus or a small lateral sinus, not considered to be the dominant outflow for the confluens, were managed by ligation or occlusion without significant morbidity.

Neurological Signs

The neurological presentation was variable depending on the area of venous stasis and associated cortical injuries. Spastic paresis of the legs, and occasionally of the arms as well, was seen most often with injuries of the middle third superior sagittal sinus. Cortical blindness was noted preoperatively with injuries of the posterior third of the sagittal sinus. Seven patients had severe initial neurological deficits including coma, denoting extensive cortical damage and cerebral edema.

Two patients with superior sagittal sinus injuries showed hemiplegia and progressive deterioration. Each of these patients had an associated large subdural hematoma. One with minimal associated direct cortical injury showed rapid neurological improvement postoperatively. A 3 × 1 cm patch graft had been placed over an aperture in the left lateral aspect of the middle third of the superior sagittal sinus 1 cm proximal to a large Rolandic vein insertion. There were no neurological deficits detectable 2 weeks postoperatively, and a 6-month evaluation revealed no sequelae of increased intracranial pressure.

Of the two patients requiring posterior repairs, the first had minimal associated direct cortical damage; he began to show improvement in the cortical blindness immediately postoperatively and had functional vision by 1 week. He did not demonstrate any additional neurological deficits or increased intracranial pressure in the 2 weeks of postoperative hospitalization. The repair was a 4 × 1 cm patch graft placed externally 1 cm above the torcular. The second patient in this category had an extensive occipital injury and required a large lateral patch repair at the torcular and ligation of the right lateral sinus; he died 10 hours postoperatively.
Autogenous venorrhaphy in dural venous sinus wounds

without regaining consciousness and no post-mortem examination was permitted.

The second fatality occurred 72 hours postoperatively, in a soldier who had presented coma with spastic paraplegia. A small patch graft was placed in the lateral wall of the middle third of the superior sagittal sinus directly in the Rolandoic area. There was extensive bilateral cortical damage secondary to multiple penetrating fragment wounds. Postmortem examination revealed the graft to be intact and the sinus patent. The third fatality occurred 48 hours postoperatively. This Marine had sustained a high velocity missile wound across the vertex. A 2.5 cm saphenous vein insert graft had been placed in the middle third of the superior sagittal sinus. Extensive cortical avulsion was present in the adjacent Rolandoic area. The graft was intact and not thrombosed at postmortem examination.

A Vietnamese woman sustained a tangential fragment wound with minimal associated cortical damage and presented hypotension, stupor, and spastic paraplegia. A saphenous vein insert graft was placed 2 cm posterior to the entrance of the large Rolandoic veins into the superior sagittal sinus to span a 3 cm defect. On the first postoperative day she was more alert and had regained functional use of her legs. Six weeks postoperatively her only residual sign was hyperactive deep tendon reflexes in the legs. No signs of increased intracranial pressure were noted during the postoperative course.

In another case, a $3 \times 1$ cm patch repair of a large lateral sinus wound was found intact and functional during a repeat craniotomy on the second postoperative day for a retained bone fragment.

One patient with a $2 \times 1$ cm patch applied to the superior wall of the superior sagittal sinus directly at the Rolandoic inflow developed progressive postoperative triplegia, papilledema, and stupor, indicating sinus thrombosis. He gradually improved over the next 6 months but has a residual spastic paresis of the legs, optic atrophy, and deficient visual acuity.

The remaining two patients progressed well clinically without signs of embarrassed venous drainage or neurological deterioration.

Angiograms were not performed under combat zone conditions. No complications due to infection were seen. Prophylactic antibiotics and Dilantin were routinely used.

Conclusion

When treating acute wounds of the critical dural venous sinuses, namely, those of the posterior two-thirds of the superior longitudinal sinus, the torcular, or a dominant transverse sinus, autogenous venorrhaphy seems warranted. In other less critical areas where sacrifice or compromise of the sinus is better tolerated, ligation, primary suture repair, or securing with metallic clips is acceptable. Similarly, when an elective sinus resection is contemplated, where the loss of vascular continuity could increase morbidity, an autogenous venous restoration should be considered.

References

3. Donaghy RMP: Personal communication, June, 1970

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The opinions or assertions contained herein are those of the author and are not to be construed as official or reflecting the views of the U.S. Navy Department or of the Naval Service at large.

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