Rare disease

Penetrating intracranial gunshot wound transecting the right transverse sinus

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Summary

A 23-year-old man sustained a gunshot wound to the posterior head. Imaging demonstrated a transection of the right transverse sinus, a retained bullet fragment and significant cerebellar oedema. The patient emergently underwent suboccipital decompression associated with brisk bleeding from the transverse sinus. Reported examples of surgical management of cerebral venous sinuses include: packing, grafting, patching and ligation. Our patient had a codominant transverse sinus and underwent successful unilateral ligation. His postoperative course was uneventful, however, he did require a ventriculoperitoneal shunt. He was subsequently discharged to rehab with a favourable outcome.

BACKGROUND

The current medical literature has described only a handful of successful surgical outcomes for treatment of gunshot wounds transecting the posterior intracranial venous sinuses. Only one report details a case with retained bullet fragment; however, the sinus was not transected. We present a transecting transverse sinus injury with retained bullet fragment and significant cerebellar and occipital injury treated successfully with rapid suboccipital decompression and ligation of the injured sinus. We also review the literature pertaining to penetrating venous sinus injury.

CASE PRESENTATION

A 23-year-old man was struck in the posterior aspect of the head by a small caliber bullet from close range during a motor vehicle theft. The patient was immediately airlifted to the University of Maryland Shock Trauma Center. At admission, his Glasgow Coma Score was 12 (E2/M6/V4), he had a gross visual field deficit on the left, truncal ataxia and right side dyskinesia. The bullet entry point was 2.5 cm right of theinion. The entry wound was left unwrapped and allowed to bleed externally. CT angiography of the head and neck was obtained (figure 1). A bullet fragment was found in the right transverse sinus, a 10 ml intracerebellar clot was present along with a small posterior fossa subdural haematoma. Brainstem compression was noted with loss of the prepontine cistern and effacement of the fourth ventricle. Antiepileptic prophylaxis and broad-spectrum antibiotics were initiated, per protocol. Directly after admission the patient's neurological exam deteriorated to Glasgow Coma Score of 6 (E1/M4/V1) with a right minimally reactive pupil. The patient was intubated and a right frontal external ventricular drain was rapidly inserted, followed by emergent surgical decompression, ligation of the transverse sinus and debridement.

He initially required two units of packed red blood cells and the anaesthesia team had started intravenous

norepinephrine to maintain sustainable mean arterial pressures. In the operating room a midline incision was made starting below the occiput hooking to the right towards the parietal boss. The bony entry point was exposed through a subperiosteal dissection. A single burr hole was made inferior and lateral to the entry wound overlying the right cerebellar hemisphere. A craniectomy was turned encapsulating the entry wound with care to leave the bony roof of the torcula intact. Brisk bleeding from the venous sinuses was encountered before and directly after exposure. This bleeding was controlled manually by applying pressure against the bony craniectomy lip. A single large bullet slug was removed. Both the external sinus wall and the internal wall were in tatters. The proximal and distal sinuses were exposed and closed using large vicryl sutures. The intraparenchymal clot was evacuated. Bullet and bone fragments were removed if visible within the surgical cavity. Arterial bleeding was controlled using bipolar electrocautery. Copious irrigation was used to ensure haemostasis and wound debridement. The evacuation cavity was lined with surgical. Wound closure

Figure 1 Pre-operative axial CT demonstrating gunshot to the transverse sinus with resultant metal artifact and bone fragments in the region of transverse sinus.

was obtained with inverted galial sutures followed by vertical mattress nylon sutures. No surgical drain was placed to avoid cerebrospinal fluid fistula.

The patient was moved to the intensive care unit. Systolic blood pressure was maintained below 140 mm Hg for 72 h, antiseizure medication was continued for 7 days. The patient required multiple units of fresh frozen plasma and packed red blood cells in the postoperative period. A postoperative CT was obtained (figure 2). Broad-spectrum antibiotics and antifungals were continued for 7 days for penetrating intracranial infection prophylaxis. The night after surgery the patient was localising briskly with both arms. Two days postoperatively he followed commands, which he continued to do for the remainder of his hospital course.

During the second and third week of the hospitalisation, attempts were made to wean the external ventricular drain. After two failed attempts a ventriculo-peritoneal shunt was placed. On the 11th hospital day, ventilator-associated pneumonia was diagnosed eventually leading to the patient requiring a tracheostomy.

OUTCOME AND FOLLOW-UP

Three weeks after the injury the patient was transferred to traumatic brain injury rehabilitation. At 3 months the patient was cognitively intact, a left visual field cut persisted and the patient's right-sided dyskinesia was improving. He was ambulating independently and the tracheostomy had been removed. He had returned home and intends to restart graduate education in the foreseeable future.

DISCUSSION

Penetrating brain injury has been described in numerous civilian and military series.^{1–11} However, because of its

rarity and eminent morbidity, there is a deficit in the literature describing surgical treatment and outcome of patients with penetrating missile injury to the venous sinuses, particularly the posterior venous sinuses. Most of the case series come from individual neurosurgeon's experiences during times of war. The majority of wartime injuries is from smaller, low-velocity shrapnel and not direct, high-velocity gunshot wounds. Further, many patients in the military series reached tertiary care centres days after the original injury, these survivors likely had less severe injuries and were not haemodynamically unstable from penetrating sinus injury. Our case describes a civilian, high-velocity, gunshot wound, with transection of the right transverse sinus, underlying cortical injury and a retained bullet fragment within the sinus in a haemodynamically unstable patient, treated operatively with good outcome.

The earliest reported cases of penetrating missile injury to a venous sinus are from World War I. Three patients were identified, two of whom died shortly after presentation; the third survived after successful gauze packing of the anterior superior sagittal sinus.⁷ During this war, Harvey Cushing⁸ also described his treatment of injury to the dural sinuses. In his small case series he noted that early surgical repair could prevent complications of progressive venous thrombosis, cerebral oedema, acute haemorrhage and infection.

During the World War II our treatment of penetrating missile injury improved. Donald Matson⁹ described 27 cases of venous sinus injury in his treatise of acute cranio-cerebral injuries due to missiles. He describes precisely primary suture closure and the use of fibrin foam soaked in thrombin for closure ligation injury. He is the first to describe the need for ligation in transecting injury to the venous sinus using silk suture or silver clips. He does not discuss his surgical outcome in this small series, except for one patient with a transection injury. Nor does he describe a patient requiring transverse sinus ligation whom survived.

Sixty years ago during the Korean Police Action, Meierowsky¹⁰ meticulously documented the most precise and sizable case series of injury to the dural sinuses. Of his 121 patients, he describes 25 unilateral transverse sinus injuries, three of these were transecting injuries. One transection required ligation similar to our patient, but no further description of this case exists. The other two transecting transverse sinus injuries had existing thrombosis at the time of surgery and thus did not undergo repair or ligation. One of the two transecting injuries with existing thrombosis had a fungating cerebritis at the time of surgery and died 2 days after surgery from respiratory compromise. It is important to consider that current rapid emergency medical transport would obviate gross infection at time of presentation and conceivably decrease preoperative sinus thrombosis.

With the advent of improved microsurgical techniques, the Vietnam War brought new more aggressive attempts at flow sparing dural sinus repair and venous grafts.^{12–13} Four publications from this wartime experience detail these efforts.^{11–14–16} Kapp and Gielchinsky report a total of 24 injuries to the transverse sinus between 1968 and 1972 without description of injury mechanism or decision making for therapies delivered. However, they do describe

Figure 2 Post-operative axial CT venogram demonstrating craniectomy in region of transverse sinus with removal of metal and bone debris, with evidence of sacrifice of the right transverse sinus.

in detail, their efforts to primarily repair two separate transected transverse sinus injuries using saphenous vein grafts. One of these patients survived with a patent vein graft and the other expired 5 days later, due to graft thrombosis. Rish also describes his efforts at repairing transected posterior venous sinuses. He presents two cases of posterior sinus injury requiring repair by autogenous venorrhaphy. One of these patients had associated cortical injury similar to our patient and expired 10 h after surgery. The second patient had minimal-associated cortical injury and survived, with improving visual field deficits post-operatively. Unfortunately, neither the mechanism of injury nor timing of surgery was described for either of these patients.

The literature on penetrating sinus injury from modern conflicts such as: Iran, Iraq or Afghanistan is sparse. This may be due to improved body armour designed to cover the venous sinuses or a fundamental change in the style of ballistics. There are a total of seven reports of operative management of transecting injury to the transverse sinus in the literature post-World War II. The description of injury in all seven is vague. Injury time to treatment is poorly recorded and in at least one case sufficient time had elapsed to allow for fungating infection. Treatments varied from no direct surgical therapy of the sinus because of thrombosis (2), ligation (1) and saphenous vein grafts (4). Three of the seven patients expired including half of the vein grafting patients.

The current civilian literature is rich with series describing epidemiology, surgical/medical management and prognostic factors (such as Glasgow Coma Scale, bihemispheric and ventricular injury).^{1–5} The only case of operative management for penetrating missile injury to a venous since Vietnam, presents a patient with a retained bullet fragment within the torcular herophili. This patient presented with minimal cortical damage and the ligation injury to the torcula was repaired successfully with a pericranial patch graft.¹⁷

Our case is unique in that we present a modern-day, civilian, gunshot wound, transecting the transverse sinus, repaired by emergent decompression and ligation. The patient was young, reached our centre rapidly, and had a favourable neurological exam on initial presentation. Given the location of the injury, we recognised the potential for transverse sinus injury and obtained vascular imaging early in the course of management. This identified the injury to the right transverse sinus, which was initially managed expectantly given the patients neurological exam. Upon neurological deterioration, the patient was immediately taken to the operating room where a ventricular drain was placed and a suboccipital decompression was performed. Brisk bleeding from the sinus was encountered which was initially controlled with manual pressure followed by ligation of the sinus with suture. This illustrates the importance of evaluating patency and dominance of the transverse sinuses preoperatively. The outflow from the torcula is unilateral in 24% of cases. Sixteen per cent of the population have right-sided dominance and 8% are left-side dominant.¹⁸ In unilateral dominant patients, autogenous venography is necessary as suggested by Kapp *et al.*¹⁴ However, in the remaining 74% of patients with a codominant transverse sinus, simple ligation may be safer and quicker, particularly in a haemodynamically unstable patient. This was the case in our

patient who was haemodynamically unstable with a codominant transverse sinus, thus ligation was performed. We also performed a large suboccipital decompression for several reasons. First, we wanted to allow for adequate brainstem decompression, as the preoperative imaging already suggested formation of cerebellar oedema. Also, ligation of the transverse sinus on the side of the injury could further exacerbate cerebellar swelling. Finally, a large craniectomy allowed for adequate access to the transverse sinus in order to obtain haemostasis.

Operative cases involving posterior penetrating injury to the venous sinuses are exceedingly rare subsequent to patient mortality before ever reaching the operating room. When encountered, we recommend rapid vascular imaging studies, close observation of the patient and urgent intervention if necessary. Intraoperatively a wide craniectomy flap ensures adequate decompression and allows for access for venous sinus repair. If a ligation injury exists, a pericranial patch graft may be most appropriate. If a transecting injury is present and venous ligation is possible because of sufficient contralateral venous drainage, vein grafting is not necessary and favourable outcomes are possible.

Learning points

- ▶ Early vascular imaging is important in suspected sinus injury to help plan operative management.
- ▶ It is important to assess transverse sinus patency and dominance when dealing with injury to the posterior sinuses.
- ▶ Unilateral dominant transverse sinus injury must be managed with grafting while codominant injury can be successfully managed with ligation.
- ▶ Large craniectomy flaps can aid in decompression of the posterior fossa and allow adequate access for venous sinus repair.

Competing interests None.

Patient consent Obtained.

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