Cerebral arteriovenous malformation (AVM) is a rare, idiopathic condition that occurs in 1% of the general population, occurring when arteries in the brain connect directly to nearby veins with a lack of capillaries between them. Absence of capillaries decreases gas exchange across the vessels and may cause blood pooling within the brain. Pressure or trauma to the blood vessel may cause the AVM to rupture, reducing blood flow to the brain tissue. This condition is believed to be congenital, and patients may be asymptomatic until later in life (15 to 20-year-old patients present symptoms most often). A secondary and potential fatal complication of AVM is cerebral aneurysm, which is a widening or ballooning of a blood vessel due to weakness of its wall. Cerebral aneurysm is potentially avoidable if identified and early intervention is implemented. Although rare, the potential complications associated with AVM rupture require that clinicians have knowledge of the key clinical features to both discriminate it from nonemergency conditions and to ensure appropriate and expedient interventions. The following case report reviews diagnostic procedures, surgical management, and return to participation for a collegiate football athlete with an AVM rupture.

Case Review

A healthy 18-year-old collegiate football athlete reported to the athletic training staff during spring practice that he was experiencing an intense headache, cervical pain, and photosensitivity. He was removed from practice within 10 minutes after the onset of symptoms. The athlete reported no previous history of severe headaches. When describing the initial onset of symptoms, he reported feeling a “pop” in his head, which was followed by immediate pain as he performed single-leg bounding exercises. The pain was localized over the posterior portion of his head and neck. Vital sign measurements demonstrated slightly elevated oral temperature (99.8°F) and normal blood pressure (116/72 mmHg). He was alert and oriented but uncharacteristically apprehensive. Cervical range of motion (ROM; active, passive, and resistive) was assessed to identify the possible source of his cervical pain, which demonstrated normal results. The atraumatic nature of the injury, absence of concussion-like symptoms, and normal cra-
nial nerve function ruled out traumatic brain injury. During functional movements (similar to the dynamic warm-up activities) and any bounding activity, the athlete reported increased pain deep in the right occipital region. Meningitis and encephalitis testing (Kernig’s and Brudzinski’s tests) yielded negative results. Migraine headache was initially suspected as the cause of the athlete’s symptoms. The athlete returned to the athletic training facility approximately 1 hour postpractice with intensified symptoms, and he was transported to the emergency room for further evaluation. Computed tomography (CT) imaging revealed an acute intraparenchymal hemorrhaging near the right thalamus, with intraventricular extension in the right lateral, left lateral, third, and fourth ventricles. A CT angiogram revealed a 1.8 cm AVM of the right thalamus, with no cerebral aneurysm. After two days of bed rest in the hospital, magnetic resonance imaging (MRI) suggested reabsorption of the intraventricular blood (Figures 1 and 2) and the athlete was discharged. He remained under 24-hour supervision (with family) to ensure safe recovery.

**Initial Management and Surgical Intervention**

After 2 weeks of complete rest and administration of pain medication (acetaminophen – 400mg every 6 hours), the athlete was seen by a neurosurgeon to discuss management options. The patient chose to have a surgical intervention performed, rather than a pharmacological treatment option. Nonsurgical management would have presented greater likelihood that the patient would experience another cranial bleed if he returned to sport participation. Surgical intervention would allow for the athlete’s return to sport after a latency period (e.g., 1–2 years) and a lesser likelihood for relapse. Due to the size and location of his AVM, a stereotactic radiosurgery procedure offered the greatest potential for success. Stereotactic radiosurgery uses focused radiation to scar, shrink, and obliterate the AVM. During the closed surgical procedure, the patient’s head was fixed in a halo brace and 20-25 Gy (units of radiation dosed as absorbed energy per unit mass of tissue) bursts of energy were delivered; the entire procedure lasted 43 minutes. After postoperative imaging suggested that shrinkage of the AVM had occurred, no additional radiation treatment was deemed necessary. The patient was prescribed Warfarin to reduce risk of clotting or aneurysm. The Warfarin dosage prescribed by the physician maintained the patient’s international normalized ratio (INR) between 2.0 and 3.0; a high INR indicates a slower time to clot (i.e., bleeding risk) and a low INR indicates a faster time to clot (i.e., clotting or thrombosis risk). After a 6-month activity restriction following the radiosurgical procedure, the athlete was asymptomatic and allowed to begin strength training limited to body weight resistance, and the use of Warfarin was discontinued. During the following month, the athlete incorporated isotonic strength training, plyometric and sport-specific drills (e.g., cutting, speed training, bounding, etc.), progressing his training program as tolerated. After 12 months, the athlete was cleared for full participation in football. He is required to have annual follow-up.
imaging to monitor the healing of the AVM, but he has no sport restrictions, assuming that he remains asymptomatic.

Discussion

A cerebral AVM is a rare congenital idiopathic condition.\(^1\) Hemorrhage from a rupture may present symptoms such as seizures, headaches, migraines, or in some cases sudden death.\(^1\) Symptoms can have an acute or gradual onset, depending on the size and location of the bleeding.\(^2\) In this case, a severe headache resulted from a bounding aerobic conditioning activity. This may have resulted from increased diastolic blood pressure, but dynamic movements are not necessary to elicit symptoms.\(^2\)

Patients with an AVM may present symptoms such as headache or photophobia (i.e., similar to concussion) but without a preceding traumatic event. Most cases do not demonstrate remarkable changes in cranial nerve function or cervical spine muscle function, but photosensitivity may be present.\(^1\) Balance could be impaired in advanced stages and functional whole-body movements may increase symptoms.\(^2\) Proper clinical assessment should rule out other conditions (e.g., migraine headache, concussion), and referral for neuroimaging should be considered to rule out AVM when other diagnoses are excluded. Currently, no clinical test identifies the presence of an AVM.\(^3\) Sagittal and transverse CT scans are most commonly used to identify the accumulation of blood in the intracranial spaces, but a CT angiogram is considered the “gold standard” for identifying the presence of the AVM.\(^3\)

There is no research evidence that indicates elevated risk for AVMs on the basis of race, gender, or sport, but family history may predispose an individual to having the condition.\(^1\) Proper preparticipation screening (i.e., self-reported medical history) may identify individual athletes who possess elevated risk.

Stereotactic radiosurgery is frequently utilized to treat AVMs smaller than 4 cm in diameter that are located in the eloquent part of the brain (i.e., the area for perception and communication). This radiosurgical procedure, however, has been shown to be ineffective for treatment of medium or large AVMs.\(^4\) A typical dosage of 20–25 Gy has a morbidity rate of 2–4\(\%\) and a mortality rate of 0–1\(\%\).\(^4\) Approximately 50\(\%\) of patients heal within 1 year of radiosurgery, and 85\(\%\) heal within 2 years.\(^4\) If a patient shows signs that surgery was unsuccessful, symptoms of intracranial bleeding, lack of contralateral coordination, or muscle weakness may occur within the latency period.\(^4\)

Athletes presenting with symptoms of AVM should be removed from activity until treatment is initiated, whether it involves conservative management (i.e., bed rest and medication) or stereotactic radiosurgery. Stereotactic radiosurgery is most successful with AVMs \(\leq 4\) cubic cm\(^2\) in size. Alternative treatment options include resection (craniotomy), cerebral embolization, or the combination of the two, which may provide a better outcome for a large AVM or an AVM in a location other than the eloquent part of the brain.\(^3,4\) Sport participation may need to be restricted if symptoms persist or complications arise; typical return to play protocols include progressive resistance training, functional exertion activities, and clinical monitoring (i.e., CT imaging).

Conclusion

An athlete who presents an unprovoked headache and/or seizure-like symptoms should be referred for physician evaluation and imaging (e.g., CT angiogram) to rule out AVM. Surgical management of a small AVM may allow an athlete the opportunity to return to competitive sport participation.\(^3\) Continued sport participation, however, will depend on the results of follow-up imaging that is necessary to rule out AVM complications.

References


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