Posttraumatic subgaleal herniation of an intracranial cerebral arterial segment

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ABSTRACT

A rare case of extracranial herniation of an intracranial arterial segment is described in an elderly patient presenting with loss of consciousness following mild head trauma. Cross-sectional imaging of the brain revealed a temporal skull fracture with associated intra-axial and extra-axial bleeding, and a computed tomography angiogram of the head and cerebral digital subtraction angiogram performed a few hours later displayed a rare finding. A small segment of a parietal branch of the right middle cerebral artery (M4 segment) herniated through the skull fracture, which coursed into the extracranial subgaleal space overlying the fracture site, before coursing back into the intracranial compartment. There was no evidence of cerebral ischemia or vascular compromise. The presence of a subgaleal artery on computed tomography angiogram may point to herniation of intracranial artery. In the absence of knowledge of this entity, even basic routine emergency care such as application of a scalp bandage or suturing of a scalp laceration could potentially result in devastating complications of vascular compromise and stroke.

KEYWORDS CT angiogram head; head trauma; middle cerebral artery herniation; subgaleal artery sign

Transcompartmental herniation of intracranial structures can have significant clinical implications. We present a case of extracranial herniation of a middle cerebral artery (MCA) branch through fracture defect, readily identifiable on computed tomography arteriography (CTA). An understanding of the scalp's vascularity and soft tissue planes is helpful in making the diagnosis. Diagnostic features on CTA and digital subtraction angiography (DSA) are discussed, along with anatomic rationale supporting the diagnosis.

CASE PRESENTATION

A 62-year-old man presented to the emergency room following a witnessed fall on a sidewalk from standing height. He was on warfarin for atrial fibrillation with an international normalized ratio of 3.1. His Glasgow Coma Scale score improved from 3 at the trauma site to 11 at presentation. An unenhanced computed tomography (CT) scan of the head was followed by vascular imaging to evaluate for possible underlying vascular etiology that might explain the

fall and altered mental status. CT revealed bifrontal hemorrhagic contusions, extensive subarachnoid hemorrhage, small right subdural hematoma, and a thin epidural hematoma adjoining a nondepressed right squamous temporal bone fracture. The fracture extended 9 mm in anteroposterior dimension. CTA showed no arterial dissection, pseudoaneurysm, stenosis, or occlusion. On the arterial phase images, a 1.2-mm-diameter enhancing vessel was seen in the right temporal subgaleal space overlying the fracture (*Figure 1*). Though an intracranial MCA branch was identifiable near the temporal fracture opposite the subgaleal vessel, intra-to-extracranial arterial continuity could not be proven on CTA due to lack of image contrast between the skull and artery. There was no early venous filling or communication with external carotid artery (ECA) branches or venous structures. DSA findings correlated with CTA. A cortical (parietal) branch of right MCA (M4 segment) coursed through the fracture defect, herniating extracranially into the subgaleal space (*Figure 2*) (Video Online Supplement). The artery coursed posteriorly for approximately 1 cm before looping and reentering the intracranial compartment. Both the intra-

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Figure 1. Computed tomography angiogram of the head. **(a)** Axial view through the site of the right temporal fracture showing tiny 1.2-mm vascular structure in the subgaleal space (arrow). **(b)** Coronal reformatted image showing the herniated vessel in the subgaleal space overlying the right temporal bone fracture (arrow).

Figure 2. Cerebral digital subtraction angiogram. **(a)** View showing a segment of the M4 branch of the right middle cerebral artery extending outside the skull vault and reentering the intracranial compartment (circle); note that the herniated and reentered segment remain patent. **(b)** Lateral projection showing a straight segment of the right middle cerebral artery branch overlapping the fracture lucency (arrows).

and extracranial arterial segments were patent. The patient was managed conservatively with an uneventful clinical course. Subsequent CT exams were indicative of maturing posttraumatic findings without right parietal MCA vascular stroke.

DISCUSSION

The scalp layers from superficial to deep include skin, subcutaneous tissue, aponeurosis, loose areolar tissue, and the pericranium (following the acronym SCALP). Galea is an anatomically important landmark that anchors superficial scalp layers to the pericranium, with an intervening layer of subgaleal fascia, and is considered a crude dividing plane between the intracranial and extracranial vasculature. Galeal aponeurotic sheath blends with the paired frontalis muscles anteriorly, occipitalis muscles posteriorly, and temporoparietalis muscles laterally.¹ Two small ophthalmic distribution arteries (supratrochlear, supraorbital) supply the forehead, and three ECA distribution arteries (posterior auricular, superficial temporal, and occipital) supply most of the scalp, including the aponeurosis. These vessels are anchored in the galea and send penetrating branches to overlying subcutaneous tissue and to underlying less vascularized subgaleal space, where they arborize to form a meshwork that extends to the

pericranium.¹ Bone perforators from meningeal arteries contribute minimal blood supply to the scalp.¹

Arteries in the subgaleal space are, however, beyond the current spatial resolution of CTA. Diploic veins are thin-walled venous channels located between the inner and outer tables of the skull, which communicate with dural sinuses and pericranial veins through the meningeal and emissary veins, respectively. Unless developmentally large, diploic veins are often not delineated on CTA or DSA.² The scalp veins communicate with the diploic veins and superior sagittal sinus through the posterior parietal emissary veins and the transverse sinus through the mastoid veins. There should be no CTA-identifiable venous channel seen in the subgaleal space.

The MCA has four segments: M1 (sphenoidal: MCA origin to insular genu), M2 (insular: limen insulae to circular sulcus), M3 (opercular: circular sulcus to sylvian fissure surface), and M4 (cortical: sylvian surface to cortical branches over lateral hemisphere). Cortical branches may arise from superior, inferior, or intermediate trunks, are two to eight in number, and have a mean diameter of 0.44 to 2.47 mm.³ The diameters of M1, M2–M3, and cortical branches range from 2.5 to 4 mm, 1 to 2 mm, and 1 mm, respectively.⁴ Situated in the subarachnoid space, the cortical branches enter the brain by perforating the pia mater. The diagnostic utility of CTA relies on optimal image acquisition with respect to contrast bolus.⁵ The smallest arterial size detected on CTA and DSA is 0.7 and 0.4 mm, respectively.⁶ No normal-caliber arteries in the subgaleal space are visible with current CTA resolution.

Other conditions that might explain contrast in the subgalea include active contrast extravasation, traumatic pseudoaneurysm of the ECA branch, arteriovenous malformation, arteriovenous fistula, and MCA to superficial temporal bypass graft. Traumatic pseudoaneurysm and fistula presenting with a painless pulsatile mass 2 to 6 weeks following trauma have been reported.^{7,8} Arteriovenous fistulas or malformations could produce enlarged subgaleal vessels but, unlike this case, will show early opacifying draining vein(s). Cases of atraumatic bilateral as well as atypical arteriovenous fistulas have been reported.^{9,10} In addition to readily evident postoperative changes, a bypass graft is typically centered 6 cm superior to the external auditory meatus.¹⁰ The exact mechanism behind the traumatic transcranial MCA herniation is not known, but a trauma-induced increased intracranial pressure coupled with a skull fracture and dural with or without arachnoid tear are favored. Though management of this condition has not been described, a prompt diagnosis may prevent time-sensitive complications such as vascular mishaps and cerebral stroke.

VIDEO ONLINE SUPPLEMENT

Cine image of the cerebral digital subtraction angiogram showing the herniating M4 branch of the right middle cerebral artery through the temporal bone fracture. Nonhemodynamically significant luminal narrowing of the vessel is seen as it exits through the fracture defect.

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