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Case Report

Traumatic epidural hematoma treated with endovascular coil embolization

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ABSTRACT

Background: Traumatic cerebrovascular injury may result in epidural hematoma (EDH) from laceration of the middle meningeal artery (MMA), which is a potentially life-threatening emergency. Treatment ranges from surgical evacuation to conservative management based on a variety of clinical and imaging factors.

Case Description: A 14-year-old male presented to our institution after falling from his bicycle with traumatic subarachnoid hemorrhage and a right frontotemporal EDH. The patient did not meet criteria for surgical evacuation and endovascular embolization of the right MMA was performed. Rapid resolution of the EDH was observed.

Conclusion: This case corroborates the sparse existing literature for the potential role of endovascular embolization to treat acute EDH in carefully selected patients who do not meet or have borderline indications for surgical management.

Keywords: Endovascular procedures, Epidural hematoma, Meningeal arteries, Traumatic cerebral hematoma, Traumatic subarachnoid hemorrhage

INTRODUCTION

Traumatic epidural hematoma (EDH) is typically associated with a skull fracture and laceration of the meningeal artery.[18,36,41] Treatment decisions depend on the severity of the patient's injury and neurological condition. In most scenarios, surgical evacuation is the treatment of choice, but in patients who do not meet surgical criteria, conservative management with serial imaging is performed to monitor the EDH.

The increasing use of endovascular therapies has reduced mortality rates associated with cerebrovascular injuries and disease.[7,31] However, few reports of embolization in the setting of EDH have been published, only two of which were performed in the United States.[32,42] We describe a rare case of blunt trauma causing subarachnoid hemorrhage (SAH) and frontotemporal EDH in a pediatric patient that was treated successfully through endovascular coil embolization of the right middle meningeal artery (MMA). The positive result in this case demonstrates the

technical feasibility of performing embolization to expedite EDH regression in appropriately selected patients who do not meet or have borderline indications for surgery.

CASE REPORT

Patient history

A 14-year-old male presented to our facility after falling from his bicycle. He had lacerations on the right parietal area of his scalp and mild confusion that resolved quickly. He had lost consciousness for 1–2 min but remembered the events up to and through the traumatic incident. At the time of the original trauma, he had no associated vomiting, weakness, numbness, blurry vision, double vision, or neck pain and was not on blood thinning medication.

Clinical findings

At presentation, neurological examination was benign with no focal neurologic deficits. The patient then began to have large volume emesis and increasing lethargy in the emergency department (ED), although he remained clinically stable. A head CT was performed which showed an EDH in the right frontotemporal region, measuring up to 7 mm in transverse dimension, with additional thin subdural hemorrhage extending along the lateral margin of the right temporal lobe [Figure 1]. Acute SAH and a small hemorrhagic contusion of the lateral left temporal lobe were also present, as well as a 3 mm thickness acute subdural hematoma along the left tentorial leaflet. There was evidence of an acute, nondepressed fracture of the anterior right parietal bone associated with a scalp laceration, propagating through the anterior squamous portion of the right temporal bone into the greater wing of the right sphenoid bone. After a discussion with the neurosurgery and ED teams, embolization was requested with no indication for open surgical evacuation. The patient's parents provided consent for treatment and the patient was taken to the neuroangiography suite in stable condition.

Figure 1: Preembolization coronal plane reformatted CT image demonstrating a small epidural hematoma over the right hemispheric convexity.

Therapeutic intervention

Following diagnostic angiography [Figure 2], the right MMA was embolized with coils. Due to robust ophthalmic region anastomoses, polyvinyl alcohol particles were not used. With a 6 French catheter in the right external carotid artery (ECA), a microcatheter was used to subselectively catheterize the right MMA over a micro-guidewire. Microcatheter angiography confirmed appropriate catheter positioning before subsequent embolization. Embolization was performed by instilling three fibered microcoils through the microcatheter into the right MMA. The right ECA angiography demonstrated complete occlusion of the right MMA postembolization [Figure 3]. At this point, the procedure was concluded and all catheters were removed from the patient. A total of 60 cc of Omnipaque 300 were administered. Total fluoroscopic time was 8.6 min, and Air Kerma dose was 469.41 mGy. A pediatric neurosurgeon was present from admission to the ED, throughout the embolization procedure, and after the procedure to monitor the patient. An operating room (OR) was kept on standby if emergent craniotomy was needed.

Follow-up and outcomes

There were no apparent complications, and the patient awoke from general anesthesia at his preprocedure neurologic baseline [Figure 4]. The patient is neurologically intact with full recovery other than mild residual right lower extremity pain at 2-month follow-up.

DISCUSSION

In this case, a traumatic cerebrovascular injury with EDH was quickly resolved following endovascular coil embolization

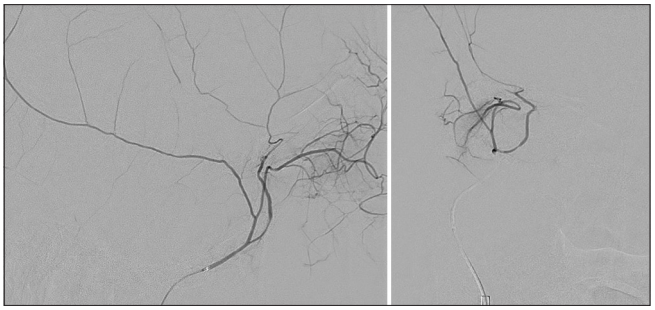

Figure 2: Frontal (left) and lateral (right) microangiography of the right MMA without evidence of pseudoaneurysm or active extravasation.

Figure 3: ECA angiography, lateral view, demonstrating coil occlusion of the MMA proximal trunk.

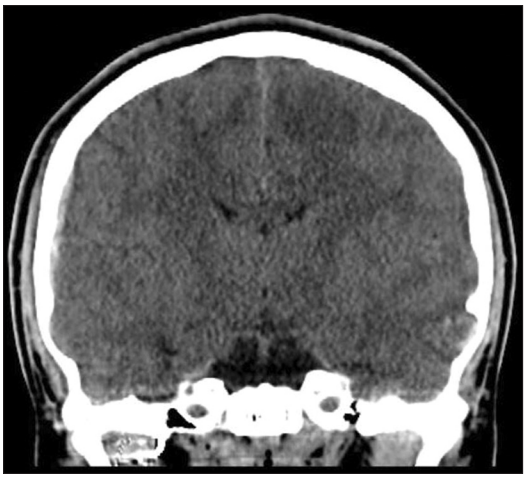

Figure 4: Postembolization coronal plane reformatted CT image postprocedure day 1 demonstrating markedly decreased size of the hematoma.

in a pediatric patient. This case demonstrates the potential role of endovascular coil embolization to treat acute EDH in carefully selected patients.

Cerebrovascular injuries occur in approximately 1% of all blunt traumatic brain injuries[12] and represent emergency situations with high rates of mortality.[1] Such injuries typically present with carotid artery and vertebral artery injury,[2,14] requiring prompt treatment through carefully selected interventions. Patients with an EDH volume >30 mL, thickness >15 mm, a midline shift >5 mm, or clinical deterioration are typically offered surgical treatment;[4] however, endovascular therapy has been used with success in patients with EDH when open clot evacuation is not required. A review of the literature, including the present case, revealed 15 articles of embolization for EDH in 153 patients [Table 1].[3,5,8,19,21,22,24,27,29,32,36,39,41,42] In 98.0% of cases (150/153), EDH occurred due to traumatic injury; 1 case (0.69%) was caused by a nontraumatic dural arteriovenous fistula.[39] The MMA was embolized in all cases (100%), leading to successful outcome with no complications in all but 1 complicated case, where the patient died of hypoxic injury and medical conditions 2 months after treatment for intracranial hemorrhage requiring an external ventricular drain.[27] Of note, only 2 of the embolization procedures in our literature review were performed in the United States, one of which was recently published in 2019.[32,42]

A recent study by Peres *et al*. reported results of 80 patients with acute, mainly temporal, EDH treated endovascularly.[29] The causes of head injury were falls, traffic-related accidents, and assaults. Contrast extravasation from the MMA was observed in 57.5% of patients. Embolizations were performed with N-butyl-2-cyanoacrylate, polyvinyl alcohol particles, or gelatin sponge (either alone or in combination), resulting in MMA occlusion and complete resolution in all cases. All patients had follow-up CT scans between 1 and 7 days postprocedure. No increase in size of the EDH was observed and the clinical evolution was uneventful, with no need for surgical evacuation. In addition, the author reported a historical cohort of 471 patients, 82 (17.4%) of whom were managed conservatively and eventually required surgical evacuation.

EDH occurs in approximately 6% of traumatic brain injuries in pediatric patients.[9-11,16] Management has not been standardized in this patient population through large prospective trials or professional society guidelines, particularly in patients with small EDH and no neurological deficits. Many studies in the pediatric population have reported high rates of good outcomes with conservative management.[6,9,10,17,20,25,26] Given the potential for EDH progression, repeated monitoring through CT imaging is routinely performed in cases managed conservatively. However, authors have recently argued against this practice in the absence of clinical signs, given the low percentage of patients with EDH progression and the risks associated with radiation exposure in young patients.[11,33] Radiation exposure from a head CT in pediatric patients ranges from 40 to 60 mGy per scan.[28,34,35] While endovascular procedures expose patients to significant radiation doses, this technique can quickly resolve EDH and reduce the need for repeated imaging over a prolonged period of time in carefully selected patients that are not otherwise candidates for surgery. Conservative management requires extended, close ICU monitoring for signs of clinical deterioration that may require emergent operative intervention. Hematoma expansion can be rapid enough that poor outcomes may occur even with prompt, much less delayed, OR management. Therefore, this technique may ultimately lead to cost savings with rapid

Table 1: Literature review of epidural hematomas treated with embolization.

Study	Country	Patient age/sex	Location of EDH	Cause of EDH	Location (s) embolized	Description of procedure	Outcome
Suzuki *et al.*, 2004[36]	Japan	9 patients, mean age 37.7 years (range, 18–62)	MMA	Mainly traumatic injury	MMA	Embolization through Microferret catheters advanced with a micro-guidewire just before the bleeding point. Platinum balls and microfibrillary collagen were used as embolic materials	Successful embolization, no complications
Bortoluzzi and Pavia, 2006[3]	Italy	22 F	Right MMA	Facial trauma	Right MMA, right IMA	Coaxial catheter technique in the IMA: 5 French guiding catheter inserted into the common trunk of the ECA, with an Excel 14 microcatheter and a Transend microwire. The microcatheter tip was placed in the distal IMA. Gelita® fragments were released on both sides, and the right MMA was catheterized and embolized	Successful embolization, no complications
Misaki *et al.*, 2008[22]	Japan	44 F	Right temporal area	Head trauma	Right MMA	3 French microcatheter was introduced to the MMA and embolization completed with PVA particles and gelatin sponge pieces	Successful embolization, no complications
de Andrade *et al.*, 2008[5]	Brazil	24 patients, mean age 27.7 years (range, 16–47)	Branches of the MMA	Head injury (20 MVAs, 4 falls)	MMA and branches	Embolization of the MMA and branches was performed after superselective injection with a micro-guidewire up to an area just before the arterial lesion had been reached	Successful embolization, no complications
Ross, 2009[32]	USA	40 M	Left MMA branches near bone flap for SDH evacuation	Large, nontraumatic SDH	Left MMA branches	Left external carotid artery was selected with a guiding catheter, and a microcatheter was directed into the MMA. The branches were embolized with particles 250–350 μm in diameter until flow stasis was achieved. The heparin was reversed with protamine sulfate at the end of the procedure	Successful embolization, no complications
Ohshima *et al.*, 2012[24]	Japan	74 F	Right temporal region	Head trauma (fall down stairs)	Right MMA	Transfemoral endovascular embolization with a 6 French guiding catheter placed at the origin of the right ECA. NBCA mixture was then injected using single-column technique. Endoscopic hematoma evacuation was completed due to hard hematoma	Successful embolization, no complications
Lammy *et al.*, 2013[21]	UK	32 M, 49 M	Right subtemporal, right frontoparietal	Head trauma (1 fall and 1 MVC)	Right MMA	The MMA was catheterized using a Rebar 14 catheter and 0.1 mL of Onyx was infused occluding the MMA and stopping further contrast extravasation, three platinum coils were inserted inside the MMA followed by a small hydrogel coil occluding it and preventing further extravasation	Successful embolization, no complications
Kim *et al.*, 2015[19]	South Korea	21 F	Left temporal region	Head trauma (MVA)	Left MMA	An angled 5-Fr Envoy guiding catheter was advanced into the left ECA. Embolization of the MMA was performed using an Excelsior SL-10 microcatheter up to the orifice of a pseudoaneurysm, and 1.4 mL of 33% NBCA was infused occluding the pseudoaneurysm and MMA	Successful embolization, no complications

(*Contd...*)

Table 1: *(Continued).*

Study	Country	Patient age/sex	Location of EDH	Cause of EDH	Location (s) embolized	Description of procedure	Outcome
Yoshioka *et al.*, 2015[39]	Japan	22 M	Right frontal convexity	Nontraumatic DAVF	Right MMA, distal internal maxillary artery	Embolization of the MMA and the distal internal maxillary artery with 17% NBCA.	Successful embolization, no complications
Peres *et al.*, 2018[29]	Brazil	80 patients, mean age 39.8 years (range, 12–72)	29 temporal-lateral, 28 temporal pole, 11 frontal, 9 parietal, 3 frontotemporal	Head trauma (26 falls, 36 MVAs, 9 assaults, 9 other/ unknown	Branches of MMA	Embolizations were performed with PVA particles and Gelfoam in 60 patients (75%). In 17 patients (21.2%), PVA alone was used. Combined microcoils, NBCA, and Gelfoam were used in three patients	Successful embolization, no complications
Zhang *et al.*, 2018[41]	China	23 patients, mean age 42 years (range, 15–53)	Temporal area in 8 cases, frontotemporal area in 9 cases, and temporoparietal area in 6 cases	Head trauma (13 MVAs, 4 falls, 6 impact by falling objects)	MMA	The bleeding point was embolized by advancing a 4-Fr catheter to the bleeding point with Gelfoam particles. The hematoma was sucked with a soft-tipped aspirator. A drainage tube was implanted into the hematoma cyst to aspirate some clots. Urokinase was injected into the hematoma cyst. Postoperative, urokinase was repeatedly injected into the hematoma cyst twice a day	Successful embolization, no complications
Zussman *et al.*, 2019[42]	USA	31 M	Bilateral parietal (left greater than right)	Probable head trauma (found unresponsive)	Right MMA	A microcatheter was advanced into the posterior branch of the right MMA, and embolization was performed using 1–300 μm embospheres followed by Onyx 18 liquid embolization. The microcatheter was then pulled back to the MMA bifurcation and proximal embolization was performed using Tornado Embolization Coils	Successful embolization, no complications
Park *et al.*, 2020[27]	Korea	85 M, 51 F	Left temporoparietal area, right side of brain at site of preexisting external ventricular drain	Head trauma (fall), puncture from external ventricular drain	Left MMA, right MMA	A 6-Fr guiding catheter was inserted by a wire, and positioned in the left CCA. An Excelsior SL-19 microcatheter was navigated to the MMA. MMA embolization was performed with 45–150 μm Contour PVA embolization particles	Male patient had successful embolization with no complications; female patient had successful embolization of EDH but died 2 months later due to hypoxic damage and medical complications

(Contd...)

Table 1: *(Continued)*.

Study	Country	Patient age/sex	Location of EDH	Cause of EDH	Location (s) embolized	Description of procedure	Outcome
Fan *et al*., 2020[8]	China	5 patients; 1<30, 3>30, 1>60	2 left, 3 right	Acute head trauma	MMA	A 6-Fr guiding catheter was inserted, followed by an SL-10 microcatheter into the ECA under fluoroscopic guidance. A Traxcess 14 micro-guidewire was placed into the trunk of the MMA followed by slow injection of absolute alcohol through the microcatheter for embolization. Combined with burr hole drainage	Successful embolization, no complications
Present study	USA	14 M	Right frontotemporal	Blunt trauma	Right MMA, right AMA	A microcatheter was used to catheterize the right MMA. Embolization was performed by instilling three fibered microcoils through the microcatheter into the right MMA. Embolization of the right accessory MMA was performed by instilling two fibered microcoils through the microcatheter	Successful embolization, no complications

AMA: Accessory meningeal artery, CCA: Common Carotid Artery, DAVF: arteriovenous fistula, IMA: Internal maxillary artery, MMA: Middle meningeal artery, ECA: External carotid artery, NBCA: N-butyl cyanoacrylate, PVA: Polyvinyl alcohol, SDH: Subdural hematoma, MVA: Motor Vehicle Accident, MVC: Motor Vehicle Collision

hematoma stabilization, earlier discharge, and less repetitive imaging utilization.

Embolization procedures involving the MMA should only be performed by experienced neurointerventionalists familiar with head-and-neck vascular neuroanatomy, given the known potential anastomoses and variant collaterals between the MMA and the ophthalmic artery or facial arcade.[13,15,30,37,40] Embolization in these cases may lead to retinal or cranial nerve ischemic injury.[23,38,40] Thus, consideration of this technique as an alternative to conservative management assumes an acceptably low procedural complication rate at any given center. Randomized, controlled studies comparing embolization and conservative management could be considered for borderline surgical cases within acceptable clinical parameters.

CONCLUSION

This case demonstrates that a positive outcome and quick resolution can be achieved following embolization for acute traumatic EDH in appropriately selected patients. This technique may be considered for patients who do not meet or have borderline indications for surgical evacuation where the alternative of conservative serial imaging is expected to be prolonged.

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Declaration of patient consent

Patient's consent not required as patients identify is not disclosed or compromised.

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Conflicts of interest

Jillienne C Touchette is CEO and has ownership interest in Superior Medical Experts.

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