

Middle Meningeal Artery Embolization for Combined Traumatic Acute Epidural and Subdural Hematomas: A Case Report and Review of the Literature

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How to cite this paper: Baumgartner, T., Fernández, L.G. and Nalbach, S.V. (2026) Middle Meningeal Artery Embolization for Combined Traumatic Acute Epidural and Subdural Hematomas: A Case Report and Review of the Literature. *Surgical Science*, 17, 235-245.

<https://doi.org/10.4236/ss.2026.176024>

Received: April 8, 2026

Accepted: June 27, 2026

Published: June 30, 2026

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Abstract

Background: Traumatic epidural hematoma (EDH) is classically associated with skull fracture and injury to the middle meningeal artery (MMA). Standard management includes emergent craniotomy for neurologically deteriorating patients and close observation for those who do not meet surgical criteria. Endovascular MMA embolization has emerged as an adjunctive or alternative strategy in select cases, though its role in acute traumatic EDH remains incompletely defined. A focused literature review was performed to identify published cases describing middle meningeal artery (MMA) embolization for acute traumatic epidural hematoma (EDH). **Case Presentation:** We report the case of a 17-year-old male who sustained blunt head trauma following an all-terrain vehicle rollover, resulting in a progressively enlarging acute epidural hematoma with an associated acute subdural hematoma. Despite radiographic progression, the patient remained neurologically intact and did not meet criteria for surgical evacuation. Cerebral angiography demonstrated active extravasation from the anterior branch of the middle meningeal artery, which was successfully treated with coil embolization. Post-procedural imaging demonstrated hematoma stability without mass effect or neurological decline. The patient had an uneventful clinical course and was discharged home without neurologic deficit. **Conclusion:** This case illustrates that middle meningeal artery embolization may be a feasible and effective therapeutic option for selected patients with traumatic epidural hematomas who remain neurologically stable but demonstrate radiographic progression. Careful patient selection and close neuroimaging surveillance remain essential.

Keywords

Traumatic Epidural Hematoma, Middle Meningeal Artery, Endovascular Embolization, Acute Subdural Hematoma, Traumatic Brain Injury, Case Report

1. Introduction

Epidural hematoma (EDH) occurs in approximately 10% of patients with traumatic brain injury and is commonly associated with skull fracture and injury to the middle meningeal artery (MMA) [1] [2]. Large EDHs accompanied by neurological deterioration or significant mass effect require urgent surgical evacuation. In contrast, smaller hematomas in neurologically intact patients are often managed conservatively with serial imaging, although conversion rates to surgical intervention have been reported in up to 17% of cases [3].

Advances in neuro-endovascular techniques have expanded the therapeutic options for traumatic intracranial hemorrhage [4]-[6]. MMA embolization has become an established treatment for chronic subdural hematomas and has been increasingly reported in selected cases of acute traumatic EDH, including intraoperatively during emergent cases. However, its role in the acute trauma setting remains limited to case reports and small series.

We present a CARE-compliant case report of a neurologically intact adolescent with an enlarging traumatic EDH and associated acute SDH successfully managed with endovascular MMA embolization.

2. Case Presentation

2.1. Patient Information

A 17-year-old previously healthy male was transferred to our Level I Trauma Center following an all-terrain vehicle rollover with a reported head strike. He denied loss of consciousness. On initial evaluation, the patient was awake, alert, and oriented with a Glasgow Coma Scale (GCS) score of 15.

2.2. Clinical Findings

Primary and secondary surveys revealed a scalp laceration (repaired at the outside hospital), left clavicle fracture, right wrist dislocation, right radius and ulna fractures, and facial pain. The neurological examination was non-focal. The patient was not intubated and remained hemodynamically stable throughout evaluation.

2.3. Diagnostic Assessment

Initial non-contrast computed tomography (CT) of the head at the outside hospital demonstrated a small left frontal acute subdural hematoma (SDH) measuring approximately $5.8 \times 0.8 \times 2.0$ cm. No evidence of calvarium fracture, hydrocephalus

or midline shift. A repeat CT head approximately seven hours later demonstrated interval enlargement of the subdural hematoma to approximately $8.6 \times 2.5 \times 1.9$ cm.

A subsequent CT head obtained about six hours later showed progression with development of a left acute epidural hematoma (EDH) measuring up to 2.8 cm in maximal thickness, associated with the acute subdural component. The radiographic appearance was worrisome for a middle meningeal artery injury. Despite radiographic progression, the patient remained neurologically intact without signs of elevated intracranial pressure or midline shift requiring emergent craniotomy.

2.4. Therapeutic Intervention

Given the enlarging EDH, evidence of vascular injury, and preserved neurological status, a decision was made to proceed with diagnostic cerebral angiography and possible embolization. Patient proceeded to the radiology suite approximately 16 hours after arrival to the hospital. As the patient was without any degree of neurological decline and at baseline functional status, taking the patient to the operative suite for evacuation did not seem appropriate.

Angiography of the left external carotid artery demonstrated active contrast extravasation from the anterior branch of the left middle meningeal artery. Endovascular embolization was performed using platinum coils, achieving complete occlusion of the injured MMA branch and cessation of contrast extravasation (**Figure 1(A)**, **Figure 1(B)**, **Figure 2(A)**, **Figure 2(B)**).

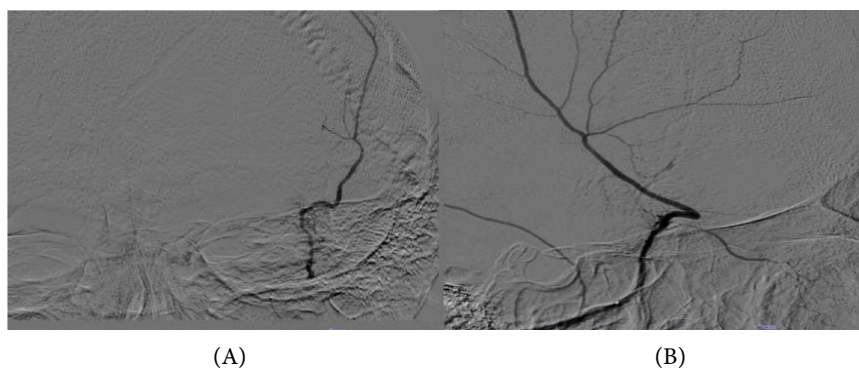


Figure 1. Pre-embolization cerebral angiogram (A), (B).

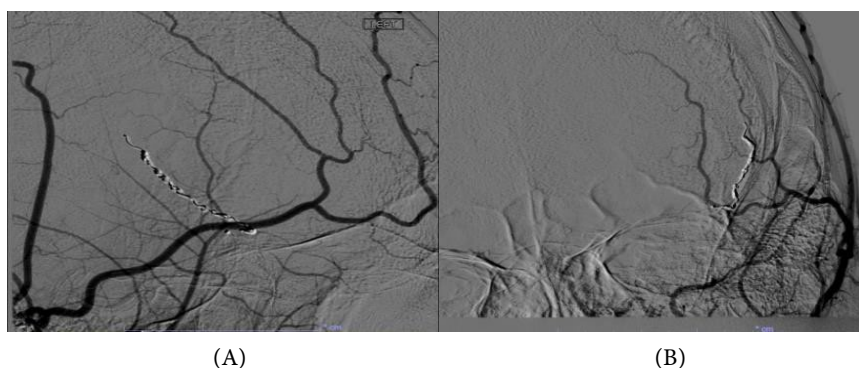


Figure 2. Post-embolization cerebral angiogram (A), (B).

Immediate post-embolization of CT imaging demonstrated stable epidural and subdural hematomas with minimal mass effect and no midline shift. Serial CT scans on hospital days 2 and 3 demonstrated stable findings without interval expansion (**Figure 3(A)**, **Figure 3(B)**).

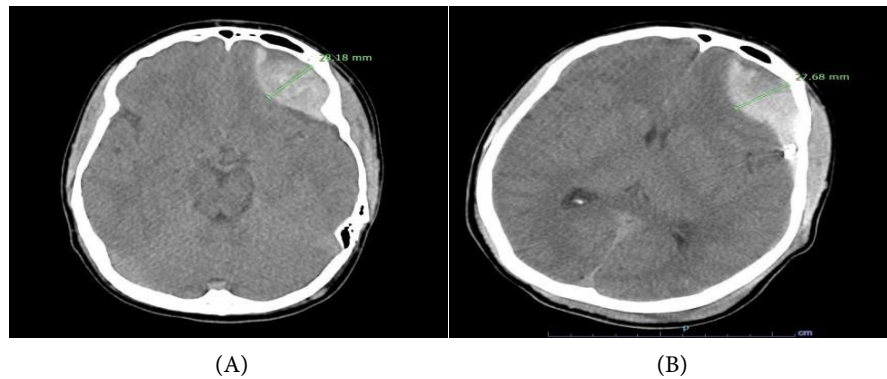


Figure 3. Pre (A)-and post(B)-embolization CT of the brain findings with minimal mass effect and midline shift. The patient had serial head CT on hospital day (HD) 2 and 3 with stable findings noted.

2.5. Follow-Up and Outcomes

The patient subsequently underwent orthopedic fixation of his clavicle and forearm fractures without complication. Facial CT revealed a nondisplaced pterygoid process fracture managed conservatively. He remained neurologically intact throughout hospitalization and was discharged home on hospital day 4 with outpatient neurosurgical follow-up. No delayed neurological complications were identified, including any unusual signs or symptoms during follow-up examinations. An outpatient CT of the head was done 64 days after the MMA procedure, which showed complete radiographic resolution of the EDH and SDH (**Figure 4(A)**, **Figure 4(B)**).

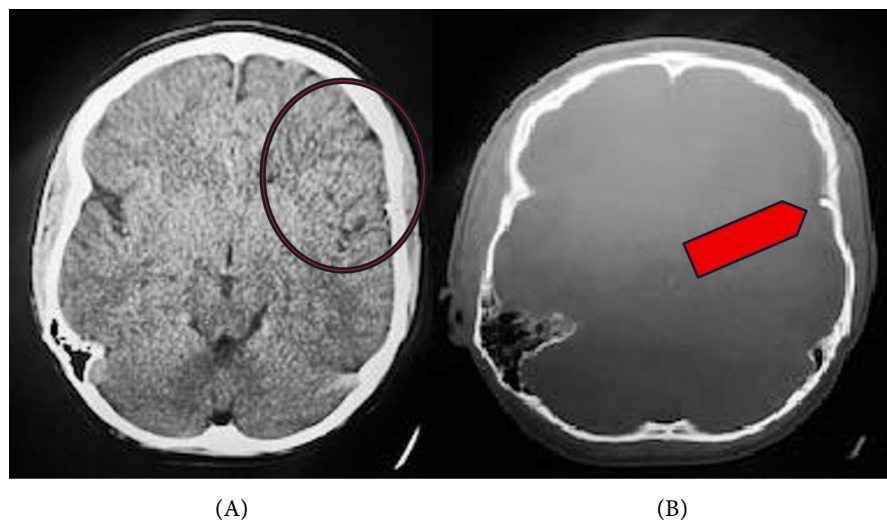


Figure 4. CT scan of the brain, 64 days post MMA. No residual EDH/SDH (A, red oval); MMA coil is demonstrated (B, red arrow).

3. PRISMA-Style Mini-Review of Reported Cases

3.1. Methods

A focused literature review was performed to identify published cases describing middle meningeal artery (MMA) embolization for acute traumatic epidural hematoma (EDH). A search of PubMed/MEDLINE and Google Scholar was conducted using the following keywords and Boolean operators:

“epidural hematoma” AND “middle meningeal artery embolization” “traumatic epidural hematoma” AND “endovascular” “acute epidural hematoma” AND “MMA embolization”

The search included articles published from January 2000 through December 2024. Only English-language publications were reviewed.

3.2. Inclusion Criteria

- Original reports describing acute traumatic EDH
- Use of endovascular MMA embolization as part of management
- Case reports, case series, or observational studies
- Clear documentation of clinical presentation, intervention, and outcome

3.3. Exclusion Criteria

- Chronic subdural hematoma without EDH
- Non-traumatic EDH
- Review articles without original cases
- Pediatric or adult cases lacking intervention detail

Article selection was performed manually by reviewing titles, abstracts, and full texts when relevant. (**Table 1**, **Figure 5**)

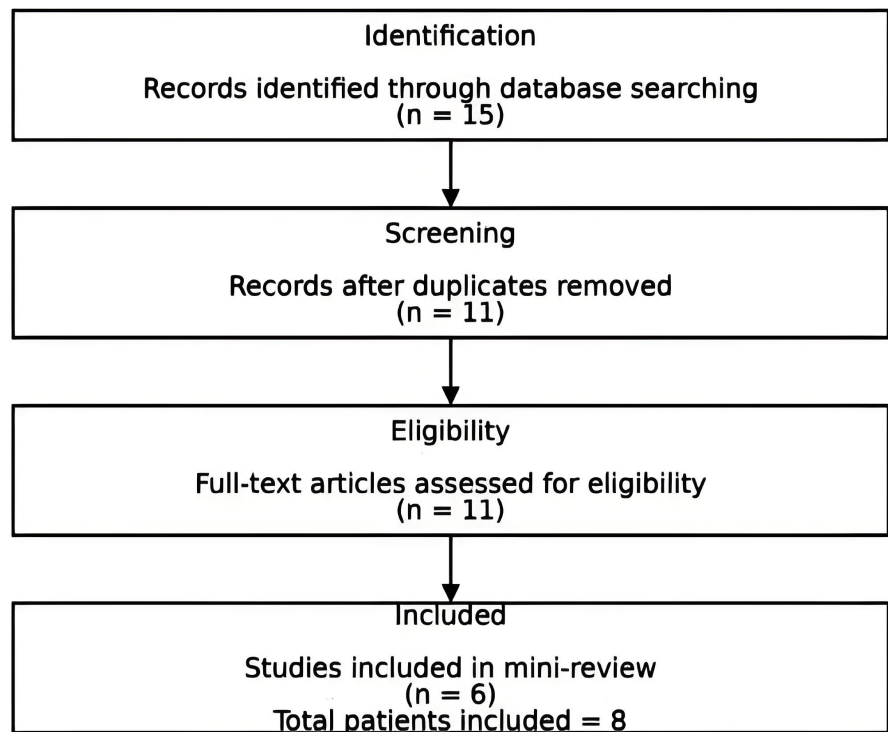
PRISMA flow diagram demonstrating study identification, screening, eligibility, and inclusion for the mini review of middle meningeal artery embolization in acute traumatic epidural hematoma. Counts are derived directly from the dataset summarized in **Table 1**.

Table 1. Published cases of middle meningeal artery embolization for acute traumatic epidural hematoma.

Ref	Author (Year)	Patients (n)	Age	Sex	Presentation	Imaging/Workup	IR Management	Outcome
1	Madison et al. (2021)	1	14	M	Fall from bicycle with loss of consciousness	7 mm right frontoparietal EDH with thin SDH and skull fracture	Right middle meningeal artery coil embolization	Full recovery; mild residual right lower extremity pain
2	Zussman et al. (2019)	1	32	M	Found down and rapidly obtunded	Bilateral EDH with expanding right-sided EDH	Right middle meningeal artery coil embolization	Discharged without neurological deficit
3	Park et al. (2020)	1	85	M	Fall from ladder; Glasgow Coma Scale score of 13	Left temporoparietal EDH with skull fracture and interval expansion	Left middle meningeal artery embolization	Near-complete resolution at 1 month

Continued

4	Suzuki et al. (2004)	2	33 - 54 M/F	Motor vehicle collision with minimal neurologic symptoms	Temporal EDH adjacent to skull fracture with contrast extravasation	Middle meningeal artery embolization	EDH resolved on follow-up imaging
5	Oshima et al. (2012)	1	74 F	Fall with drowsiness and mild hemiparesis; GCS 12	3.5 cm right EDH with temporal bone fracture and acute myocardial infarction	Middle meningeal artery embolization plus burr hole evacuation	Complete resolution at 1 month
6	de Andrade et al. (2009)	2	20 - 31 M/F	Falls or motor vehicle collision with headache or loss of consciousness	Small EDH adjacent to fracture with middle meningeal artery pseudoaneurysm	Middle meningeal artery embolization	Stable hematomas without enlargement

PRISMA 2020 Flow Diagram**Figure 5.** PRISMA 2020 flow diagram.**3.4. Results**

A total of six studies met the inclusion criteria, encompassing eight patients treated with MMA embolization for acute traumatic EDH.

3.5. Patient and Injury Characteristics

- **Age range:** 14 - 85 years
- **Sex:** Predominantly male (5 males, 3 females)
- **Mechanism of injury:** Falls, motor vehicle collisions, and bicycle accidents
- **Neurologic status:** Most patients were neurologically intact or mildly symp-

tomatic at presentation (GCS 12-15)

3.6. Radiographic Findings

- EDHs were typically temporal or temporoparietal, often adjacent to a skull fracture.
- Several cases demonstrated active contrast extravasation, MMA pseudoaneurysm, or interval hematoma expansion on serial imaging.
- In some patients, EDH was associated with concurrent subdural hematoma.

3.7. Indications for Embolization

MMA embolization was performed for:

- Radiographic progression of EDH despite neurological stability
- Identification of active MMA bleeding or pseudoaneurysm
- High surgical risk due to medical comorbidities
- Adjunctive hemorrhage control following partial surgical evacuation

Intervention

- All cases utilized endovascular MMA embolization, most commonly with coil embolization
- One case combined embolization with burr hole evacuation
- Embolization was unilateral and targeted to the involved MMA branch

Outcomes

- Radiographic stabilization or resolution of EDH occurred in the majority of patients
- Avoidance of craniotomy was achieved in most cases
- One patient required additional surgery for a contralateral subdural hematoma
- Neurological outcomes were favorable, with no reported embolization-related complications
- No mortality attributable to EDH progression was reported

PRISMA Summary

- Records identified through database searching: **n = 15**
- Records after duplicates removed: **n = 11**
- Full-text articles assessed for eligibility: **n = 11**
- Studies included in mini review: **n = 6**
- Total patients included: **n = 8**

3.8. Interpretation

Based on the limited available literature summarized in **Table 1**, MMA embolization is a feasible and safe therapeutic option for carefully selected patients with acute traumatic EDH, particularly those who remain neurologically stable but demonstrate radiographic progression or evidence of MMA injury. The technique may reduce the need for craniotomy in select cases, though evidence remains limited to small observational reports.

This mini review is limited by the small number of reported patients, reliance

on case reports and small case series, and heterogeneity indications and timing of embolization. No comparative or randomized data is available, and long-term outcomes are reported.

4. Discussion

Traumatic epidural hematoma (EDH) is classically associated with skull fracture and injury to the middle meningeal artery (MMA), with management strategies traditionally dichotomized between emergent surgical evacuation and close radiographic observation. While craniotomy is clearly indicated for patients with neurological deterioration or significant mass effect, the optimal management of patients who remain neurologically intact despite radiographic progression remains less well defined [2]. This subset of patients presents a therapeutic dilemma, as delayed deterioration is well described, yet operative intervention may expose patients to unnecessary morbidity [1] [2] [4].

In recent years, endovascular embolization of the MMA has emerged as a potential adjunct or alternative strategy for hemorrhage control in selected cases of traumatic EDH. Although well established in the treatment of chronic subdural hematoma, its role in acute traumatic EDH remains limited to small observational reports. To contextualize the present case, we reviewed the published literature summarized in **Table 1**, comprising six studies and a total of eight reported patients treated with MMA embolization for acute traumatic EDH.5-10, [7]-[10].

Across these reports, patients ranged in age from adolescence to advanced age, with mechanisms of injury including falls, motor vehicle collisions, and bicycle accidents. Most patients were neurologically intact or only mildly symptomatic at presentation, typically with Glasgow Coma Scale scores between 12 and 15. Radiographically, EDHs were most often located in the temporal or temporoparietal region, frequently adjacent to a skull fracture. Several cases demonstrated active contrast extravasation, pseudoaneurysm formation, or interval hematoma enlargement on serial imaging, prompting intervention despite preserved neurological status [6]-[10].

Indications for MMA embolization in the reviewed cases included radiographic progression of EDH under observation, angiographic evidence of MMA injury, poor candidacy for craniotomy due to medical comorbidities, or the need for adjunctive hemorrhage control following partial surgical evacuation. Embolization was most performed using coil embolization of the involved MMA branch, with one report combining embolization with burr hole evacuation. Importantly, radiographic stabilization or resolution of the EDH was achieved in most cases, and avoidance of formal craniotomy was possible in most patients. Neurological outcomes were uniformly favorable, with no reported embolization-related complications and no EDH-related mortality. Only one patient required subsequent surgery for a contralateral subdural hematoma, rather than progression of the treated EDH.

The present case aligns closely with these observations. Our patient demon-

strated interval enlargement of a traumatic EDH with associated acute subdural hematoma but remained neurologically intact and did not meet conventional criteria for surgical evacuation. Angiography confirmed active extravasation from the anterior branch of the MMA, providing a clear target for endovascular therapy. Successful embolization resulted in radiographic stability, avoidance of craniotomy, and an uncomplicated clinical course, allowing safe progression to treatment associated orthopedic injuries.

Taken together, the limited but consistent evidence suggests that MMA embolization may represent a viable minimally invasive option for carefully selected patients with acute traumatic EDH who demonstrate radiographic progression without neurological deterioration. This approach directly addresses the presumed source of hemorrhage while avoiding the morbidity of open surgery [11] [12]. Nevertheless, the existing literature is constrained by small sample sizes, heterogeneity of indications and timing, and reliance on case reports and small case series. No comparative or randomized data currently exists to define superiority over conservative or surgical management.

5. Limitations

This report describes a single patient and therefore cannot establish causality or general outcomes. Long-term radiographic follow-up was limited, and selection bias is inherent in choosing a neurologically intact patient for embolization. Larger prospective studies are needed to define patient selection criteria, timing, and comparative efficacy versus conservative or surgical management.

The conclusions drawn from both the present case and the integrated mini review are limited by the observational nature of the available data, small patient numbers, and potential selection bias toward neurologically stable patients. Long-term outcomes and standardized selection criteria remain inadequately defined.

6. Conclusion

Within these limitations, the accumulated evidence summarized in **Table 1**, together with the present case, supports the concept that middle meningeal artery embolization may serve as a feasible and safe adjunct or alternative in the management of selected acute traumatic epidural hematomas. Middle meningeal artery embolization may represent a viable therapeutic option for carefully selected patients with traumatic epidural hematomas who demonstrate radiographic progression without neurological deterioration. This case supports the feasibility of endovascular intervention as an adjunct to standard trauma management and highlights the need for further study to define its role in acute traumatic brain injury. Further prospective studies are required to better delineate patient selection, optimal timing, and comparative effectiveness relative to established treatment paradigms.

Acknowledgements

Avoid the stilted expression, “One of us (R. B. G.) thanks...” Instead, try “R. B. G.

thanks". Do NOT put sponsor acknowledgements in the unnumbered footnote on the first page, but at here.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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