Brief Report

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Is Embolization a Safe Treatment Option for Certain Traumatic Subdural Hematomas?

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ABSTRACT

Introduction. Middle meningeal artery (MMA) embolization is effective in chronic subdural hematoma (SDH), but its safety in acute SDH remains unclear. Authors of this study evaluated the safety of MMA embolization in acute SDH management.

Methods. We conducted a retrospective review of adult acute SDH patients treated between July 2021 and July 2023 at a community-based Level I Trauma Center. Demographics, injury characteristics, treatments, and outcomes were compared between patients who did and did not undergo MMA embolization.

Results. Records from 33 patients with acute SDH were reviewed: 17 underwent MMA embolization and 16 did not. Patients in the embolization group were older (median age 71.0 vs. 37.5 years). Minimal differences were observed between groups with respect to sex, race, or injury severity score. Non-embolized patients presented with a lower median Glasgow Coma Scale (GCS) score (11.5 vs. 14.0). Among the 17 embolized patients, 11 presented with acute bleeding and 6 with acute-on-chronic bleeding. Two patients in each subgroup required craniotomy prior to embolization. Of the remaining non-operatively managed patients, one underwent burr hole evacuation one day after embolization and was subsequently discharged to hospice. No patients required craniotomy after MMA embolization.

Conclusions. MMA embolization appears to be a safe and potentially effective adjunct in the management of acute SDH, particularly in less severe cases. Larger, controlled studies are needed to better define its role and to determine whether it should be incorporated into standard treatment paradigms.

INTRODUCTION

Subdural hematoma (SDH) is an intracranial hemorrhage defined as bleeding into the space between the dura and arachnoid membranes surrounding the brain. Traumatic injury is a common cause of SDH, with acute traumatic SDH most often resulting from tearing of bridging veins between the arachnoid and dura, and less commonly from arterial rupture. The risk of traumatic acute SDH increases with age.[1]

Management of traumatic SDH typically begins with nonoperative strategies, including serial neuroimaging and neurologic examinations; however, certain clinical and radiographic features may warrant surgical intervention.[1] Subdural hematomas are classified as acute, characterized by a subdural clot without a protective membrane, or chronic, defined by an encapsulated, liquefied hematoma within the subdural space.[2] Surgical treatment options include craniotomy, craniectomy, or a combination of both, but operative management has been associated with higher mortality, complication, and recurrence rates.[3-5]

Middle meningeal artery (MMA) embolization has emerged as an alternative treatment for chronic SDH. This approach is thought to reduce immature capillary proliferation and membrane formation, thereby decreasing recurrent bleeding. Radiographic findings of irregular MMA branches in chronic SDH support this mechanism.[2] Sioutas et al.[6] have demonstrated MMA embolization to be a safe and effective treatment for chronic SDH and non-inferior to surgical evacuation alone.

To date, MMA embolization primarily has been used in chronic and subacute SDH, and there is limited literature evaluating its role in acute SDH.[7] The objective of this study was to assess the safety of MMA embolization in the management of acute SDH at a community-based Level I Trauma Center.

METHODS

This study was reviewed and approved by the Human Subjects Protection Program at the University of Kansas Medical Center and the Institutional Review Board (IRB) at Ascension Health. The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines[8] were followed to ensure appropriate reporting of methods, results, and discussion.

A retrospective chart review was conducted of all adult patients (≥18 years) presenting through the trauma service with a SDH between July 1, 2021, and July 1, 2023. Patients were identified using the trauma registry database at our American College of Surgeons Committee on Trauma (ACS-COT)-verified Level I trauma center.

Patients' medical records were reviewed to collect data on demographics (age, sex, race), Injury Severity Score (ISS), Glasgow Coma Scale[9] (GCS) score, initial vital signs (systolic and diastolic blood pressure, heart rate, respiratory rate), laboratory values (hemoglobin, hematocrit, lactate), comorbidities, anticoagulant use, procedures performed, middle meningeal artery embolization status, blood product utilization, intensive care unit (ICU) admission and length of stay, hospital length of stay, complications, discharge disposition, and mortality. Post-discharge complications were identified through chart review of events occurring within 30 days of discharge. To evaluate safety, we decided to look at the rates of complications, hospital outcomes, and the number of failed embolizations. Failed embolizations were defined as embolizations that required a craniotomy after embolization.

Statistical analyses were performed using SPSS version 29.0 (IBM Corp., Armonk, NY). Patients were grouped based on whether middle meningeal artery embolization was performed. Continuous variables are reported as medians with interquartile ranges, and categorical variables as frequencies and percentages.

Group comparisons are presented as the standardized mean difference between study groups. All analyses were performed as complete case analyses.

RESULTS

The initial trauma registry query identified 37 patients treated for SDH. Patients were excluded for chronic SDH (n = 1), acute-on-subacute SDH (n = 2), and ward-of-the-state status (n = 1). The final analysis included 33 patients with acute SDH, of whom 17 underwent MMA embolization and 16 received standard management without embolization.

Table 1. Patient demographics.

Parameter	Embolized (n = 17)	Not Embolized (n = 16)	*Standardized Mean Difference*
Age (yr)	71.0 (61.5-84.0)	37.5 (25.0-78.5)	-1.12
Gender (male)	64.7% (11)	75.0% (12)	0.23
Race			0.51
White	88.2% (15)	87.5% (14)	
Black or African American	0.0% (0)	6.3% (1)	
Asian	5.9% (1)	0.0% (0)	
Unknown	5.9% (1)	6.3% (1)	

Patients who underwent embolization were older than those who did not (median age 71.0 vs. 37.5 years). Minimal differences were observed between groups in sex or race (Table 1). Non-embolized patients presented with a lower median Glasgow Coma Scale (GCS) score (11.5 vs. 14.0), lower median systolic blood pressure (132.5 vs. 150 mmHg), and lower median respiratory rate (14 vs. 18 breaths/min) compared with embolized patients. Injury severity, initial laboratory values (hematocrit and lactate), and comorbidity burden did not differ greatly between groups (Table 2).

Among the 17 embolized patients, 11 presented with acute SDH and six with acute-on-chronic SDH. Four patients (two in each subgroup) underwent craniotomy as part of initial management prior to embolization. Of the four embolized patients initially managed non-operatively, one subsequently required burr hole decompression due to worsening mental status and radiographic progression; this patient was later discharged to hospice. No patients underwent craniotomy after MMA embolization.

Post-treatment complication rates did not differ meaningfully between groups. However, embolized patients were less likely to require mechanical ventilation (23.5% vs. 62.5%) and had a longer median hospital length of stay (9 vs. 4 days). Discharge disposition was similar between groups based. Mortality was lower in the embolization group (5.9% vs. 37.5%; Table 3). The single death in the embolization group was attributed to ischemic stroke with subsequent SDH expansion on hospital day 3; anticoagulation initiated for stroke management confounded assessment of embolization effectiveness. In the non-embolized group, deaths were due to spinal cord injury (n = 1), anoxic brain injury (n = 3), and non-traumatic brain injury (n = 2).

Table 2. Injury severity, initial vital signs, and comorbidities.

Parameter	Embolized (n = 17)[a]	Not Embolized (n = 16)[a]	*Standardized Mean Difference*
ISS	10 (10-18)	21 (6.5-32)	0.71
GCS	14 (13-15)	11.5 (3-14)	-1.00
SBP	150 (137.8-165.8)	132.5 (120-141.5)	-0.07
DBP	83 (75.3-102.8)	83 (68.5-97.3)	-0.43
Heart Rate	83 (69-101)	93 (72.8-126)	0.35
Respiratory Rate	18 (16-20)	14 (2.3-19)	-1.13
Hematocrit	36.9 (31.8-39.4)	41.3 (35.5-44.7)	0.51
Lactate	1.8 (0.8-2.8)	3.1 (1.4-4.5)	0.77
Comorbidities			
Smoker	17.6% (3)	12.5% (2)	-0.12
Functionally Dependent	35.3% (6)	12.5% (2)	-0.75
Mental/Personality Disorder	5.9% (1)	18.8% (3)	0.43
COPD	29.4% (5)	6.3% (1)	-0.62
HTN	70.6% (12)	43.8% (7)	-0.65
DM	41.2% (7)	25.0% (4)	-0.47
Anticoagulant Use	35.3% (6)	25.0% (4)	-0.19
Other Comorbidities	47.1% (8)	43.8% (7)	-0.14

[a]The n (n_1 = Embolized, n_2 = Not Embolized) for the following variables is different than those listed at the top of each table: ISS (n_1 = 13, n_2 = 15), GCS (n_1 = 16, n_2 = 15), SBP (n_1 = 14, n_2 = 16), DBP (n_1 = 14, n_2 = 16), Heart Rate (n_1 = 14, n_2 = 16), Respiratory Rate (n_1 = 14, n_2 = 15), Hematocrit (n_2 = 15), Lactate (n_1 = 15, n_2 = 7)
Abbreviations: Injury Severity Score (ISS); Glasgow Coma Scale Score (GCS); Systolic Blood Pressure (SBP); Diastolic Blood Pressure (DBP); Chronic Obstructive Pulmonary Disease (COPD); Hypertension (HTN); Diabetes Mellitus (DM)

DISCUSSION

The purpose of this study was to evaluate the safety of MMA embolization in the management of acute SDH. Patients who underwent embolization presented with a higher median GCS score, suggesting less severe initial neurologic impairment. This may have contributed to their reduced need for mechanical ventilation and more favorable clinical course. Importantly, use of MMA embolization in these patients did not result in unanticipated adverse events or require subsequent craniotomy.

MMA embolization is a relatively novel intervention for SDH, with existing evidence largely limited to chronic cases. Prior studies have demonstrated lower treatment failure rates and comparable complication rates for MMA embolization compared with conventional management of chronic SDH.[10,11] Although these findings cannot be directly extrapolated to acute SDH, they support consideration of MMA embolization as a potential therapeutic option in carefully selected acute cases.

This study has several limitations. Its retrospective design and small sample size limit statistical power and introduce potential selection bias and unmeasured confounding. The 30-day follow-up period may not capture delayed complications, recurrence, or long-term outcomes such as functional recovery

Table 3. Patient procedures and hospital outcomes.

Parameter	Embolized (n = 17)[a]	Not Embolized (n = 16)[a]	*Standardized Mean Difference*
Burr Holes	5.9% (1)	6.3% (1)	0.02
Craniotomy	23.5% (4)	18.8% (3)	10.15
Fluoroscopy	64.7% (11)	81.3% (13)	0.38
Transfusion	11.8% (2)	18.8% (3)	0.20
PRBC (cc)	620 (620-620)	1240 (930-n/a)	1.47
Time to Initiation of VTE prophylaxis (days)	2 (1-5)	3 (1.5-5)	0.06
Duration of VTE (days)	2.5 (1.8-6)	4 (2-5)	0.10
ICU Admission	100% (17)	100% (16)	0.00
ICU Days	8 (3-14)	4 (3-8.8)	-0.71
Vent Use	23.5% (4)	62.5% (10)	0.86
Vent Days b	2 (2-2)	2 (2-3)	0.97
HLOS (days)	9 (4-15.5)	4 (2-8.8)	-0.76
Complications			
Readmission	10.0% (2)	6.3% (1)	-0.19
Stroke/CVA	5.0% (1)	0.0% (0)	-0.35
Sepsis	5.0% (1)	0.0% (0)	-0.35
AKI	5.0% (1)	6.3% (1)	0.02
ETOH Withdrawal	5.0% (1)	6.3% (1)	0.02
Unplanned Operation	10.0% (2)	6.3% (1)	-0.19
Delirium	25.0% (5)	6.3% (1)	-0.63
Other complication	55.0% (9)	81.3% (13)	0.63
Mortality	5.9% (1)	37.5% (6)	0.83

[a]The n (n_1 = Embolized; n_2 = Not Embolized) for the following variables is different than those listed at the top of each table: PRBC ($n_1 = 3$; $n_2 = 1$), time to initiation of VTE prophylaxis ($n_1 = 9$; $n_2 = 10$), duration of VTE ($n_1 = 9$; $n_2 = 10$).
[b]Cases with zero days were excluded from this analysis.
Abbreviations: Packed Red Blood Cells (PRBC); Intensive Care Unit (ICU); Venous Thromboembolism (VTE); Hospital Length of Stay (HLOS); Cerebrovascular Accident (CVA); Acute Kidney Injury (AKI); Alcohol (ETOH).

and quality of life. Consequently, these findings should be interpreted cautiously. Larger retrospective analyses and prospective trials are needed to more definitively evaluate the safety, effectiveness, and optimal role of MMA embolization in the acute SDH setting.

In conclusion, MMA embolization demonstrated promise as a management strategy for traumatic acute SDH, with no major procedure-related complications observed. These preliminary findings suggest that MMA embolization may be a safe option for select patients and could reduce the need for more invasive surgical interventions; however, further investigation is required to establish its efficacy and define appropriate patient selection.

ARTICLE INFORMATION

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