

Management of Chronic Subdural Hematoma; Middle Meningeal Artery Embolization versus Surgical Evacuation: A Comparative Study.

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ABSTRACT:

Background: Chronic subdural hematoma (CSDH) is a prevalent neurosurgical pathology greatly impacting elderly cases and is correlated to significant morbidity and death

Aim: This study aimed to compare the clinical and radiological results between surgical evacuation and middle meningeal artery embolization in the management of chronic subdural hematoma.

Material and Methods: This was a prospective, non-randomized case series clinical trial study that was conducted on symptomatic chronic subdural patients who were admitted to Cairo University Hospitals starting from October 2022 to October 2023.

Results: All patients experienced postoperative headache relief, with immediate improvement in Group A and delayed improvement from the second month in Group B. Motor power also improved immediately in Group A, while Group B showed improvement starting from the second month. According to the Markwalder grading system, Group A showed non-significant improvement ($p = 0.082$), with most patients initially at grade 1, while all Group B patients were grade 1 on admission. The average postoperative hospital stay was significantly shorter in Group B (2.5 ± 1.0 days) in comparison with Group A (5.20 ± 4.31 days), reducing infection risk; this variance was highly statistically significant ($p < 0.001$).

Conclusion: Surgical evacuation offers immediate symptom relief and reduced hematoma thickness, while long-term clinical and radiological outcomes are comparable to surgery and MMA embolization. MMA embolization is less invasive, lower-risk, and quicker, but requires close monitoring and is effective in carefully selected non-acute cases.

Keywords: Chronic Subdural Hematoma, Middle Meningeal Artery Embolization, Surgical Evacuation

INTRODUCTION

Chronic subdural hematoma (CSDH) is a prevalent neurosurgical pathology greatly impacting elderly cases and is correlated to significant morbidity and death (1). CSDH is believed to have developed from a previous traumatic acute subdural bleeding occurring between the arachnoid and dura layers (1). While this acute hematoma can resolve completely, inflammation, fibrinolysis, and/or angiogenesis often result in the development of a vascularized neomembrane, leading to fluid exudation and subsequent bleeding, which ultimately leads to volume expansion and neurological deficits (ND) (2). Histologically, the outer neomembrane consists of friable sinusoidal neovessels that easily rupture spontaneously, resulting in recurrent bleeding (3). The neovessels receive their blood supply from the middle meningeal artery (MMA), which traverses the dura to connect to these fragile vessels (3). Support for this theory originated from imaging investigations indicating ipsilateral expansion of the MMA in cases that had CSDH (1).

Surgical evacuation and drain placement are conducted for symptomatic, refractory, and/or great CSDH that cause brain compression (4-6). In contrast, asymptomatic and/or small chronic subdural hematomas without cerebral compression are frequently managed conservatively and monitored frequently with serial imaging (7-8). This study aimed to compare the clinical and radiological results between surgical evacuation and middle meningeal artery embolization in the management of chronic subdural hematoma.

MATERIALS AND METHODS

This was a prospective non-randomized case series clinical trial study that was conducted on symptomatic chronic subdural patients who were admitted to Cairo University Hospitals starting from October 2022 to October 2023.

Patients were divided into two groups: **Group A:** 10 cases underwent double burr hole with subgaleal drain for evacuation of CSDH, and **Group B:** 10 patients underwent middle meningeal artery embolization.

Inclusion criteria: Primary and recurrent cases that are compatible with the inclusion criteria, unless the patient refused the procedure, and minimal symptoms like mild neurological deficit (ND), headache, or changed mental status.

Exclusion criteria: significant midline shift of more than 5mm in the embolization group or neurologic symptoms requiring urgent decompression (group B) and significant contraindication to angiography (example: renal failure).

Patients and methods: All patients were subjected to the following: Patients were assessed through history (including age, sex, trauma, coagulopathies, and relevant medications), neurological symptoms (e.g., headache, weakness, seizures), clinical examination (general condition, surgical fitness, full neurological exam), and imaging. All underwent CT brain to evaluate hematoma characteristics, with MRI used in selected cases for detailed assessment of hematoma membranes.

Surgical technique:

Group A patients underwent surgical evacuation under general anesthesia in the supine position with head rotation, where 1 or 2 burr holes had been made according to preoperative CT, the dura was cauterized and incised, and the subdural cavity was irrigated with saline until clear. A subgaleal drain has been placed and maintained for 48–72 hours. Group B patients underwent middle meningeal artery embolization under light or no sedation via femoral artery access, with

selective catheterization of the MMA and embolization using 150–250-micron polyvinyl alcohol particles, avoiding reflux and dangerous anastomoses. Post-procedure, patients were monitored with regular neurological assessments and a follow-up CT on day one.

Postoperative period:

Medical treatment: prophylactic intravenous antibiotics were given to all patients and stopped after removal of the drain, and the patient continued on oral antibiotics for 3-5 days. Analgesics, prophylactic antiepileptic drugs, gastric protecting drugs, I.V. fluids, and neurotonic drugs. **Clinical follow-up:** Neurological assessment was performed for all patients immediately post-operative. Assessment focused on conscious level, weakness improvement, and occurrence of fit. **Radiological follow-up:** Post-operative imaging by CT brain was done immediately post, three, and six months.

Ethical Approval and Consent

This study was approved by the Institutional Review Board (IRB) of Cairo University Hospitals. All procedures performed in this study involving human participants were conducted by the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments. Informed written consent was obtained from all individual participants included in the study

RESULTS AND DISCUSSION

Table 1: Demographic data of the studied groups

		Group A		Group B	
		Number	%	Number	%
Age (years)	Mean	58.6		63.6	
	±SD	21.9		8.5	
Sex	Males	6	60 %	7	70%
	Females	4	40 %	3	30%

The study involved a total of 20 cases with chronic subdural hematoma, consisting of 13 men (65%) and 7 women (35%). **Group A:** 6 men (60%) and 4 women (40%), with an average age of 58.6 ± 21.9 years; and **Group B:** 7 men (70%) and 3 women (30%), with an average age of 63.6 ± 8.5 years. (Table 1).

Table 2: Showing the radiological findings in the study group

Radiological findings		Group A	Group B
Hematoma thickness	> 20-25mm	1	10
	26-30mm	3	0
	> 30	6	0

Shifting midline	< 3mm	1	8
	3-5mm	9	2
	> 5	0	0
Effacement to gyri and sulci		10	8

Hematoma thickness ranged from 20 to 35 mm in group A. In group B ranged from 20-25mm. Midline shift in group A from 3-6mm and in group B from 2-4mm. The effacement of gyri and sulci is seen in all patients in two groups except the two patients in group B (Table 2).

Table (3): Clinical results in groups on Markwalder grading system.

Clinical grade	Full recovery	Mild ND	Severe ND
Group A (Number = 10)			
0 (n=0)	0	0	0
1 (n=6)	6	0	0
2 (n=2)	2	0	0
3 (n=2)	2	0	0
4 (n=0)	0	0	0
Group B (Number = 10)			
0 (n=0)	0	0	0
1 (n=10)	10	0	0
2 (n=0)	0	0	0
3 (n=0)	0	0	0
4 (n=0)	0	0	0

All patients experienced postoperative headache relief, with immediate improvement in Group A and delayed improvement from the second month in Group B. Motor power also improved immediately in Group A, while Group B showed improvement starting from the second month. According to the Markwalder grading system, Group A showed non-significant improvement ($p = 0.082$), with most patients initially at grade 1, while all Group B patients were grade 1 on admission. (Table 3)

Table (4): Comparison of hematoma thickness between studied groups.

Hematoma thickness		Group A (Number = 10)	Group B (Number = 10)	Stat. test	P-value
Pre-op	Mean	30.1	26.1	T = 2.02	0.058 NS
	±SD	4.3	4.4		
2nd day post-op	Mean	8.4	26.1	T = 10.9	< 0.001 HS

	$\pm$ SD	2.5	4.4		
3 months post-op	Mean	0.0	0.0	----	----
	$\pm$ SD	0.0	0.0		
6 months post-op	Mean	0.0	0.0	----	----
	$\pm$ SD	0.0	0.0		

In Group A, postoperative improvement in hematoma thickness (mean = 8.4 ± 2.5 mm) and midline shift (mean = 2.5 ± 0.7 mm) was immediate, with complete resolution by six months. In contrast, Group B showed no immediate improvement; changes began between the second- and third-month post-embolization, with full resolution of hematoma and midline shift in all patients by six months. (Table 4)

Table (5): Comparison of complications between studied groups.

		Group A (Number = 10)		Group B (Number = 10)		X²	P-value
Recurrence	No	10	100%	10	100%	----	-----
	Yes	0	0%	0	0%		
Pneumocephaly	No	6	60%	10	100%	5	0.025 S
	Yes	4	40%	0	0%		

X²: Chi-square test.

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Pneumocephalus occurred in 40% of patients in the surgical group but was absent in the embolization group (p-value = 0.025). Affected patients were managed conservatively without the need for further surgical intervention. (Table 5)

Table (61): Comparison of hospital stay between examined groups

		Group A (Number = 10)	Group B (Number = 10)	T	P-value
Hospital stay (days)	Mean	5.20	2.5	8.5	< 0.001 HS
	$\pm$ SD	4.31	1.0		

The average postoperative hospital stay was significantly shorter in Group B (2.5 ± 1.0 days) in comparison with Group A (5.20 ± 4.31 days), reducing infection risk; this variance was highly statistically significant (p < 0.001). (Table 6)

Case presentation:

Case (1): A 40-year-old man presented with a headache and right-side weakness with a history of head trauma one month ago. On examination, the patient was confused. Motor power: right upper limb G3, lower limb G3; otherwise, full motor power and the rest of the neurological examination were normal. CT brain showed a left fronto-parietal chronic subdural hematoma that was operated upon by evacuation via two burrholes with subgaleal drain. The patient post-operatively

immediately was fully conscious with full motor power. The drain tube was removed after 48 hours.

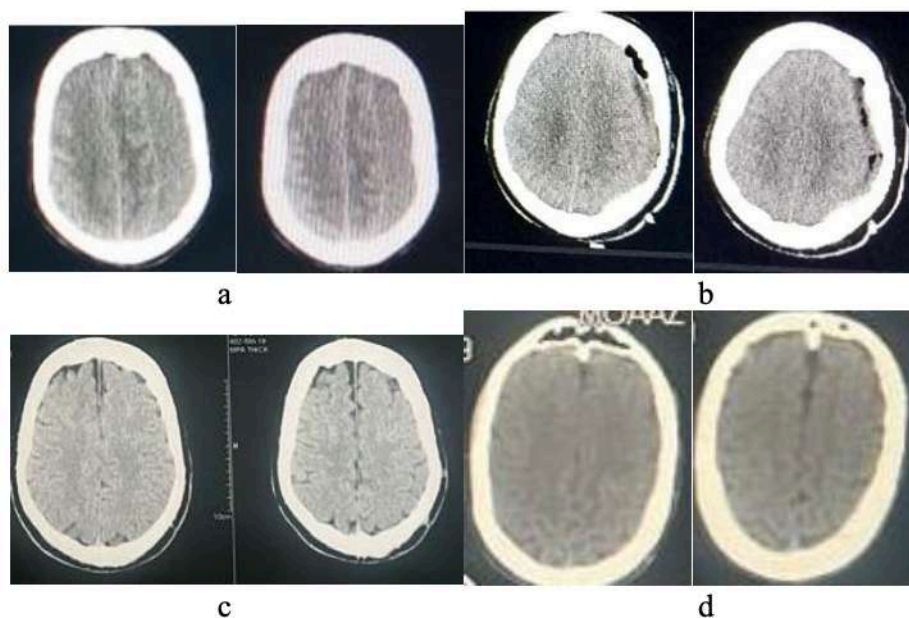
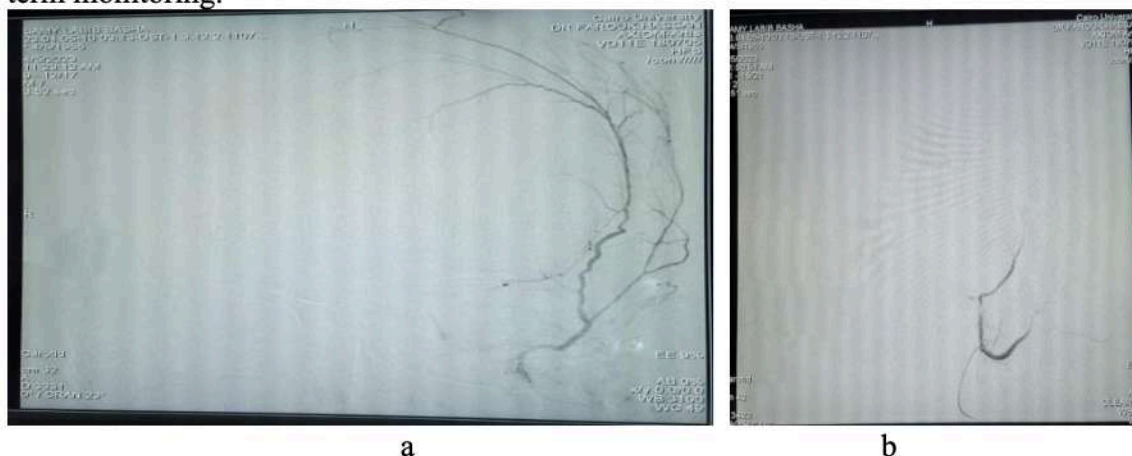


Figure (1): CT images showing preoperative and postoperative changes following surgical evacuation. "a) pre-surgical evacuation of hematoma, b) Immediately post-surgical evacuation, c) Follow-up CT brain after three months of evacuation, f) Monitoring computed tomography brain after 6 months of evacuation.

Case (2): A 65-year-old male patient presented with a headache, right-side weakness, and a history of a fall on the floor 1.5 months ago with no past medical history of diseases. On examination, the patient was fully conscious, with motor power: right upper limb G 4, lower limb G 4, otherwise full motor power, and the rest of the neurological examination was normal. A CT brain showed a left fronto-parietal chronic subdural hematoma, that was managed by left middle meningeal artery embolization. The patient post-intervention was fully conscious, with full motor power on long-term monitoring.



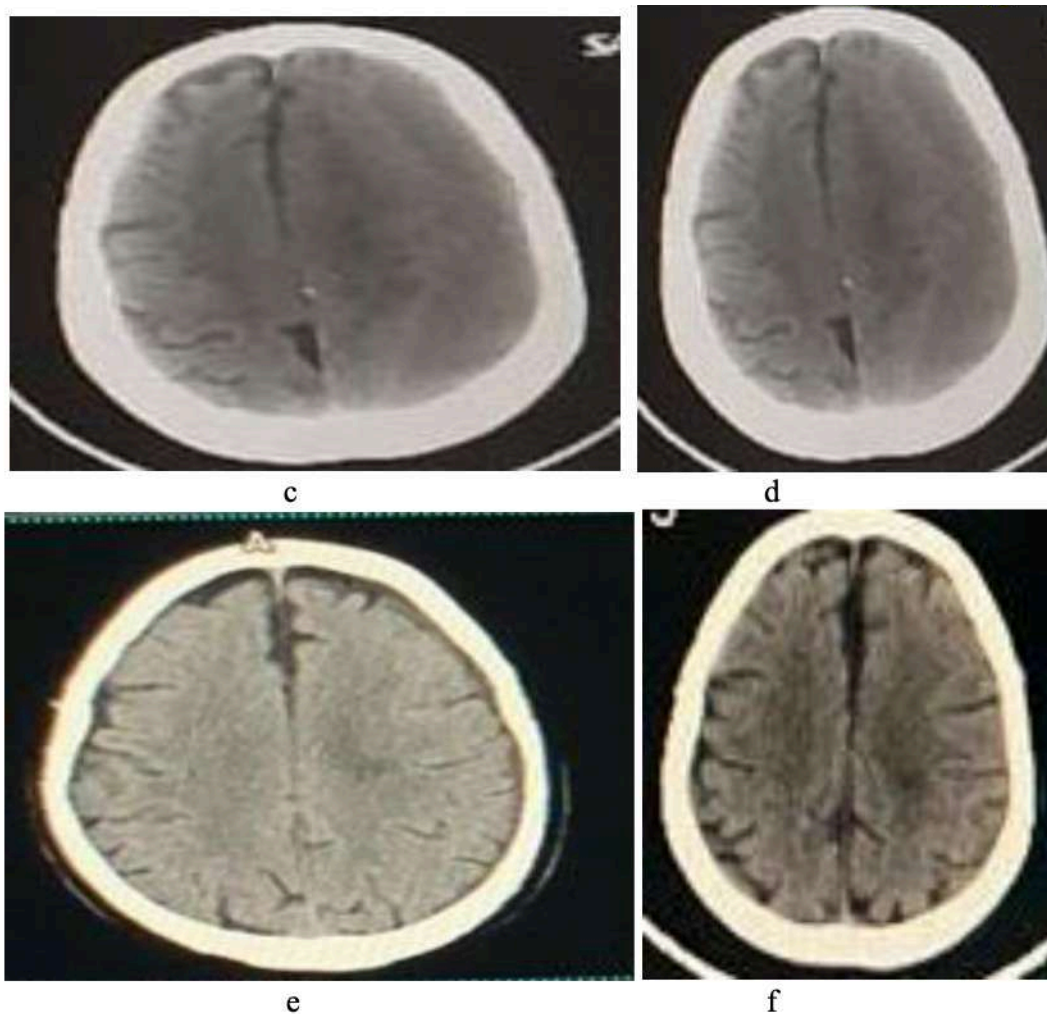


Figure (2): CT images showing a) pre-embolization, b) immediately post embolization, c) CT brain pre-embolization, d) CT brain immediately post embolization, e) follow up CT brain after three months of embolization, f) follow up CT brain after six months of embolization.

DISCUSSION

In our results, hematoma thickness ranged from 20 to 35 mm in group A, in group B the range was 20-25mm. Midline shift in group A from 3-6mm and in group B from 2-4mm. The flattening of gyri and sulci is seen in all patients in two groups except the two patients in group B. In concordance with our results, **Sila et al. (9)** found that in the surgery group, mean hematoma width in mm (SD) was 21 (5) and mean midline shift in mm (SD) was 8 (5). While in the MMA embolization group, mean hematoma width in mm (SD) was 18 (6), and mean midline shift in mm (SD) was 5 (4). These results indicated there was statistically significant variance among the 2 groups as regards mean hematoma width and mean midline shift, with p-values in each = .001. In our findings, the postoperative improvement in the hematoma thickness (mean = 8.4 ± 2.5) and midline shift (mean = 2.5 ± 0.7) was immediate in group A, with complete resolution of the hematoma after 6 months. In group B there was no immediate improvement in the hematoma thickness and midline shift; in this group the improvement started after the second to third month of embolization, with complete resolution of the hematoma and midline shift in every case after six months. **Kan et al. (10)** found that fifteen cases had bilateral interventions, resulting in an overall

total of 154 embolizations. The median thickness of chronic subdural hematoma at admission was fourteen millimeters. On the last monitoring, the median thickness of the chronic subdural hematoma was four millimeters, indicating a seventy-one percent reduction in median thickness. In our findings, in the surgical group, pneumocephalus was seen in the postoperative CT of 4 patients (40 %), while in the embolization group, it was not a postoperative complication ($P = 0.025$). These patients with pneumocephalus were subjected to conservative treatment and required no surgical intervention. There was no recurrence of wound infection or non-procedural-related complications or death. In both groups, patients had no postoperative attacks of seizures. Every patient got prophylactic AEDs. Furthermore, **Sattari et al. (11)** reported that 337 patients (22.2 %) had middle meningeal artery embolization, while 1186 patients (77.8 %) received conventional management, correspondingly. They stated that there was no variance among the two groups for complications ($P = .72$). As well, **Ironsides et al. (12)** reported that in comparison with conventional treatment, middle meningeal artery embolization has been correlated with reduced rates of chronic subdural hematoma recurrence. Furthermore, **Sattari et al. (11)** aimed to conduct a systematic review and meta-analysis on research that compared middle meningeal artery embolization against conventional management. Nine investigations yielding 1523 cases have been enrolled, of which 337 (22.2 %) and 1186 (77.8 %) received middle meningeal artery embolization and conventional management, respectively. They revealed that middle meningeal artery embolization was superior to conventional management for treatment failure ($P = .02$) and surgical rescue ($P = .01$). There was no variance among the 2 groups for monitoring morbidity and death ($P = .89$). For middle meningeal artery embolization, the numbers required to treat for treatment failure and operative rescue were seven and nine, correspondingly. The certainty of the proof was moderate to high for 1st results and low to moderate for 2nd results. MMA embolization diminishes treatment failure and the necessity for operative rescue without furthering the risk of death and morbidity. In addition, **Kan et al. (10)** found that of the 15 cases that had bilateral intervention for 154 total embolizations, there were 16 complications, with nine (6.5 %) due to continued hematoma expansion. The rate of death was 4.4%, mostly not associated with the index procedure but due to underlying comorbidities. In the present study, we demonstrated that regarding the postoperative hospitalization, the average hospitalization in group (A) of our research was 5.20 ± 4.31 days. In group (B), the average hospitalization was 2.5 ± 1.0 days. Notably, the hospital stay period in the embolization group was less than in the surgical group, which reduced the risk of infection. The difference was highly statistically significant ($p\text{-value} < 0.001$). In line with our results, **Sattari et al. (11)** compared MMA embolization vs. conventional management. They revealed that there was no variance among the 2 groups for length of hospitalization ($P\text{-value} = 0.57$).

CONCLUSION

Surgical evacuation shows superior short-term outcomes with immediate symptom relief and reduction in hematoma thickness and midline shift, while long-term clinical and radiological outcomes are comparable between surgery and MMA embolization. MMA embolization is a less invasive, lower-risk, and quicker procedure that can be performed under local anesthesia, though it is pricier and requires close monitoring. It is especially effective in carefully selected non-acute cases, particularly in high-risk patients on anticoagulants or with recurrent hematomas.

REFERENCES

1. Foreman P, Goren O, Griessenauer CJ, Dalal SS, Weiner G, Schirmer CM. Middle meningeal artery embolization for chronic subdural hematomas: cautious optimism for a challenging pathology. *World Neurosurg.* 2019; 126:528–9.
2. Edlmann E, Giorgi-Coll S, Whitfield PC, Carpenter KLH, Hutchinson PJ. Pathophysiology of chronic subdural haematoma: inflammation, angiogenesis and implications for pharmacotherapy. *J Neuroinflammation.* 2017; 14:108.
3. Takizawa K, Sorimachi T, Ishizaka H, Osada T, Srivatanakul K, Momose H, et al. Enlargement of the middle meningeal artery on MR angiography in chronic subdural hematoma. *J Neurosurg.* 2016; 124:1679–83.
4. Lee RP, Chaichana KL, Huang J, Tamargo RJ, Caplan JM. Neurosurgical emergencies. *Neurointensive Care Unit: Clinical Practice and Organization.* 2020:195-230.
5. Nouri A, Gondar R, Schaller K, Meling T. Chronic Subdural Hematoma (cSDH): A review of the current state of the art. *Brain and Spine.* 2021 Jan 1;1:100300.
6. Mehta V, Harward SC, Sankey EW, Nayar G, Codd PJ. Evidence based diagnosis and management of chronic subdural hematoma: a review of the literature. *Journal of clinical neuroscience.* 2018 Apr 1;50:7-15.
7. Alam S, Rahman MM, Sarker MH, Ahmed N, Chowdhury FH. Head injury. *Principles of Neurosurgery: A Concise Text.* 2024 Dec 30:133.
8. Ban SP, Hwang G, Byoun HS, Kim T, Lee SU, Bang JS, et al. Middle meningeal artery embolization for chronic subdural hematoma. *Radiology.* 2018; 286:992–9.
9. Sila D, Casnati FL, Vojtková M, Kirsch P, Rath S, Charvát F. Middle Meningeal Artery Embolization versus Surgery in Patients with Chronic Subdural Hematoma—No More Fence Sitting?. *Neurology International.* 2023 Dec 6;15(4):1480-8.
10. Kan P, Maragos GA, Srivatsan A, Srikanth V, Johnson T, Burkhardt JK, Robinson TM, Salem MM, Chen S, Riina HA, Tanweer O. Middle meningeal artery embolization for chronic subdural hematoma: a multi-center experience of 154 consecutive embolizations. *Neurosurgery.* 2021 Feb 1;88(2):268-77.
11. Sattari SA, Yang W, Shahbandi A, Feghali J. Middle meningeal artery embolization versus conventional management for patients with chronic subdural hematoma: a systematic review and meta-analysis. *Neurosurgery.* 2023 Jun 1;92(6):1142-54.
12. Ironside N, Nguyen C, Do Q, Ugiliweneza B, Chen CJ, Sieg EP, James RF, Ding D. Middle meningeal artery embolization for chronic subdural hematoma: a systematic review and meta-analysis. *Journal of neurointerventional surgery.* 2021 Oct 1;13(10):951-7.