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Original Article

Different Indications of Middle Meningeal Artery Embolization for Chronic Subdural Hematoma (Retrospective Analysis and Single Institutional Experience)

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BACKGROUND: Chronic subdural hematoma (CSDH) has significant patient morbidity and recurrence that drives the management towards less invasive procedures. We describe the different indications of middle meningeal artery embolization (MME) in management of CSDH.

OBJECTIVE: We aimed to report and evaluate our institutional experience using MME in management of CSDH.

PATIENTS AND METHODS: Retrospective analysis was conducted between 2020 and 2023, we reviewed the different indications of MME using different embolization material. Clinical and radiological outcomes were described 6 months and 1 year postoperatively.

RESULTS: Twenty one CSDHs were treated in 16 patients (5 patients had bilateral CSDH). In patients with bilateral CSDH each hematoma was considered separately. Of the 21 hematomas, 7 (33.3%) were treated upfront without prior surgical treatment, 4 (19.1%) were treated for recurrence after prior surgical evacuation, and 10 (47.6%) were treated prophylactically following surgical evacuation. Post embolization, one hematoma needed to be evacuated due to failure of hematoma volume reduction. By the end of one year follow up, 50% reduction in hematoma size was achieved in 13 hematomas (62%), while total disappearance was evident in 7 hematomas (33.3%). Recurrence was noted in one patient on renal dialysis which was managed conservatively. The modified Rankin scale (mRS) improved after 6 months in comparison to the admission time from 3 ± 1.2 to 1.6 ± 0.63 with p value of 0.003.

CONCLUSION: The MME is a safe and effective technique that should be considered in management of CSDH in patients with multiple morbidities and patients who have high risk of recurrence.

KEYWORDS: Chronic Subdural Hematoma, Embolization, Middle Meningeal Artery.

INTRODUCTION

Chronic subdural hematomas (CSDH) are one of the daily cases in neurosurgical practice that can be easily managed using burr holes or craniotomy. However, it can be a nightmare that any neurosurgeon does not want to face particularly in severely comorbid patients. These difficulties stem from being more prevalent among old ages whose multiple comorbidities require antiplatelets and anticoagulants with recurrence rates after evacuation ranging from 0.33%- to 37% and mortality rates up to 32% in the literature.[1-4] The general patients' condition can be mitigated using conscious sedation and local anesthetics. However, coagulopathies are very difficult to manage with dreadful complications like post-surgical acute subdural hematoma and recurrence.[5]

Pathogenesis theories regarding initiation and expansion of chronic subdural hematoma are a matter of controversy.[6,7] The most accepted theory nowadays is that an inflammatory process lead by dural border cells induce fibroblasts to form the outer membrane of the hematoma. The outer membrane consists of blood sinusoids with weak endothelial cells junctions resulting in multiple bleeding points that trigger more inflammatory response and that cascade continues.[6-12]

Thus interruption of the blood supply to the outer membrane of the hematoma to break this vicious circle, is the foundation of the relatively new middle meningeal artery embolization treatment **(Fig. 1)** for chronic subdural hematoma.[13-17] In this study we aim to present the different indications using this technique in treating cases of chronic subdural hematoma.

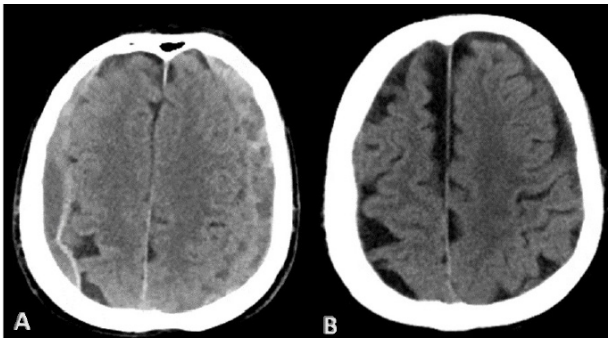

Fig 1: A 76 male on regular antiplatelets. (A) Pre-embolization computerized tomography (CT) scan showed bilateral chronic subdural hematoma, (B) 6 months post upfront - embolization CT scan showed complete resolution of the bilateral chronic subdural hematoma.

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PATIENT AND METHODS

Patient selections

After obtaining ethical approval of our institutions, the patients' electronic records were revised from 2020 till 2023, and all patients with chronic subdural hematoma who were treated by MME, and have at least one year of follow up, were included in the study. All patients were consented before procedure and agreed to publish the results of their treatment. We reported and analyzed demographic criteria, clinical presentation, and presence of comorbidities. Hematomas characteristics, MME technique, and the different indications were observed and outcome using modified Rankin scale (mRS) and hematomas' response to the embolization was measured.

Statistical analysis

Data was fed to the computer and analyzed using IBM statistical packages for social sciences (SPSS) software package version 20.0. (Armonk, NY: IBM Corp). Categorical data were represented as numbers and percentages. McNemar test was used to analyze the significance between the different stages. For continuous data, they were tested for normality by the Shapiro-Wilk test. Quantitative data were expressed as range (minimum and maximum), mean, standard deviation and median. Friedman test for abnormally distributed quantitative variables, to compare between more than two periods or stages and Post Hoc Test (Dunn's) was used for pairwise comparisons. Significance of the obtained results was judged at the 5% level.

Endovascular procedure

Written informed consent was obtained from the patient. The patient was placed supine on the angiographic table. Right wrist (in case of trans- radial approach) and right groin (in case of trans- femoral approach) was prepped and draped in usual sterile fashion.

Access phase

Trans- radial approach

Under general anesthesia, access was secured in the right proximal radial artery (diameter is 2.2 mm) using ultrasound (US) guidance and a 5-French sheath. Cocktail was given through the sheath (mixture of 2.5 mg of verapamil, 200 mcg of nitroglycerin and 2000 IU of heparin). Subsequently using a 5-French diagnostic (SIM II) catheter, selective angiogram of the right and left common carotid arteries were done.

Trans-femoral approach

Access was secured in the right common femoral artery using US guidance and a 6-French sheath. Subsequently using a 5-French guiding (Chaperon 5F angled, 95 cm) catheter over the regular 0.035" guidewire, selective angiogram of the bilateral common carotid, bilateral internal carotid, bilateral external carotid arteries was done.

Intervention phase

The external carotid artery (ECA) was catheterized and the guiding catheter was parked in the ECA. Subsequently, selective angiogram of the right external carotid artery on the hematoma side was performed using hand injection of contrast. middle meningeal artery (MMA) was selectively catheterized using micro catheter over a micro wire and selective angiogram was done to define the absence or presence of dangerous anastomoses connecting the middle meningeal arteries, ophthalmic, and petrosal branches. The branches that supply the hematoma were recognized by the abnormally enlarged caliber and their cotton-wall staining appearance.[13] Depending on the anatomy of middle meningeal artery and the size and location of hematoma, selective frontal or parietal branch embolization versus whole trunk was decided. Embolization was done using different embolization material including precipitating hydrophobic injectable liquid (PHIL) 25%, surgical glue (N-butyl-2-cyanoacrylate (NBCA), and polyvinyl alcohol (PVA) (250-355), and control run showed complete embolization without evidence of reflux or inadvertent feeder embolized **(Figs. 2,3).** The procedure was repeated in cases of bilateral lesions. After removal of catheters and obtaining hemostasis using manual compression or a closure device, the patient was shifted to a high dependency unit. A computerized tomography (CT) scan was done on the next day to exclude the presence of complications.

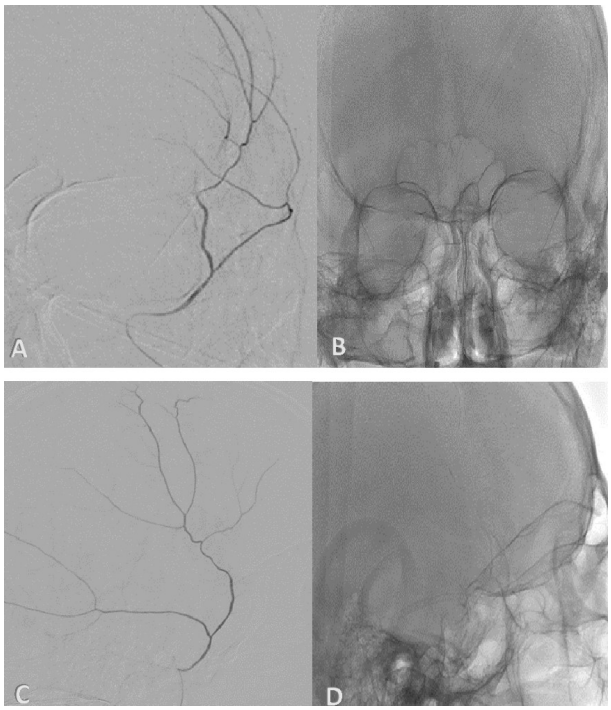

Fig 2: Angiographic views (A) Selective injection of the left MMA pre- embolization in anteroposterior view, (B) Post glue embolization in fluoroscopic anteroposterior view showed contrast stagnation in the distribution of MMA, (C) Left lateral view of MMA pre-embolization, (D) Left lateral fluoroscopic image showed stagnation in territory of left MMA post-embolization.

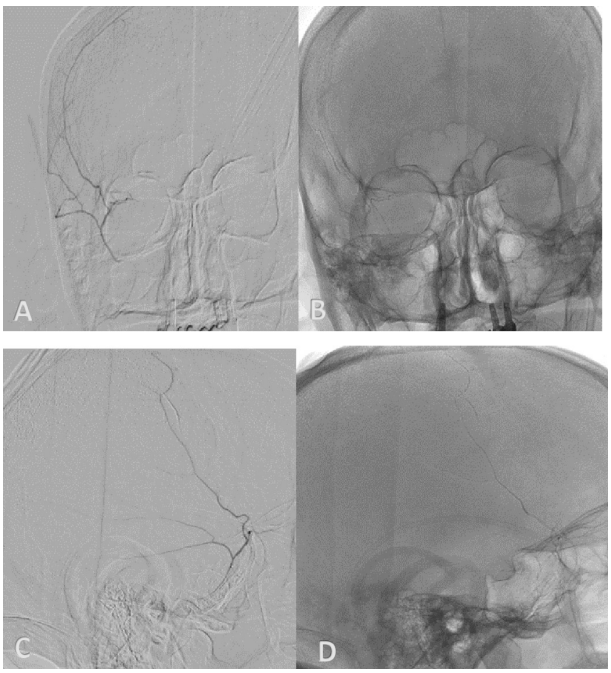

Fig 3: ANGIOGRAPHIC views (A) pre- embolization in anteroposterior view selective injection of the right MMA, (B) Contrast stagnation in the distribution of right MMA post glue embolization in fluoroscopic anteroposterior view, (C) Right lateral view of MMA pre-embolization, (D) Right lateral fluoroscopic image with stagnation in territory of right MMA post-embolization.

RESULTS

Twenty one CSDHs were treated in 16 patients (5 patients had bilateral CSDH). In patients with bilateral CSDH each hematoma was considered separately **(Table 2).** Of the 21 hematomas, 7 (33.3%) were treated upfront without prior surgical treatment, 4 (19.1%) were treated for recurrence after prior surgical evacuation, and 10 hematomas (47.6%) were treated prophylactically following surgical evacuation. All procedures were technically successful. The right radial approach and the right femoral approach were used to treat 12 (57.2%) and 9 (42.8%) hematomas, respectively. The embolization materials were summarized in **(Table 2).** Intraoperative vasospasm was encountered in 6 hematomas (28.6%) which was treated by intra-arterial injection of vasodilator. One patient developed postoperative facial palsy (House-Brackman grade V) which improved after 6 months on follow up (grade II) **(Table 5).** Patients' demographic criteria and their clinical picture were summarized in **(Table 1).** The 16 patients (9 males and 7 females with mean age (71.9±13.8 years), presented with headache as well as neurological symptoms and signs equally. Headache was the main presentation in 50%, while the other 50% presented with other complaints. Mild motor weakness was encountered in 12.5% and confusion in 37.5%. Three patients had a recent history of head trauma and 15 patients were on antiplatelet and anticoagulant medications used for associated comorbidities. Post embolization, one hematoma needed to be evacuated due to failure of hematoma volume reduction **(Table 3).** By the end of one year follow up, 50 % reduction in hematoma size was achieved in 13 hematomas (62%), while total disappearance was evident in 7 hematomas (33.3%). Recurrence was noted in one patient on renal dialysis which was managed conservatively. The modified Rankin scale (mRS) was improved after 6 months in comparison to the admission time from 3 ± 1.2 to 1.6 ± 0.63, with p value of 0.003 **(Fig. 4)**. The change in MRS was also significant after 1 –year- time from the admission; however, there was no significant difference between the mRS at 6 months and 1 year (P value =0.724) **(Tables 4, 5).**

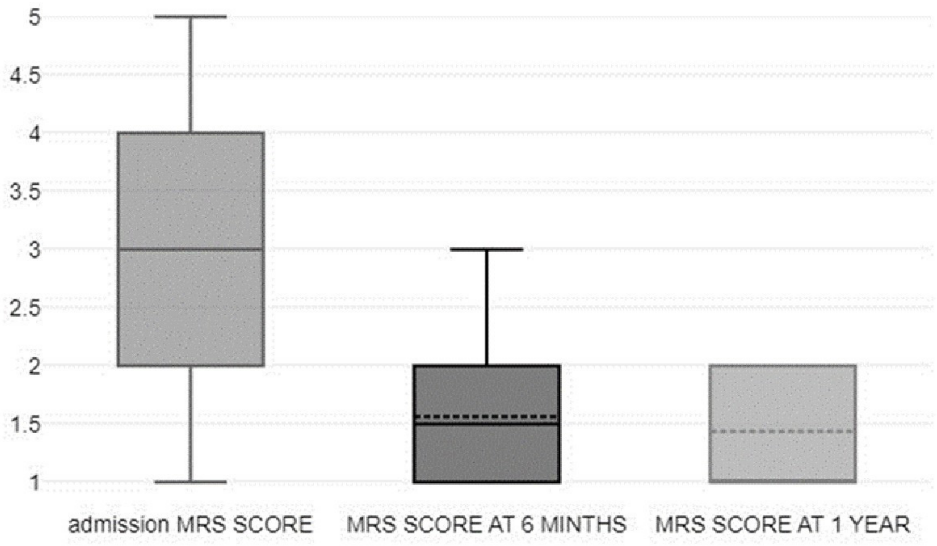

Fig. 4: Clustered box blot graph showed the change in MRS after 6 months and 1 –year- time intervals from the admission.

Table 1: Demographic criteria and clinical picture (16 patients)

	Number (%)
Gender	
Male	9 (56.3%)
Female	7 (43.8%)
Age (years)	
Mean ± SD	71.9 ± 13.8
Median	76.5
Recent history of head trauma	3 (18.8%)
Antiplatelet \ anticoagulants	
Antiplatelet	11 (68.8%)
Anticoagulants	4 (25%)
Presenting symptoms	
Headache	8 (50%)
Mild motor Weakness	2 (12.5 %)
Confusion	6 (37.5%)

Table 2: Radiographic and treatment factors of 21 CSDH (Bilateral hematoma in 5 patients)

CSDH parameter	**Number (%)**
Width of hematoma (cm)	
Mean ± SD	1.6 ± 0.72
Median	1.5
Site	
Right	12 (57.2 %)
Left	9 (42.8%)
Ct scan appearance	
Homogenous	3 (14.3%)
Laminar	6 (28.6%)
layered	10 (47.6%)
Trabecular	2 (9.5%)
Indication of embolization	
Primary treatment	7 (33.3%)
Treatment for Recurrence	4 (19.1%)
Prophylactic treatment after surgery	10 (47.6%)
Approach for MME	
Right radial	12 (57.2%)
Right femoral	9 (42.8%)
Dangerous anastomosis	
MMA to ophthalmic artery	2 (9.5%)
MMA to petrosal artery	1 (4.76%)
Embolization material	
PHIL	5 (23.8%)
Surgical glue	14 (66.6%)
Polyvinyl alcohol	2 (9.52%)
Intra procedural complications	
Vasospasm	6 (28.6%)

SD: Standard deviation

Table 3: Measurement of hematomas outcome parameter

Hematoma Outcome parameter	Number (%)
Need for post embolization surgery	1 (4.67%)
Radiological	
Size reduction by 50%	13 (62%)
Total disappearance	7 (33.3%)

Table 4: MRS score at different time periods

Variable \ score	1	2	3	4	5
MRS at admission	1 (6.25%)	7 (43.75%)	0	7 (43.75%)	1 (6.25%)
MRS at 6 months	8 (50%)	7 (43.75%)	1	0	0
MRS at 1 year	9 (56.25%)	7 (43.75%)	0	0	0

Table 5: Patient's outcome measures (number =16)

Patient outcome measure	Value
Postoperative complications	
Facial paralysis	1 (6.3%)
Recurrence	1 (6.3%)
MRS	
Admission	3 ± 1.2
6 months	1.56 ± 0.63
1 year	1.4 ± 0.51
Fr	22.947*
P	<0.001*
Significance between periods	
p1	0.003*
p2	0.001*
p3	0.724*

SD: Standard deviation.

Fr: Friedman test, significance between periods was done using Post Hoc Test (Dunn's).

P: p value for comparing between the studied groups.

p1: p value for comparing between admission and 6 months.

p2: p value for comparing between admission and 1year.

p3: p value for comparing between 6 months and 1year *: Statistically significant at $p \leq 0.05$.

DISCUSSION

In this study we present our experience in treating CSDH using the MME technique for the following indications; primary treatment, recurrent cases, and prophylactic post-surgical evacuation to prevent recurrence especially in high risk patients. This was similar to multiple studies that were conveyed recently for different indications.[14,18,19] A review of 60 hematomas in 49 patients showed that 42 hematomas were primarily treated with MME, 8 hematomas due to recurrence, and 10 hematomas as a prophylaxis after surgical evacuation.[14] The same treatment for perioperative prophylaxis was used in 44 cases by different authors.[18] CSDH affects mainly old fragile patients with multiple comorbidities and receiving blood thinners.[20] In our study 14 patients were older than 70 years and all of them were using blood thinners. Several studies recommended MME for old patients specifically who have multiple comorbidities that are considered risk factors for recurrence. This was showed by Hashimoto et al.,[15] who treated five refractory cases using this technique. Joyce et al. also analyzed 151 elderly cases and showed that this treatment method is effective in elderly age group (age 65–79 years) and advanced age group (age > 80 years) as well.[21]

The technique of embolization was widely described using both femoral and radial approach by different embolization materials. One study,[23] showed that trans-arterial approaches either trans-femoral and trans- radial can be used effectively. The trans-radial approach was performed in 64 patients with 95.7% success rate and the authors recommended to be used in elderly patients with comorbidities.[20,22,23] In this study both approaches were done according to the operator preference based on preoperative computed tomography angiography (CTA). In our study embolization materials were variably used including PHIL (precipitating hydrophobic injectable liquid), surgical glue (N-butyl-2-cyanoacrylate (NBCA), and polyvinyl alcohol (PVA). Some authors prefer using PVA because it goes more distally, occludes the difficult to reach branches and can be used with local sedation which is appropriate for elderly and comorbid patients. In contrast, liquid embolic materials like onyx and n-butyl cyanoacrylate which are readily visible, cause stump closure but being painful requiring general anesthesia and associated cranial nerves neurotoxicity make it less favorable.[22,24] The safety of the technique and complications were studied in multiple series that studied MME for CSDH and other pathologies such as meningioma and arteriovenous fistulas.[25,26] Cranial nerve palsies and blindness were reported; however exclusion of such dangerous anastomoses can tackle this problem.[15,27] In this study, vasospasm (28.6% of hematomas) was noted during frequent attempts to catheterize difficult branches of MMA which was managed by local injection of vasodilator. One case of facial palsy was also reported in our study. A meta-analysis of four studies concluded that recurrence rates, non-procedure related complications, and need for surgical evacuation reached 0% after upfront MME.[28] In the same meta-analysis, 15 studies analyzing the postoperative MME found that the recurrence rates, non-procedure related complications, and surgical intervention were 3.9% (95% (CI) 1.4% to 6.4%), 2.8% (0.7% to 4.8%), and 2.9% (0.8% to 5.0%), respectively.[28] The primary outcome of this technique is promising in hematoma resolution and prevention of recurrent cases. In our study, only one case needed surgical evacuation probably due to poor embolization of the MMA. The recurrence was in one dialysis patient, however it was small and does not need surgery. Several studies reported low recurrence rate of CSDH after MME in comparison to the conventional surgical treatment.[17,29] Other studies showed that MME technique was effective in avoiding surgery in (91.1%) of their series and the reduction of hematoma size of more than 50% was evident in 68.9%,[17,30] which was comparable to our study (62%). These findings were also supported by a meta-analysis performed by Srivastan et al. and Ironside et al.[31,32] The MRS significantly improved in our series on 6 months and 1 year follow up (1.6±0.63 and 1.4±0.51 respectively). Fifteen patients (93.7%) and 16 patients(100%) have MRS score equal to or less than 2 in 6 months and 1 year times respectively. This was comparable to what was reported by Kim et al.[17] Also, Matsumoto et al. found that mRS was 2 on follow up in 87% and 100%, respectively.[32] This study is limited by being retrospective in nature and of small patient number relatively as well as it represents an early institutional experience. There was also no control group to proove that MME is superior to surgical evacuation.

CONCLUSION

The MME is a safe and effective technique to treat CSDH with different indications that help to reduce recurrence, however surgical evacuation is the gold standard treatment to be effort in neurologically unstable patients and to augment surgery by MME to prevent recurrence especially in patients who need long life treatment with antiplatelet and anticoagulants.

List of Abbreviations

CSDH: Chronic subdural hematoma
CT: Computerized tomography
CTA: Computerized tomography angiography
ECA: External carotid artery
MMA: Middle meningeal artery
MME: Middle meningeal artery embolization
MRS: Modified rankin scale
NBCA: N-butyl-2-cyanoacrylate
PHIL: Precipitating hydrophobic injectable liquid
PVA: Polyvinyl alcohol

Disclosure

The authors report no conflict of interest in the materials or methods used in this study or the findings specified in this paper.

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