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Embolization of Middle Meningeal Artery for Management of Chronic Subdural Hematoma

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Abstract

Background: Embolization of middle meningeal artery (EMMA) has rapidly gained in popularity as a novel treatment for CSDH and as a method to decrease rates of CSDH recurrence. The purpose of our study is to report a single Canadian center experience of EMMA for the management of CSDH.

Method: The consecutive patients undergoing EMMA during the period July 2020 to September 2021 at our tertiary care center were included in this series. EMMA procedures were performed using polyvinyl alcohol (PVA) particles or liquid embolic agent (LEA) based on the operators preference. All patients were followed clinically and radiographically as per standard of care. Patient demographic, clinical and imaging data were collected.

Results: A total of 19 patients (mean age - 65.6 years; range- 14-85 yrs; Male - 16) with CSDH underwent 20 EMMA procedures. None of these patients have peri-procedural complications related to EMMA. There was no recurrence of CSDH on the side treated with EMMA. The size of CSDH decreased in all patients on follow up.

Conclusion: In our small series with limited follow up, EMMA was found to be effective and safe in the management of CSDH with no peri-procedural complications and no evidence of recurrence on the treated side.

Keyword: Chronic subdural hematoma; Subdural hematoma; Middle Meningeal Artery; Embolization of middle meningeal artery (EMMA).

Introduction

Chronic subdural hematoma (CSDH) is the accumulation of liquified blood products in the space between the dura and the arachnoid. CSDH is a common pathology, particularly in the elderly population, with an incidence of 17.6/100000/year that has more than doubled in the past 25 years in parallel with an aging population [1]. CSDH has also been identified as a sentinel event leading to increased mortality particularly in younger age groups with a standardized mortality ratio of 17 in the 55 - 64 year old group [2]. Surgical treatment significantly decreases mortality even in the very elderly (age > 90) population [3]; however, rates of recurrence of 10.1%-29% are associated with poor outcomes [4-6].

Embolization of middle meningeal artery (EMMA) has rapidly gained in popularity as a novel treatment for CSDH and as a method to decrease rates of CSDH recurrence. Numerous case series have investigated its safety and

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efficacy as both an adjunctive and primary treatment [7-10]. Taken together, EMMA appears to significantly decrease rates of CSDH recurrence from 23.5% to 3.5% [11].

The purpose of our study is to report a single Canadian center experience of EMMA for the management of CSDH.

Methods

The study was approved by our institutional research ethics board (REB number-B2020:077). The consecutive patients undergoing EMMA during the period July 2020 to September 2021 at our tertiary care center were included in this series. EMMA procedures were performed on patients admitted to the neurosurgical service. All patients were followed both clinically as well as with imaging as per standard of care. Radiographic follow up was arranged at the discretion of the admitting neurosurgeon. Clinical follow up occurred virtually or in person in the outpatient clinic. Patient demographic, clinical and imaging data were collected from electronic medical records, paper charts and PACS.

MMA Embolization Procedure

EMMA was performed using polyvinyl alcohol (PVA) particles or liquid embolic agent (LEA) - Onyx 18 or Squid-18 or Squid-12, based on operator's preference. Patients treated with PVA were performed under sedation (Fentanyl/Midazolam) and those treated with liquid embolic agents were under general anesthesia. Common femoral artery access was obtained on the right side and a 5Fr standard sheath was placed. A 5Fr guide catheter was used to cannulate the common carotid artery (CCA) and external carotid artery (ECA) on the side of interest. After confirming the origin of the MMA from ECA and absent patent communication between branches of ECA and internal carotid artery (ICA), the guide catheter was placed in the main trunk of the ECA. A Prowler Select microcatheter was used to inject PVA. The microcatheter tip was positioned in the proximal aspect of MMA to inject PVA mixed with contrast under blank roadmap technique. The size of PVA used was 150-250 microns.

For LEA, a Marathon microcatheter was used to select the posterior and anterior division of MMA. For LEA injection, the microcather tip was positioned very distally in the MMA closer to the vertex. This helped better distal capillary level penetration of the LEA allowing for safe prolonged injection without a risk of embolizing dangerous collaterals with ICA or vertebral arteries. Sometime the anterior division of MMA was also filled retrogradely during injection in the posterior division. A separate microcatheter was used to catheterize the anterior division of the MMA if the anterior division continued to fill on control angiogram. LEA used were Onyx-18 and Squid-18. In one patient, Squid-12 was used, which was made available under special access program of Health Canada.

An EMMA grade 2 or 3 was considered successful EMMA [12]. Whole head angiograms were obtained before and after EMMA in both CCA and ECA to assess the EMMA grade. Hemostasis after sheath removal was obtained using vascular closure device or manual compression if vascular closure device was either not possible or failed. Any technical or clinical complications associated with EMMA or surgical drainage of CSDH were recorded.

Follow up

Imaging follow up was based upon CT or MRI of the head. Thickness of CSDH was measured on axial images at its maximum thickness. Same slice levels were used for follow up imaging measurement. Clinical follow up was part of the standard of care at 6 weeks from the time of surgery/ EMMA. Most patients had 3 months clinical follow up. The neurological status (in modified Rankin score) and size of the CSDH were documented at the last follow up available.

Statistical analysis

Descriptive statistics including mean, standard deviations, frequencies, proportions and 95% confidence intervals were calculated using GNU Octave.

Results

A total of 19 patients (mean age - 65.6 years; range- 14-85 yrs; Male - 16) underwent 20 EMMA procedures in the study period (table 1). One patient underwent EMMA for left CSDH and had to undergo another EMMA 2 months later for contralateral CSDH. For statistical purposes, the second EMMA for the patient is counted as a separate patient. Patients 13 and 20 in table 1 are the same patient that underwent EMMA on opposite sides in two different sessions. CSDH were on the left side in 10 patients, right side in 4 patients and bilateral in 5 patients. Hypertension was the most prevalent comorbidity, present in (n = 6/19, 32%) of the population (table 1). Antiplatelet agents were used by (n = 6/19, 32%) of patients with a single patient on dual antiplatelet therapy. Anticoagulation was used by (n = 3/19, 16%) of the study population. The most common presenting symptoms were headache (n = 10/19) followed by confusion (n = 9/19). One patient presented with no discernable symptoms and the CSDH was discovered incidentally. Localizing symptoms were present in (n = 10/19) patients and were most commonly contralateral weakness. CSDH had a mean initial size of 18.6 +/- 6.4 mm and were associated with middle line shift (MLS) of 8.9 +/- 4.9 mm.

Surgery was performed on 17 occasions in 16 patients. It took place under general anesthesia in (n = 13/17) patients and local anesthesia with sedation in (n = 4/17) patients. Subdural drains were employed in 16 out of these 17 patients. In (n = 9/17) cases, simple burr holes were performed while the remainder had mini-craniotomies. There were no immediate procedural complications noted.

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A total of 20 EMMA procedures were performed. EMMA was performed as the primary treatment of CSDH in 4 patients; however, EMMA was not possible in one patient due to an ophthalmic origin MMA. EMMA was used as an adjunctive treatment in 16 patients including one patient who was treated twice on opposite sides. Unilateral EMMA was performed in (n = 16/20) cases whereas (n = 3/20) underwent bilateral EMMA in the same sitting. In one patient with bilateral CSDH, EMMA was also performed on the contralateral side to surgical evacuation. General anesthesia was employed in (n = 12/20) cases while local with sedation was used in the remainder. Liquid embolic agent was used in (n = 12/20) cases and particles in (n = 7/20) cases. There were no immediate periprocedural or access related complications noted.

Post-surgical CT scans were performed in all cases and follow-up CT scans were performed in 17 cases. The maximum duration of radiological follow-up was 180 days. Following surgical evacuation, the mean CSDH size was 11.9 +/- 3.4 mm with a midline shift of 5.1 +/- 2.6 mm. An illustrative case demonstrating preoperative, procedural and follow-up imaging is shown in figure 1. CSDH decreased in size or remained unchanged in all patients within the follow-

Table 1: Demographic and clinical characteristics for patients with chronic subdural hematoma (CSDH) that underwent embolization of middle meningeal artery (EMMA).

Patient	Preop Size (mm)	Preop MLS (mm)	Postop Size (mm)	Postop MLS (mm)	Size at last followup (mm)	Discharge Disposition
1	20	6	7	0	2	Transfer
2	33	13	10	6	3	Home
3	14	2			2	Home
4	16	5		4	5	Home
5	L 14 R 12		R 12 L 10		R 6 L 8	Transfer
6	R 25 L 13	7	R 13 L 8	0	R 3 L 1	Home
7	15	3	12	6	2	Home
8	24	9	11	6	4	Transfer
9	30	17	9	6	8	Home
10	20	9	16	5	8	Home
11	19	14	10	8	5	Home
12	17	7			18	Home
13	L 12 R 10		L 10 R 11	7	2	Home
14	19	18	15	7	7	Home
15	26	9	9	6	9	Transfer
16	14					Home
17	R 12 L 11				R 11 L 10	Transfer
18	15	10				Transfer
19	9	4	20		1	Home
20	14	5	10	3		Inpatient

HTN – hypertension; PVD – peripheral vascular disease; DM – diabetes mellitus; CAD – coronary artery disease; R- Right; L- Left.

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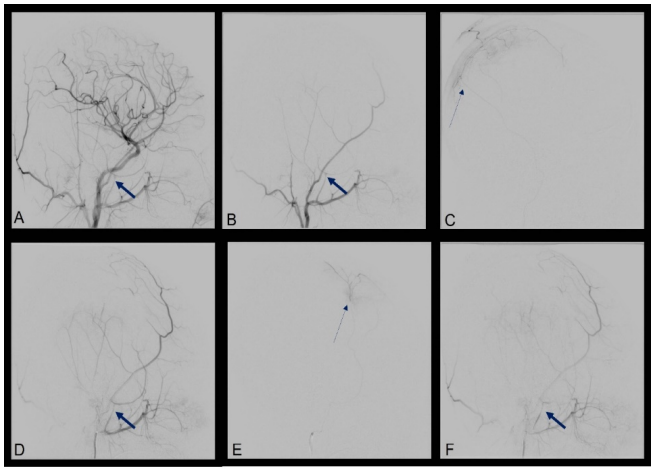

Figure 1: Embolization of middle meningeal artery (EMMA). Lateral angiogram of (A) left common carotid artery (B) left external carotid artery showing middle meningeal artery (small arrow). (C) Microcatheter angiogram in the posterior division (long arrow) of the middle meningeal artery. (D) Post EMMA in the posterior division shows the common trunk of middle meningeal artery (short arrow) with persistent filling of the anterior division. (E) Microcatheter angiogram in the anterior division (long arrow) of the middle meningeal artery. (F) Post EMMA in both posterior and anterior divisions shows the proximal common trunk of middle meningeal artery (short arrow) with no filling of the distal art

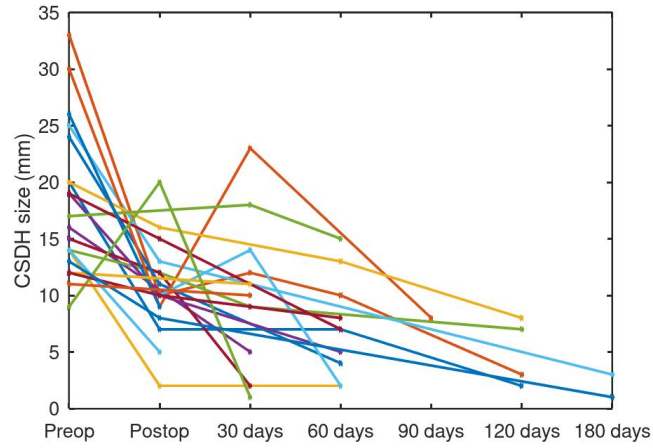

Figure 2: Temporal course of size of chronic subdural hematoma post EMMA. Each line represents a single patient and include all available follow-up data. Follow up duration is presented in days on the x-axis and size in mm on the y-axis.

up period. No patients had recurrence of CSDH on the treated side. The temporal trend in SDH size across all patients is shown in figure 2.

Discussion

To best of our knowledge this is the first Canadian case series on EMMA for treatment of CSDH. In our series of 19 patients undergoing 20 EMMAs, none of the patients had any clinical or technical complications. At the time of last follow up available, none of these patients had recurrence of the CSDH on the treated side. Our data demonstrates a strong predilection for left sided CSDH. The disproportionate incidence of left sided CSDH has previously been noted in multiple studies across diverse populations [13,14]. A number of theories have been proposed to explain the apparently discrepancy. As previously demonstrated, stroke and transient ischemic attacks (TIAs) are more prevalent on the left side at rates parallel to that which they are observed in stroke populations [15]. In a large stroke and TIA population, the incidence of left sided stroke and TIA (57.8% left side) was significantly higher than the rate of left sided MRI evident infarcts (51.9% left side) [16]. The left hemisphere is dominant in the majority of the population and presenting symptoms including dysphasia and confusion (which may be mistaken for expressive/receptive speech impairment) is a frequent presenting complaint. In contrast, non-dominant symptoms including hemineglect, coordination impairment and spatial orientation disturbance are more subtle symptoms that may be missed on examination or not recognized as easily by patients, family and care givers. Together, this suggests that right sided CSDH are likely underrepresented due to better recognition of left sided symptoms rather than a true predilection for left sided hematomas. An alternative theory suggests that CSDH may lateralize based on cranial asymmetry and in particular, left sided hematoma may be more prevalent in patients with increased cranial asymmetry [17,18].

Embolic agents used in this series include particulates (PVA) and LEA (Onyx, Squid). No studies have directly compared the recurrence rates of CSDH associated with EMMA done using particulate vs LEA. A small series suggests similar outcomes with either treatment [19]. Particulate embolization is thought to occlude vessels more proximally as compared to LEA which penetrate and fill distal branches. The implications of this difference in terms of recurrence rates and safety have yet to be resolved. The LEAs have the advantage of being visible once injected and observed to fill and devascularize distal vessels. In addition, the injection rate can be titrated to control forward flow, fill collateral pathways and avoid reflux. The very low expected rate of recurrence of 3.5% and small size of this series prevents any analysis of relation of recurrence to embolic agent in this study [11].

A mixture of conscious sedation and general anesthesia were used to facilitate EMMA. Confusion and delirium, which are frequently associated CSDH, limited our ability to perform this procedure under local and sedation in some patients. In addition, pain associated with injection of dimethyl sulfoxide (DMSO), solvent for LEAs necessitated general anesthesia

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for all cases in which we used them. A recent case series demonstrated feasibility of local and sedation in an elderly population undergoing EMMA via a transradial approach in which intraarterial lidocaine was used for analgesia [10]. To the best of our knowledge, local and sedation vs general anesthesia has not been investigated in the context of EMMA. Within the ischemic stroke population undergoing endovascular thrombectomy, a recent metaanalysis including only RCTs suggested that GA was superior to sedation for both functional outcome and recanalization rates [20]. This is in contrast to previous data suggesting worse outcomes with GA [21]. Extrapolating from stroke data may not be relevant given the lack of a time sensitive outcome (eg. Recanalization) and significant procedural differences. Optimal anesthesia for EMMA will need to investigated in the context of randomized trials to avoid selection bias (eg. GA provided to sicker patients).

Clinical trials involving EMMA for CSDH are currently enrolling patients [22-24] and aim to demonstrate the efficacy and safety of EMMA. As discussed, issues such as choice of embolic agent, anesthesia, recurrence patients, and optimal patient selection are issues to be investigated in upcoming trials.

Limitation

Our study has limitation of a small retrospective study. However, we report consecutive patients treated with EMMA in our institution. Our patient selection is biased based on the choice of the treating physicians. No randomization was done. The clinical and radiographic follow up is limited and is not available for all patients. Despite these limitations, our study demonstrates safety and efficacy of EMMA for management of CSDH in Canadian health care system.

Conclusion

In our small series with limited follow up, EMMA was found to be effective and safe in the management of CSDH with no peri-procedural complications and no evidence of recurrence on the treated side.

Statement of authorship

JD- collected data and wrote the first draft of the manuscript; JM- helped in data collection and reviewed the final manuscript; ZK- helped in data collection and reviewed the final manuscript; JS- helped in data collection and reviewed the final manuscript; JS- conceptualized the study, collected data, wrote the first draft and finalized the manuscript.

Disclosures

No financial disclosures or conflicts of interest to declare except Dr Jai Shankar is the principal investigator of EMMA-Can study in Canada.

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