



Original Article

Transradial versus transfemoral access for middle meningeal artery embolization: Choice of the access route considering delirium in the elderly

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ABSTRACT

Background: Treatment of chronic subdural hematoma (CSDH) with middle meningeal artery embolization (MMAE) is becoming well established. Transradial artery access (TRA) is considered less invasive than transfemoral artery access (TFA) and is increasingly indicated in the field of endovascular therapy. Therefore, this study focused on postoperative delirium and compared access routes.

Methods: This is a single-center and retrospective study. The strategy was to perform MMAE for CSDH with symptomatic recurrence at our hospital. Cases from July 2018 to September 2022, when MMAE was introduced in our hospital, were included in this study. Patients were divided into TRA and TFA groups and were compared descriptively for patient background, procedure duration, and incidence of postoperative delirium.

Results: Twenty-five patients underwent MMAE, of whom 12 (48%) were treated with TRA. The overall median age was 82 years, with no clear differences between the TRA and TFA groups in the presence or absence of pre-existing dementia or antithrombotic therapy. Delirium requiring medication tended to be lower in the TRA group: 2/12 (16.7%) in the TRA group versus 6/13 (46.2%) in the TFA group, and the mean procedure time for patients undergoing bilateral MMAE was 151 min (interquartile range [IQR]: 140–173 min) in the TRA group versus 174 min (IQR: 137–205 min) in the TFA group.

Conclusion: TRA was associated with an overall shorter procedure time than TFA. MMAE through TRA tended to have a lower incidence of delirium. MMAE through TRA may be useful in recurrent CSDH with a high elderly population.

Keywords: Chronic subdural hematoma, Middle meningeal artery embolization, Transradial access

INTRODUCTION

Chronic subdural hematoma (CSDH) is a common condition following head trauma, with an estimated incidence of 1.7–20.6/100,000 persons per year.^[5] The average age of CSDH patients is increasing each year, and there are many factors to consider in the management of CSDH in the elderly, including postoperative delirium and frailty.^[10] We believe that the prevention of these factors will be necessary in the future. In particular, the occurrence of delirium may affect outcomes such as the progression of dementia and inhibition of activities of daily living (ADL).

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One treatment that has recently been reported to be effective is middle meningeal artery embolization (MMAE);^[12] burr hole surgery is commonly used to treat CSDH, but this treatment has a high recurrence rate of 10–20%,^[4] which has focused attention on MMAE as an additional or alternative treatment. Knowledge of the efficacy of MMAE has been accumulating, and reports of its efficacy have been increasing in recent years. However, most of them are performed through transfemoral access (TFA)^[12,17] which is not easy for patients due to the risk of fatal puncture site complications and the need for postoperative bed rest.

Transradial access (TRA) is widely used in cardiac catheterization and is becoming increasingly common in neuro interventional procedures. TRA has the advantage of a low risk of puncture site complications, is unlikely to cause major complications, and reduces postoperative bed rest.^[3,19] Although cases of MMAE through TRA have been reported,^[1] the outcomes have not been adequately compared with TFA, and the advantages of using TRA have not been discussed. Unlike TFA, TRA did not require postoperative bed rest and may be more effective in MMAE, which is often treated in elderly patients, by reducing the burden on the patient and allowing the same level of activity as before surgery.

We hypothesized that the minimally invasive nature of MMAE through TRA, shorter procedure time, and immediate postoperative bed release would be associated with a lower incidence of postoperative delirium in CSDH patients. The purpose of this study was to compare the treatment content and efficacy of MMAE through TRA and TFA and to determine whether TRA is associated with a lower incidence of postoperative delirium. We also reported on current practices and innovations in MMAE through TRA.

MATERIALS AND METHODS

Study design and participants

This was a single-center retrospective cohort study. This study included all cases of recurrent CSDH at our hospital from July 2018, when treatment with MMAE was initiated, to September 2022; from July 2018 to December 2020, patients were treated with TFA (TFA group); and from January 2021 to September 2022, patients were treated with TRA (TRA group). There were no criteria for assigning cases to the TRA or TFA groups in this study. Recurrent CSDH is defined as a recurrence on the operative side of a patient who underwent burr-hole irrigation at the time of initial treatment and became symptomatic due to the re-growth of the hematoma.

Treatment strategy

MMAE was performed in combination with a burr hole or small craniotomy to remove the hematoma and

was performed under local and intravenous anesthesia (pentazocine for analgesia, continuous dexmedetomidine hydrochloride for sedation, and hydroxyzine or diazepam hydrochloride for sedation). Hematoma removal for recurrent CSDH was basically performed on the same day as MMAE or within 5 days before or after. Hematoma removal was performed in the operating room, and MMAE was performed in the angiography room. One of the three or four neurosurgery residents at our hospital performed MMAE as an operator under the supervision of the same endovascular surgeon, with a varied operator for each case. For TFA, a 6Fr FUBUKI HARD MP (Asahi Intecc Co., Ltd., Aichi, Japan) was used as the guiding catheter; for TRA, a right flexor artery puncture was performed, with echo-guided puncture in case of difficult puncture. The guiding system was 6Fr Cerulean DD6 (Medikit Co., Ltd., Tokyo, Japan) with 6Fr sheath, 6Fr Slim Guide Flex (Medikit Co., Ltd., Tokyo, Japan) with 6Fr sheath, and 5Fr Axcelguide Stiff-J (Medikit Co., Ltd., Tokyo, Japan). In particular, many of the 2022 cases used a 5Fr Axcelguide, which provides stable support regardless of the type of aortic arch. Final device selection was at the surgeon's discretion. As mentioned above, the guiding system differs between TFA and TRA, but the procedures after guiding catheter placement were generally the same.

The embolization procedure was identical in the TFA and TRA groups. The reasons for the choice of embolic material are summarized in Supplementary File 1. The microcatheter was guided to the anterior branch of the MMA and embolized with a coil if a dangerous anastomosis with the ophthalmic artery was observed, then the microcatheter was guided to the distal branch, and Embosphere diluted $\times 40$ with contrast agent was injected to reduce blood flow in the MMA. After the injection of the Embosphere to reduce blood flow in the MMA, the entire MMA was occluded with a c-stopper coil.

In the early cases when MMAE treatment was initiated, MMAE was performed only on the affected side. However, because we experienced a case in the TFA group in which the hematoma was thought to have recurred due to the development of the contralateral MMA after MMAE, MMAE was subsequently performed bilaterally whenever possible. In the TRA group, bilateral MMAE was attempted in all patients. TFA had a postoperative rest period of 6 h based on the previous study,^[15] while TRA did not have a postoperative rest period because of the TR band.^[2]

Data collection, outcome, and statistical analysis

Clinical data (age, sex, history of hypertension, diabetes, or dementia, anticoagulant or antiplatelet medication, vessel course, puncture vessel, devices used, procedure time, postoperative delirium, hematoma size, discharge outcome, and repeat treatment) were retrospectively extracted from

the electronic medical record. For each variable, categorical variables are presented as numbers and percentages, and continuous variables are presented as medians and interquartile ranges (IQRs).

The primary outcome of the study was the presence of postoperative delirium, and the secondary outcomes were duration of surgery, modified Rankin scale (mRS) at discharge, and symptomatic recurrence. Delirium was assessed according to the confusion assessment method,^[7] defined as a mental state that could not be controlled by attendant care or use of sleep medications and required the use of delirium control medications not used before MMAE and was determined by two neurosurgeons (YM and GF) through detailed electronic chart review. Procedure time was defined as from arterial puncture to hemostasis with angioseal or manual compression. An mRS of 0–2 was then defined as a good outcome and 3–6 as a poor outcome.^[20] Descriptive statistics were compared between the TRA group and the TFA group for each parameter, particularly the incidence of postoperative delirium and the duration of surgery.

Categorical variables were compared using the Chi-square test, and continuous variables were compared using the Mann–Whitney U-test. All statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan),^[14] which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria, version 4.3.2). More precisely, it is a modified version of R commander (version 4.2.1) designed to add statistical functions frequently used in biostatistics.

RESULTS

Patient characteristics and procedure details

All patients who met the criteria for MMAE during this period were treated with MMAE. No cases of recurrent CSDH declined MMAE. Twenty-five patients underwent MMAE, 12 (48%) by TRA and 13 (52%) by TFA. In addition, although only one side was treated in the initial period of TFA after the fifth patient had a hematoma recurrence from the contralateral blood flow, it was decided to treat both sides as much as possible. Initially, all cases were performed MMAE through TFA, but after January 2021, the technique was standardized, and all cases were performed MMAE through TRA because bilateral MMAE was started to be performed and the procedure time was prolonged in some cases, such as type 3 aortic arch and bovine arch. Eleven patients (44%) in the TRA group and 8 patients (32%) in the TFA group were treated bilaterally. The background of each patient is shown in Table 1. The median age of all patients was 82 years, and 22 (88%) were male. Treatment details in the TRA group are shown in Table 2. Eight patients (66.7%) were treated with 5 Fr Axcelguide Stiff-J. X-ray images of each guidewire placed in the common carotid artery are shown in Figure 1.

Outcome and complications

The presence of postoperative delirium, procedure time, outcome at discharge, and recurrence are shown in Table 3. Postoperative delirium occurred in 2 patients (16.7%) in the TRA group, including 1 patient with dementia, and in 6 patients (46.2%) in the TFA group, including 2 patients with dementia. The median procedure time for bilateral

Table 1: Patient characteristics and clinical data

	Total N=25	TRA N=12	TFA N=13	p-value
Sex, (male), n, (%)	22 (88)	11 (91.6)	11 (84.6)	1.000
Age, median, (IQR)	82 (76-88)	84 (80-91)	78 (75-85)	0.134
Medical history				
Hypertension, n, (%)	16 (64)	7 (58.3)	9 (69.2)	0.880
Diabetes, n, (%)	4 (16)	1 (8.3)	3 (23.1)	0.647
Dementia, n, (%)	6 (24)	3 (25)	3 (23.1)	1.000
Antithrombotic drug, n, (%)	7 (28)	4 (33.3)	3 (23.1)	1.000
mRS at arrival				1.000
2, n, (%)	0 (0)	0 (0)	0 (0)	
3, n, (%)	25 (100)	12 (100)	13 (100)	
Hematoma side				0.053
Right, n, (%)	8 (32)	4 (33.3)	4 (30.8)	
Left, n, (%)	13 (52)	4 (33.3)	9 (69.2)	
Bilateral, n, (%)	4 (16)	4 (33.3)	0 (0)	
Aortic arch type				0.136
Type 1, n, (%)	4 (16)	0 (0)	4 (30.8)	
Type 2, n, (%)	7 (28)	4 (33.3)	3 (23.1)	
Type 3, n, (%)	7 (28)	3 (25)	4 (30.8)	
Bovine, n, (%)	7 (28)	5 (45.5)	2 (15.4)	

TRA: Transradial, TFA: Transfemoral, IQR: Interquartile range, mRS: Modified Rankin Scale

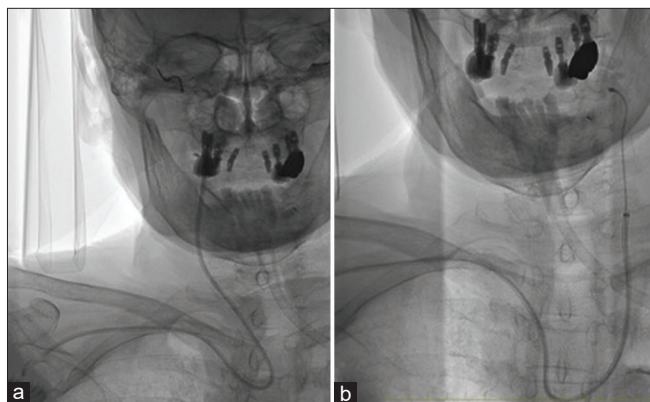


Figure 1: (a) Radiograph, 5Fr Axcelguide stiff-J navigated to the right common carotid artery (CCA). (b) Radiograph, 5Fr Axcelguide stiff-J navigated to left CCA.

MMAE was 151 min (IQR: 140–173) in the TRA group and 174 min (IQR: 137–205) in the TFA group [Figure 2]. For mRS, five patients in the TRA group and six patients in the TFA group had a good outcome ($mRS \leq 2$), with no apparent difference between the two groups. Symptomatic hematoma recurrence requiring therapeutic intervention after MMAE was observed in one case each in the TRA and TFA groups. The one case of recurrence in the TFA group occurred approximately 3 months after the initial MMAE, and both sides were again treated with MMAE as described above. The one case of recurrence in the TRA group occurred about 3 weeks after MMAE and was confirmed with hematoma removal by small craniotomy with duraplasty. There were no adverse events such as neurological disorders including visual dysfunction caused by the embolized material. In

Table 2: TRA group procedure detail

No.	Age	Sex	Type of aorta	Treatment	Time (min)	Guiding system	Micro catheter	Materials for embolization
1	83	M	Bovine	Bilateral	153	6Fr Cerulean DD6	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
2	93	M	Type3	Unilateral	177	5Fr Axcelguide stiff-J	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
3	67	M	Bovine	Bilateral	143	6Fr Cerulean DD6	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
4	91	M	Bovine	Bilateral	137	6Fr Cerulean DD6	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
5	79	M	Type2	Bilateral	186	5Fr Axcelguide stiff-J	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
6	99	M	Type2	Bilateral	164	5Fr Axcelguide stiff-J	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
7	70	M	Type3	Bilateral	177	5Fr Axcelguide stiff-J	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
8	91	M	Type3	Bilateral	149	6Fr Slimguide Flex	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
9	85	M	Type2	Bilateral	151	5Fr Axcelguide stiff-J	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
10	83	M	Type2	Bilateral	140	5Fr Axcelguide stiff-J	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
11	82	F	Bovine	Bilateral	173	5Fr Axcelguide stiff-J	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil
12	85	M	Bovine	Bilateral	134	5Fr Axcelguide stiff-J	1.7-2.9Fr Breakthrough	Embosphere 300-500µm C-stopper coil

TRA: Transradial

the TRA group, two patients were complicated by radial artery occlusion, which did not cause any dysfunction or require additional treatment. Each outcome was statistically evaluated, but no clear differences were shown.

DISCUSSION

Key observation

In this study, the TRA group tended to have a lower incidence of postoperative delirium requiring medication despite a higher median age. The TRA group also had a shorter median and narrower IQR for surgical procedure time compared to the TFA group. According to the results, MMAE through TRA may be beneficial in the preventive treatment of recurrent CSDH in the elderly population.

Interpretation and clinical implication

The lower incidence of postoperative delirium in the TRA group could be attributed to two factors. First, TRA does

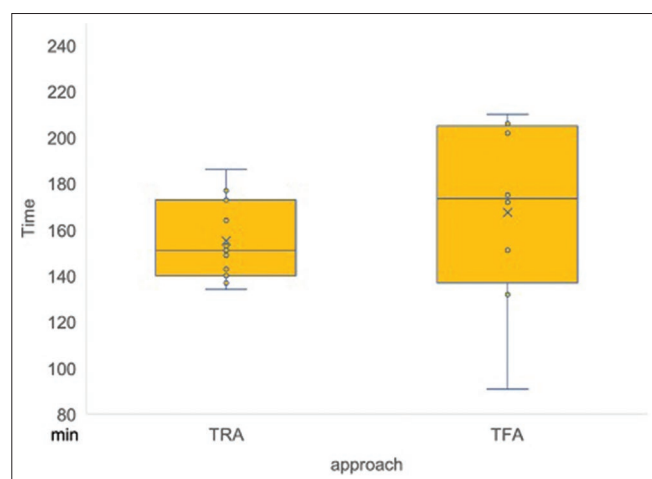


Figure 2: Procedure time for each group. TRA: Transradial. TFA: Transfemoral.

not require postoperative bed rest.^[19] Rapid mobilization in surgical procedures contributes to reduced delirium.^[16] The most obvious difference between the TRA and TFA groups was postoperative rest time, which may have influenced the incidence of postoperative delirium. In endovascular treatment, previous literature reported that there was no clear difference in the incidence of postoperative delirium between the TFA group, which required postoperative bed rest, and the TRA group, which promoted early mobilization for acute myocardial infarction patients aged 70 years and older.^[13] However, compared to the treatment of myocardial infarction, MMAE for CSDH is a prophylactic treatment, and the patient's general condition is very different, so differences in postoperative rest may alter the incidence of delirium. Second, the procedure time was shortened in the TRA group. Some literature showed that switching from TFA to TRA shortened procedure time in some cases with severe vessel tortuosity, including type 3 aortic arch and bovine arch.^[19,21] Although this study did not perform multivariate analysis adjusting for confounding factors, the background factors were similar. In particular, the large number of elderly patients, many of whom had severe vessel tortuosity,^[23] may have contributed to the shorter procedure time for TRA compared with TFA. Shorter procedure times lead to shorter anesthesia times, which, in turn, lead to less invasive treatment. Because prolonged anesthesia time is a risk factor for postoperative delirium,^[25] it was hypothesized that the risk of delirium would be reduced by shortening the procedure time.

Procedural strategy

In this study, the techniques and devices were reviewed and re-examined with feedback from previous experience in each case. The TRA group refined the technique by changing the guiding system, as shown in Table 2. It was found that seamless treatment was possible using a Simmons type catheter such as the Stiff J. The Stiff J is easy to guide regardless of whether the aortic arch is bovine or type 1–3,

Table 3: Treatment and patient outcomes

	Total N=25	TRA N=12	TFA N=13	p-value
Treatment				0.019
One sided, n, (%)	9 (36)	1 (8.3)	8 (61.5)	
Bilateral, n, (%)	16 (64)	11 (91.6)	5 (38.5)	
Time ^{*1} , median min,(IQR)		151 (140-173)	174 (137-205)	0.098
Delirium, n, (%)	8 (32)	2 (16.7)	6 (46.2)	0.250
Without dementia patient ^{**2} , (%)	5 (25)	1 (10)	4 (40)	0.301
mRS at discharge				1.000
2, n, (%)	11 (44)	5 (41.7)	6 (46.2)	
3, n, (%)	14 (56)	7 (58.3)	7 (53.8)	
Recurrence, n, (%)	2 (8)	1 (8.3)	1 (7.7)	1.000

TRA: Transradial, TFA: Transfemoral, IQR: Interquartile range, mRS: Modified Rankin Scale. The TRA group was excluded two patients. The Transfemoral TFA group was excluded three patients.

which may explain why there was less variation in procedure time from case to case in the TRA group. Therefore, as in previous studies,^[6] the Stiff J is an option for many cases of TRA. The above-mentioned procedural strategy was used to treat the patients, and only one case of MMAE by TRA was treated unilaterally due to difficulty in guiding the device, but all other cases were successfully treated bilaterally.

Implications of this study in light of previous literature

Studies of MMAE have been conducted repeatedly in the past, with some reports of MMAE through TRA.^[17] Although it has been evaluated as a useful treatment for hematoma reduction and recurrence prevention^[18,22,24] and as a relatively less invasive treatment for patients,^[12] no study was found that mentions postoperative delirium in patients after treatment. Approximately one-third of patients with CSDH have persistent psychiatric symptoms and decreased ADL after surgery.^[11] These psychiatric symptoms include postoperative delirium, and postoperative delirium in patients with CSDH often results in prolonged hospitalization.^[10] Since prolonged hospital stay has also been reported to correlate with functional decline during hospitalization,^[9] preventing postoperative delirium with MMAE, in addition to preventing hematoma recurrence, may be important for improving patients' ADL, especially in CSDH, which has a large proportion of elderly patients. Prospective studies such as the EMBOLISE clinical trial and the MEMBRANE trial^[8] are currently underway to evaluate whether MMAE can reduce CSDH recurrence, which may lead to the standardization of MMAE in the treatment of CSDH.

Limitation

At first, the present study has some limitations, including a small sample size, poor statistical power, and the presence of selection bias due to the lack of randomization. Second, this was a before-and-after comparative study, and a possible bias could be that the procedure time may have been reduced due to the improvement in the surgeon or refinement of the treatment procedure. Since the endovascular surgeon who supervised the neurosurgery residents was the same throughout all cases, it is possible that the embolization technique and device selection, in particular, were refined, leading to a reduction of procedure time in the TRA group. Third, the results of this study may not be applicable to different countries and regions. Different countries have different degrees of aging and different devices that can be used. Taking these factors into account, the appropriate choice of treatment may vary from region to region.

CONCLUSION

The study compared TRA with TFA and suggested that the incidence of postoperative delirium tends to be lower in the

TRA group. In a society with an aging patient population, MMAE through TRA may become the standard of care in the prevention of the recurrence of CSDH in elderly patients. Accumulation of more cases would be desirable in the future to show an association with favorable treatment outcomes.

Ethical approval

The research/study approved by the Institutional Review Board at Saiseikai Shiga Hospital, Imperial Gift Foundation Inc., number 546, dated April 01, 2023.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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