

INPLASY

Middle Meningeal Artery Embolization for Chronic Subdural Hematoma: An Updated Systematic Review and Meta-Analysis of Randomized Controlled Trials

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Sun, Y; Tracz, J; Hamo, M; Liptrap, E; Harrigan, M.

Corresponding author:

Mark Harrigan

mharrigan@uabmc.edu

Author Affiliation:

The University of Alabama at Birmingham, Department of Neurosurgery.

ADMINISTRATIVE INFORMATION

Support - N/A.

Review Stage at time of this submission - Piloting of the study selection process.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY202670103

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 26 July 2026 and was last updated on 26 July 2026.

INTRODUCTION

Review question / Objective

Aim 1. To determine if middle meningeal artery embolization (MMAE) is an effective treatment for chronic or nonacute subdural hematomas (cSDH).

Aim 2. To determine if the efficacy of MMAE varies across embolic agents

Patients: Adult patients undergoing MMAE for cSDH

Comparator: Standard of care

Outcomes: Treatment failure

Rationale Chronic subdural hematoma is one of the most common neurosurgical conditions, particularly among older adults, and is associated with substantial morbidity, recurrence, repeat hospitalization, and need for reoperation. Standard management includes surgical evacuation or conservative observation depending on symptoms, hematoma size, and patient comorbidities; however, recurrence remains a major limitation of

current treatment paradigms. Middle meningeal artery embolization (MMAE) has emerged as a minimally invasive strategy targeting the vascularized dural membranes thought to drive hematoma persistence and recurrence. Recently, several randomized controlled trials, including EMBOLISE, STEM, MAGIC-MT, EMPROTECT, and the newly reported MEMBRANE trial have evaluated MMAE as an adjunct to surgery or standard-of-care management. However, these trials vary in patient selection, embolic agent, timing relative to surgery, comparator group, and outcome definitions, making the overall clinical benefit and safety profile difficult to interpret. Thus, we sought to perform a systematic review and meta-analysis of RCTs evaluating MMAE for chronic subdural hematoma. In doing so, we hope to better quantify the effect of MMAE on recurrence, reoperation or surgical rescue, functional outcomes, complications, and mortality, and to clarify how this therapy should be integrated into contemporary cSDH management.

Condition being studied The utility of MMAE for cSDH is not well established. cSDH is a common subdural hematoma (1.5-3 cases per 100,000) with a heterogeneous presentation. Recovery varies across patients and definitive treatment methods are unproven.

METHODS

Search strategy

Pubmed/Medline

```
(
"Hematoma, Subdural, Chronic"[Mesh]
OR "chronic subdural hematoma"[tiab]
OR "chronic subdural haematoma"[tiab]
OR "chronic subdural hemorrhage"[tiab]
OR "chronic subdural haemorrhage"[tiab]
OR "recurrent subdural hematoma"[tiab]
OR "recurrent subdural haematoma"[tiab]
OR cSDH[tiab]
)
AND
(
"Embolization, Therapeutic"[Mesh]
OR "Meningeal Arteries"[Mesh]
OR "middle meningeal artery embolization"[tiab]
OR "middle meningeal artery embolisation"[tiab]
OR "middle meningeal embolization"[tiab]
OR "middle meningeal embolisation"[tiab]
OR "MMA embolization"[tiab]
OR "MMA embolisation"[tiab]
OR MMAE[tiab]
)
AND
(
randomized controlled trial[pt]
OR controlled clinical trial[pt]
OR clinical trial[pt]
OR random*[tiab]
OR trial[tiab]
OR placebo[tiab]
OR "standard care"[tiab]
OR "usual care"[tiab]
OR EMBOLISE[tiab]
OR STEM[tiab]
OR MAGIC-MT[tiab]
OR "MAGIC MT"[tiab]
OR EMPROTECT[tiab]
OR MEMBRANE[tiab]
)
NOT
(
animals[mh] NOT humans[mh]
)
Embase
(
'chronic subdural hematoma'/exp
OR 'chronic subdural hematoma':ti,ab,kw
```

```
OR 'chronic subdural haematoma':ti,ab,kw
OR csdh:ti,ab,kw
)
AND
(
'middle meningeal artery embolization':ti,ab,kw
OR 'middle meningeal artery embolisation':ti,ab,kw
OR 'middle meningeal embolization':ti,ab,kw
OR 'middle meningeal embolisation':ti,ab,kw
OR 'MMA embolization':ti,ab,kw
OR 'MMA embolisation':ti,ab,kw
OR MMAE:ti,ab,kw
)
AND
(
'randomized controlled trial'/exp
OR random*:ti,ab,kw
OR trial:ti,ab,kw
OR EMBOLISE:ti,ab,kw
OR STEM:ti,ab,kw
OR 'MAGIC-MT':ti,ab,kw
OR 'MAGIC MT':ti,ab,kw
OR EMPROTECT:ti,ab,kw
OR MEMBRANE:ti,ab,kw
)
NOT
(
'animal'/exp NOT 'human'/exp
)
Scopus
TITLE-ABS-KEY(
(
"chronic subdural hematoma"
OR "chronic subdural haematoma"
OR cSDH
)
)
AND
(
"middle meningeal artery embolization"
OR "middle meningeal artery embolisation"
OR "middle meningeal embolization"
OR "middle meningeal embolisation"
OR "MMA embolization"
OR "MMA embolisation"
OR MMAE
)
)
AND
(
random*
OR trial
OR "randomized controlled trial"
OR "randomised controlled trial"
OR EMBOLISE
OR STEM
OR "MAGIC-MT"
OR "MAGIC MT"
OR EMPROTECT
OR MEMBRANE
```

)
)

Google Scholar

"chronic subdural hematoma" "middle meningeal artery embolization" randomized OR trial

Participant or population

Adult patients undergoing MMAE for cSDH

Intervention

MMA embolization

Comparator

Standard of care

Study designs to be included

Randomized Controlled Trials

Eligibility criteria

Exclusion: Non-randomized clinical and observational studies, case series, case reports, brief reports, pilot reports, opinion pieces, theses, conference proceedings, letters and commentaries, editorials, meta-analysis and reviews, surgical technique papers, abstracts, conference proceedings, and non-English language articles without available translations.

Information sources

Medline, Embase, Scopus, Google Scholar

Main outcome(s)

Hematoma recurrence or progression
Residual/reaccumulated hematoma
Need for repeat surgery or surgical rescue
Assessed according to each individual trial definition
Repeat surgery / surgical rescue
Radiographic recurrence or progression
Residual hematoma thickness or residual cSDH >10 mm
Functional outcome (modified Rankin Scale, mRS)
Neurological deterioration
All-cause mortality
Serious adverse events
Procedure-related complications
Major disabling stroke
Myocardial infarction
Hospital length of stay
Hospital readmission
Health-related quality of life (e.g., EQ-5D when reported)

Additional outcome(s)

N/A

Data management

Data will be managed via Covidence Software and with a predetermined excel form.

Selection Process:

Two independent reviewers will screen articles for relevance first based on titles and abstracts, and then will assess full-text articles for eligibility. Disagreements between reviewers will be resolved in both phases of selection by consensus or by a third reviewer.

Data Collection Process:

Each selected study will be distributed to two individuals for data extraction in duplicate using a pre-determined excel database with the selected variables. We do not anticipate any need to contact the authors of the selected studies to obtain patient level data.

Data items for extraction

- Author information
- Year of publication
- Effect size
- Upper limit of Confidence Interval
- Lower limit of Confidence Interval
- Study Size (number of patients in each treatment arm)
- Incidence rates in each treatment arm
- Standard Error
- Demographic and Patient enrollment characteristics

Metadata

- Journal name where study was published
- Year of publication
- Analysis approach: intention-to-treat vs per-protocol
- Adherence to CONSORT
- Potential sources of Bias

Quality assessment / Risk of bias analysis

Risk of bias will be assessed at the study level:

- The Risk of Bias in randomized trials (RoB 2) tool will be utilized
- Competing interest in studies will be noted
- Studies will be assessed on quality based on adherence to CONSORT guidelines
- A funnel plot using Egger tests will be used to assess publication bias
- We will also use the Grading of Recommendations Assessment, Development, and Evaluation (GRADE)

Strategy of data synthesis

Due to predicted variability in patient selection among the studies, we will utilize a random effects model with restricted maximum-likelihood estimation for the meta-analysis and data

synthesis. Study heterogeneity will be assessed using the inconsistency index (I^2).

Subgroup analysis

- Definition of primary outcome
- Follow-up duration
- Embolic Agent
- Control Arm

Sensitivity analysis

Sensitivity analysis will be conducted via the leave one-out-method. Publication bias will be assessed using the Egger test and visually assessed using funnel plots. Additionally, statistical heterogeneity and magnitude of heterogeneity will be assessed utilizing the Cochran χ^2 tests and the I^2 statistic. Statistical analyses will be performed using R studio (version 4.3.1). Alpha shall be set at 0.05 and all tests for significance will be 2-sided.

Language restriction

Non-English language publications without translation

Country(ies) involved

United States

Keywords

MMA embolization, chronic Subdural

Dissemination plans

Publication in peer-reviewed journal

Contributions of each author

Author 1 – Yifei Sun BS - Study design, data analysis, guarantors of review, statistical analysis, data extraction, manuscript writing and review

Email: ysun3@uab.edu

Affiliation: Heersink School of Medicine, University of Alabama at Birmingham

Author 2 – Jovanna Tracz, MD Study design, data analysis, guarantors of review, statistical analysis, data extraction, manuscript writing and review

Email: jatracz@uabmc.edu

Affiliation: Department of Neurosurgery, University of Alabama at Birmingham

Author 3 – Mohammad Hamo, BA - Study design, data analysis, guarantors of review, statistical analysis, data extraction, manuscript writing and review

Email: mahamo@uab.edu

Affiliation: Heersink School of Medicine, University of Alabama at Birmingham

Author 4 – Elizabeth Liptrap MD - Study design, study supervision, guarantors of review, statistical analysis, data extraction, manuscript writing and review

Email: elizabethle@uabmc.edu

Affiliation: Department of Neurosurgery, University of Alabama at Birmingham

Author 5 – Mark Harrigan MD - Study design, study supervision, guarantors of review, statistical analysis, data extraction, manuscript writing and review

Email: mharrigan@uabmc.edu

Affiliation: Department of Neurosurgery, University of Alabama at Birmingham