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ABSTRACT

Background: Embolization of the middle meningeal artery (MMA) is a non-invasive procedure that is used as an alternative to surgical drainage in the treatment of subdural hematoma. The aim of our study is to represent the top-cited articles discussing the embolization of the MMA in treating chronic subdural hematoma (cSDH).

Methods: Scopus database was used in June 2022 to search for the top 50 cited articles related to the embolization of the MMA in cSDH. Articles were assessed using bibliometric parameters, H-indices, impact factor, number of citations per article, and article type. The data was statically analyzed by using SPSS 23 along with Microsoft Excel.

Results: Among the top 50 cited articles, the highest citation was 95 (article entitled "Middle meningeal artery embolization for chronic subdural hematoma"). The most productive year was 2020 with 13 articles, followed by 2021 with 11 articles. The United States of America (USA) contributed to 24 articles with 9 neurosurgical institutes. Most articles were case reports and case series (48%).

Conclusion: This study collected the top 50 cited articles about embolization of the MMA in cSDH which can be used as a resource for clinicians in their practice and helps them to find the gap in the knowledge about this topic.

BACKGROUND

A subdural hematoma is a form of intracranial injury where an abnormal collection of blood gets formed beneath the dura mater, typically from a bleeding bridging vein. Even though the hematoma may spontaneously resolve; subsequent bleeding may recur due to angiogenesis and vascularization following inflammatory processes. The newly formed vessels get their blood supply from the middle meningeal artery (MMA). Chronic subdural hematoma (cSDH) forms days or weeks after the initial bleeding and it is considered one of the most common neurological disorders.[6] Symptoms onset is gradual

Keywords

MMA,
middle meningeal artery,
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and appears after three weeks. The most common etiology for cSDH is trauma, other causes include intracranial hypotension, coagulopathy, and the use of antiplatelet or anticoagulant medications. Chronic subdural hematoma incidence ranges from 1.72 to 20.6 per 100000 people annually. [17] It's more common among the elderly age group and it is more common in males compared to females with a ratio of three to one. [1]

Treatment options for cSDH are various and there is no standardized treatment among neurosurgeons. Multiple factors such as the presence of symptoms or signs of cerebral compression on imaging affect the treatment choice which ranges from conservative to medical and/or surgical. Conservative management may be considered in asymptomatic patients with small cSDH. Neurosurgical intervention options include minimally invasive surgery, traditional surgery, and other methods. For the minimally invasive surgery, twisted drill (TD) craniotomy and burr hole (BH) trephination followed by closed system drainage are used. Rapid symptom resolution and shorter hospital stays are associated with TD and BH, thus it is considered as the mainstay of treatment of cSDH. [12] As for traditional surgery, craniotomy and craniectomy are utilized. In addition to that, uncommon methods for cSDH management include subdural tap, subduroperitoneal shunt, subgaleal reservoir, reduction craniotomy, and MMA embolization. [5, 12]

The use of MMA embolization has been introduced as an alternative to surgery for the management of acute or recurrent SDH, mostly those which recur more than two times. A case report by Hashimoto et al. in 2013 revealed that patients treated with MMA embolization for recurrent cSDH had no repeated recurrence after the procedure based on head CT imaging. This was attributed to the fact that MMA embolization suppresses the blood supply to the CSDH membrane and therefore controls the bleeding and formation of the hematoma, which later results in its resolution of it. [10]

Bibliometrics analysis or Scientometrics analysis refers to the statistical evaluation of published research to trace the relationships between academic journal citations. It is used to evaluate the impact, quality, and reliability of an academic publication. [10]

The aim of this study is to perform a detailed bibliometric analysis of publications about the role of MMA embolization in treating cSDH.

METHODS

In June 2022, we performed a Scopus database search to identify highly cited articles on embolization of the MMA in cSDH, keywords that were used in our search were "middle meningeal artery" "embolization" and "chronic subdural hematoma" "MMA" "SDH" respectively.

For each keyword, we selected the top 100 articles and then we assessed those articles for eligibility by title or by abstract and full text in case of ambiguity respectively, criteria for included articles were all articles that speak about cSDH and MMA embolization, all study design was selected, articles excluded if they are not in the scope of SDH and MMA embolization

Then top 50 selected articles were categorized by rank number, title, first author, country of origin, and neurosurgical institutions that contributed to the largest number of publications as well as annual distribution of published articles

H-indexed is used to measure journal source impact factors which include the journal title, category, quartile, impact factor, and the number of articles.

Statistical analysis was performed using SPSS version 23 and Microsoft excel, descriptive statistical analysis was performed, and descriptive data were quantified as counts or percentages of parameters.

ANALYSIS

Table 1 lists the top 50 cited articles on MMA embolization in cSDH demonstrating the number of citations and first author, the highest citation was 95 [2] and the lowest was 1. [3, 7, 8, 9, 15]

Ban, S.P., et al, studied the effect of embolization of MMA in cSDH compared to conventional therapy and they conclude that cSDH responds favorably to MMA embolization. In addition to that, they concluded that the embolization was more effective than conventional treatment. Mandai, S., et al who is the 2nd top-cited reported a case with chronic SDH due to liver coagulopathy treated successfully with MMA embolization after several standard care procedures like drainage. [14] The top 3rd cited article [13] showed a case series, which had 6 patients with 7 recurring, chronic SDHs, 6 of the 7

patients were effectively treated with MMA embolization, indicating that this minimally invasive method may be a viable alternative to surgery. Tempaku, A., et al in 2015 was the 4th top-cited aimed to determine the efficacy of MMA embolization, no patient experienced a recurrence of cSDH, so MMA embolization with close attention to

the process may be the preferred therapy for recurrent chronic SDH. [16] According to Kim, E., et al, the 5th most cited, in comparison to conventional therapy, a perioperative MMA embolization may be the least intrusive and most effective form of therapy for patients with resistant chronic SDHs who have experienced one or more recurrences. [11]

Table 1: Top 50 Articles with Their Total Citations and name of first authors

Rank	Title	First Authors	Total Cit.
1	Middle meningeal artery embolization for chronic subdural hematoma	Ban, S.P.	95.0
2	Middle meningeal artery embolization for refractory chronic subdural hematoma. Case report	Mandai, S.	75.0
3	Middle Meningeal Artery Embolization for Chronic Subdural Hematoma: A Series of 60 Cases	Link, T.W.	67.0
4	Usefulness of interventional embolization of the middle meningeal artery for recurrent chronic subdural hematoma: Five cases and a review of the literature	Tempaku, A.	50.0
5	Embolization Therapy for Refractory Hemorrhage in Patients with Chronic Subdural Hematomas	Kim, E.	49.0
6	Middle meningeal artery embolization for chronic subdural hematoma: Endovascular technique and radiographic findings	Link, T.W.	38.0
7	Embolization of the middle meningeal artery in patients with chronic subdural hematoma—a systematic review and meta-analysis	Haldrup, M..	28.0
8	Middle meningeal artery embolization for refractory chronic subdural hematoma: 3 Case reports	Takahashi, K.	27.0
9	Embolization of the middle meningeal artery for refractory chronic subdural haematoma. Usefulness for patients under anticoagulant therapy	Hirai, S.	24.0
10	Middle meningeal artery embolization as an adjuvant treatment to surgery for symptomatic chronic subdural hematoma: A pilot study assessing hematoma volume resorption	Ng, S.	23.0
11	Chronic Subdural Hematoma: Toward a New Management Paradigm for an Increasingly Complex Population	Iorio-Morin, C.	23.0
12	Middle meningeal artery embolization reduces the post-operative recurrence rate of at-risk chronic subdural hematoma	Shotar, E.	22.0
13	Middle meningeal artery embolization as treatment for chronic subdural hematoma: A case series	Link, T.W.	22.0
14	Middle Meningeal Artery Embolization for Chronic Subdural Hematoma: A Multi-Center Experience of 154 Consecutive Embolizations	Kan, P.	18.0
15	Chronic subdural hematoma associated with middle meningeal arteriovenous fistula treated by a combination of embolization and burr hole drainage	Komiyama, M.	18.0
16	Middle Meningeal Artery Embolization for Recurrent Chronic Subdural Hematoma: A Case Series	Link, T.W.	16.0
17	Middle meningeal artery embolization for chronic subdural hematoma: An institutional technical analysis	Catapano, J.S.	15.0
18	Middle meningeal artery embolization treatment of nonacute subdural hematomas in the elderly: a multiinstitutional experience of 151 cases	Joyce, E.	15.0
19	Midterm Follow-Up of Patients with Middle Meningeal Artery Embolization in Intractable Chronic Subdural Hematoma	Okuma, Y.	15.0
20	Enhanced Hematoma Membrane on DynaCT Images During Middle Meningeal Artery Embolization for Persistently Recurrent Chronic Subdural Hematoma	Nakagawa, I.	13.0
21	Transradial middle meningeal artery embolization for chronic subdural hematoma using Onyx: Case series	Rajah, G.B.	12.0

22	Meningioma with Intratumoral and Subdural Hemorrhage as an Immediate Complication of Therapeutic Embolization	Watanabe, K.	11.0
23	Middle meningeal artery embolization for chronic subdural hematoma with high risk of recurrence: A single institution experience	Yajima, H.	8.0
24	To drill or not to drill, that is the question: nonsurgical treatment of chronic subdural hematoma in the elderly. A systematic review	Scerrati, A.	7.0
25	A propensity-adjusted comparison of middle meningeal artery embolization versus conventional therapy for chronic subdural hematomas	Catapano, J.S.	6.0
26	Recurrence and conglobus volumetric resolution of subacute and chronic subdural hematoma post-middle meningeal artery embolization	Tiwari, A.	6.0
27	Angiographic Anatomy of the Middle Meningeal Artery in Relation to Chronic Subdural Hematoma Embolization	Shotar, E..	5.0
28	Risk of recurrence of subdural hematoma after EMMA vs surgical drainage - Systematic review and meta-analysis	Dian, J.	5.0
29	Upfront middle meningeal artery embolization for treatment of chronic subdural hematomas in patients with or without midline shift	Gomez-Paz, S.	5.0
30	Application of Absolute Alcohol in the Treatment of Traumatic Intracranial Hemorrhage via Interventional Embolization of Middle Meningeal Artery	Fan, G.	5.0
31	DynaCT Enhancement of Subdural Membranes After Middle Meningeal Artery Embolization: Insights into Pathophysiology	Mureb, M.C.	5.0
32	Transradial embolization of the left middle meningeal artery and accessory middle meningeal artery for treatment of subacute-chronic subdural hematoma	Rajah, G.B.	5.0
33	Embolization of a traumatic arteriovenous fistula between the middle meningeal artery and middle meningeal vein in a child with pulsatile tinnitus	Martinez, M.	5.0
34	Chronic subdural hematoma infected by Propionibacterium acnes: A case report	Yamamoto, S.	5.0
35	Delayed presentation of traumatic cerebral and dural arteriovenous fistulae after a BB gun accident in a pediatric patient: Case report	Abla, A.A.	5.0
36	High frequency of ophthalmic origin of the middle meningeal artery in chronic subdural hematoma	Fantoni, M.	4.0
37	Middle meningeal artery embolization using combined particle embolization and n-BCA with the dextrose 5% in water push technique for chronic subdural hematomas: a prospective safety and feasibility study	Al-Mufti, F..	3.0
38	Recurrent Bilateral Chronic Subdural Hematoma After Interventional Embolization Combined With Drilling and Drainage Treatment	Wang, H.	3.0
39	Contrast enhancement of chronic subdural hematomas after embolization of the middle meningeal artery	Entezami, P.	3.0
40	Perspective on Safety and Effectiveness of Middle Meningeal Artery Embolization for Chronic Subdural Hematoma	Srivatsan, A.	3.0
41	Middle Meningeal Artery Embolization for Chronic Subdural Hematomas: Cautious Optimism for a Challenging Pathology	Foreman, P.	3.0
42	Subdural and intracerebral hemorrhage caused by spontaneous bleeding in the middle meningeal artery after coil embolization of a cerebral aneurysm	Kohyama, S.	3.0
43	Middle meningeal artery embolization with subdural evacuating port system for primary management of chronic subdural hematomas	Carpenter, A.	2.0
44	Refractory Chronic Subdural Hematoma Associated with Dural Metastasis of Lung Adenocarcinoma Treated with Endovascular Embolization for the Middle Meningeal Artery: A Case Report and Review of the Literature	Kosaka, T.	2.0
45	Chronic headaches and middle meningeal artery embolization	Catapano, J.S.	1.0
46	Dural venous system: Angiographic technique and correlation with ex vivo investigations	Shapiro, M.	1.0
47	Perioperative prophylactic middle meningeal artery embolization for chronic subdural hematoma: a series of 44 cases	Schwarz, J.	1.0
48	Outpatient management of chronic expanding subdural hematomas with endovascular embolization to minimize inpatient admissions during the COVID-19 viral pandemic	Entezami, P.	1.0

49	Middle Meningeal Artery Embolization Versus Conventional Treatment of Chronic Subdural Hematomas	Enriquez-Marulanda, A.	1.0
50	Pediatric middle meningeal artery embolization for chronic subdural hematoma: A case report	Faber, R.	1.0

Table 2: Distribution of the 15 major journals according to the source impact measured by H-index:

journal title	journal category	quartile	impact factor	number of articles	h-index
Neurosurgical focus	Medicine (miscellaneous) (Q1); Neurology (clinical) (Q1); Surgery (Q1)	Q1	4.047	2	102
Radiology	Medicine (miscellaneous) (Q2); Radiology, Nuclear Medicine and Imaging (Q2)	Q1	11.1	1	307
Journal of NeuroInterventional Surgery	Medicine (miscellaneous) (Q1); Neurology (clinical) (Q1); Surgery (Q1)	Q1	5.836	7	64
Journal of Neurotrauma	Neurology (clinical) (Q1)	Q1	5.269	1	156
Journal of Neurosurgery	Neurology (clinical) (Q1); Surgery (Q1)	Q1	5.115	3	219
Neurosurgery	Neurology (clinical) (Q1); Surgery (Q1)	Q1	5.115	3	207
Frontiers in Neurology	Neurology (clinical) (Q1); Neurology (Q2)	Q2	4.003	1	80
American Journal of Neuroradiology	Medicine (miscellaneous) (Q1); Neurology (clinical) (Q1); Radiology, Nuclear Medicine and Imaging (Q1)	Q1	3.86	1	185
Diagnostics	Clinical Biochemistry (Q2)	Q2	3.706	1	35
Clinical Neuroradiology	Neurology (clinical) (Q2); Radiology, Nuclear Medicine and Imaging (Q2)	Q2	3.649	1	31
Operative Neurosurgery	Surgery (Q1); Neurology (clinical) (Q2)	Q1	2.703	1	26
Acta Neurochirurgica	Surgery (Q1); Neurology (clinical) (Q2)	Q1	2.216	1	100
World Neurosurgery	Surgery (Q1); Neurology (clinical) (Q2)	Q1	2.104	7	101
Clinical Neurosurgery	Neurology (clinical) (Q1); Surgery (Q1)	Q1	1.876	1	38
Clinical Neurology and Neurosurgery	Medicine (miscellaneous) (Q2); Surgery (Q2); Neurology (clinical) (Q3)	Q2	1.876	1	77

Figure 1 displays the overlay visualization of the keywords for the top 50 cited articles related to the embolization of the MMA in cSDH in the Scopus database. Out of the 922 keywords used, 145 had a minimum occurrence of five times at least. The size of each circle indicates the weight of occurrence. The larger the size, the more the occurrence. For example, the occurrence of the keyword “subdural hematoma” was 138 times, “human and humans” was 138 and 105 respectively, and “meningeal artery” was 121 times. The keywords “embolization” had an occurrence of 178 times which was the highest occurrence. The color density indicates the year of publication. The line connected to the circle shows

the links between the keywords. Figure 2a shows the total links of the keyword “human”. There was 2939 total connected with the other keywords. The second keyword with the highest connection was “meningeal artery” with 2645 connections (figure 2b). In comparison, the keywords “arterial embolization” had 1824 connections (figure 2c).

There was a total of 779 authors involved in the top 50 cited articles. The authors grouped into 13 clusters based on the connection with a total of 2338 connections between all authors (figure 3). The color density indicates the year of publication. The size of the circle shows the number of documents published per author. The highest number of

American Journal of Neuroradiology ((IF)=3.86), Diagnostics ((IF)=3.706), Clinical Neuroradiology ((IF)= 3.649), Operative Neurosurgery ((IF)=2.703), Acta Neurochirurgica ((IF)=2.216), World Neurosurgery ((IF)=2.104), Clinical Neurosurgery and Clinical Neurology and Neurosurgery ((IF)=1.876).

A total of 32 articles were published in these 15 journals, with the Journal of NeuroInterventional Surgery and World Neurosurgery having the highest number of articles (n=7), followed by the Journal of Neurosurgery and Neurosurgery (n=3). Two Articles were published in the neurosurgical focus journal (n=2), and the rest of the included journals all published one article (n=1). The mean H-index of the top 15 journals is 115.2 and the range is from 26 to 307. Radiology scored the highest source impact (H-index=307), followed by the Journal of Neurosurgery and Neurosurgery (219 and 207 respectively). On the other hand, the lowest source impact was scored by Diagnostics (H-index=35), followed by Clinical Neuroradiology (H-index=31), and Operative Neurosurgery scored the lowest (H-Index=26).

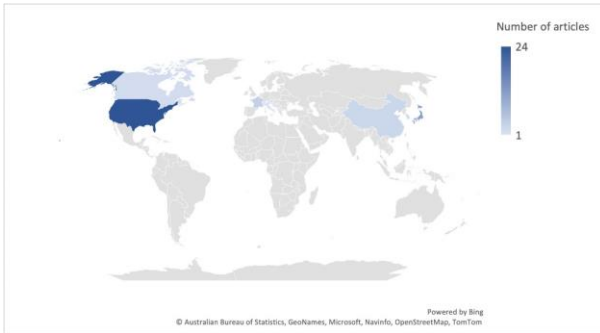


Figure 5.

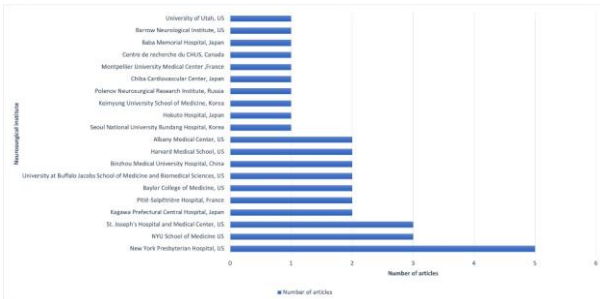


Figure 6.

Geographical trends

The top 50 articles originated from 9 countries were displayed in the figure 5, with the United States of America (USA) contributing to 24 articles, followed by Japan with 12 articles, France (4 articles), China (3 articles), Canada (2 articles), South Korea (2 articles),

Austria (1article), Denmark (1 article), and Italy (1 article).

Figure 6 illustrated the top 20 neurosurgical institutes contributing the largest number of articles. Most of the institutes were from the USA (N = 9) followed by Japan (N=4). The top neurosurgical institute was New York Presbyterian hospital contributed to 5 articles. One of their articles [13] cited 67 times, represents a series of 60 cases of embolization of MMA in new subdural hematoma, recurrent cSDH and as prophylaxis, the outcome showed 91% long-term success rate. The second institutes were NYU School of Medicine and St. Joseph's Hospital and Medical Center with 3 articles from each.

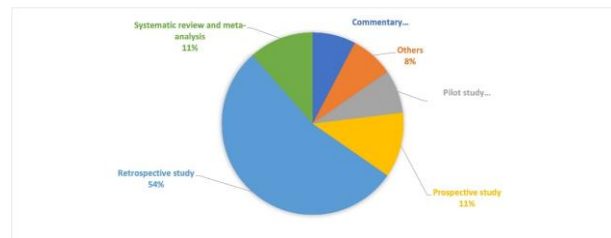


Figure 7.

As represented in the Figure 7, most articles were case reports and case-series, which is expected because of the nature of the intervention. The top cited case report of Mandai, S., et al, in 2000 that cited 75 times, represents successful embolization of the MMA after multiple attempts of surgical drainage in a patient who was 59 years old with coagulopathy secondary to liver cirrhosis. Retrospective studies accounted for more than a quarter of the articles that involved in this analysis. Three articles were systematic reviews and meta-analyses. An example of highly cited review was by (Dian, J., et al, 2021) that was cited 5 times concluded that the risk of recurrence of cSDH was reduced by 20% in those treated with embolization of MMA compared to those treated with surgical drainage alone. [4]

LIMITATIONS

First of all, bibliometric analysis is counted as a quantitative type of study not qualitative. Second, we use the SCOPUS database only, other databases were not involved. Third, the number of citations will change over time. Finally, we include the articles in the English language only, other articles in different languages were not included.

CONCLUSION

Our study includes the top 50 cited articles related to the embolization of the middle meningeal artery in chronic subdural hematoma. It helps the readers and researchers in their clinical decision and to find the unanswered questions in order to be answered in the future by further researches.

ABBREVIATIONS

MMA: middle meningeal artery
cSDH: Chronic Subdural Hematoma
SDH: Subdural Hematoma
TD: Twisted Drill
BH: Burr Hole
CT: Computerized Tomography
SPSS: Statistical Package for the Social Sciences
N: Number
USA: United State of America
NYU: New York University
COVID 19: Coronavirus disease 2019

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