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ABSTRACT

BACKGROUND AND PURPOSE: Middle meningeal artery embolization after surgical evacuation of a chronic subdural hematomas is associated with fewer treatment failures than surgical evacuation. We compared emergency department visits within 30 days for patients with chronic subdural hematomas with and without adjunctive middle meningeal artery embolization.

MATERIALS AND METHODS: All cases of chronic subdural hematoma treated from January 1, 2018, through December 31, 2020, were retrospectively reviewed. Treatment was classified as surgery only or surgery combined with middle meningeal artery embolization. The primary outcome was 30-day emergency department presentation and readmission.

RESULTS: Of 137 patients who met the study criteria, 28 (20%) underwent surgery combined with middle meningeal artery embolization. Of these 28 patients, 15 (54%) underwent planned middle meningeal artery embolization and 13 (46%) underwent embolization after surgical failure. The mean chronic subdural hematoma size at presentation in the group with surgery only ($n = 109$, 20.5 [SD, 6.9] mm) was comparable with that in the combined group ($n = 28$, 18.7 [SD, 4.5] mm; $P = .16$). A significantly higher percentage of the surgery-only group presented to the emergency department within 30 days compared with the combined group (32 of 109 [29%] versus 2 of 28 [7%] patients; $P = .02$). No significant difference was found with respect to readmission (16 [15%] versus 1 [4%] patient; $P = .11$). Nine patients (8%) in the surgery-only group were readmitted for significant reaccumulation or residual subdural hematoma compared with only 1 patient (4%) in the combined group ($P = .40$).

CONCLUSIONS: Surgical evacuation combined with middle meningeal artery embolization in patients with chronic subdural hematoma is associated with fewer 30-day emergency department visits compared with surgery alone.

ABBREVIATIONS: cSDH = chronic subdural hematoma; ED = emergency department; GCS = Glasgow Coma Scale; MMA = middle meningeal artery; SDH = subdural hematoma

Chronic subdural hematoma (cSDH) is a common neurosurgical condition that is most prevalent among elderly patients and can be challenging to treat.[1-6] Surgical evacuation using burr- hole irrigation or craniotomy is the preferred treatment option for patients with primary or recurrent subdural hematoma (SDH) who present with symptomatic brain compression.[1-3,7] However, these procedures are associated with recurrence rates as high as 28%, with nearly one-tenth of patients requiring re-operation within 30–60 days.[3,7,8] Conservative management may be indicated in patients with small or asymptomatic SDHs, but many cSDHs may eventually require surgical evacuation.[9-11] Middle meningeal artery (MMA) embolization has recently been proposed as an alternative or adjunct to surgery for primary or recurrent cSDHs, and it has been associated with a decreased risk of treatment failure.[3,9,12]

Although several case series have outlined the potential benefits of MMA embolization during the past few years, no studies have used standard outcome measures to examine these findings. In this single-center study conducted during a 3-year study period, we compared the rates of emergency department (ED) use and readmission within 30 days for patients with cSDHs who underwent surgical evacuation with and without adjunctive MMA embolization.

MATERIALS AND METHODS

The medical records of all patients who presented with a cSDH to a single quaternary center from January 1, 2018, through December 31, 2020, were retrospectively reviewed. The study was approved by the institutional review board at St. Joseph's Hospital and Medical Center in Phoenix, Arizona, and informed consent was waived because of the low risk to patients. The endovascular treatment

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Table 1: Characteristics of 137 patients with cSDH who underwent surgery only versus surgery combined with MMA embolization[a]

Characteristic	Surgery-Only Group (n = 109)	Combined Group (n = 28)	P Value
Age (mean) (SD) (yr)	70 (12.8)	71 (10.2)	.86
Sex			.94
Male	81 (74)	21 (75)	
Female	28 (26)	7 (25)	
GCS score (mean) (SD)			
At presentation	14 (2.2)	14 (2.6)	.77
At discharge	14 (2.1)	14 (2.3)	.70
Comorbid condition			
Hypertension	54 (50)	16 (57)	.47
Diabetes mellitus	27 (25)	8 (29)	.68
CAD	36 (33)	12 (43)	.33
Liver disease	3 (3)	1 (4)	.82
Alcohol abuse	14 (13)	1 (4)	.16
CVA	10 (9)	2 (7)	.73
Coagulopathy	4 (4)	3 (11)	.13
Previous trauma	78 (72)	17 (61)	.27
Length of hospital stay (mean) (SD) (day)	9.9 (6.3)	8.6 (5.5)	.51
Disposition home	60 (55)	18 (64)	.38

Note:—CAD indicates coronary artery disease; CVA, cerebrovascular accident.
[a] Data are presented as No. (%) unless otherwise indicated.

Table 2: ED visits and readmissions within 30 days for patients with cSDH who underwent surgery only versus surgery combined with MMA embolization

Characteristic	Surgery-Only Group, No. (%) (n = 109)	Combined Group, No. (%) (n = 28)	P Value
ED visits	32 (29)	2 (7)	.02
Readmissions	16 (15)	1 (4)	.11

database was reviewed to abstract data on age, sex, Glasgow Coma Scale (GCS) scores at admission and discharge, comorbid conditions, and previous trauma. Patients in this cohort were assigned to 2 groups: surgical evacuation only or surgery combined with MMA embolization. The group with surgery only included patients who presented during the first 2 years of the study, whereas the surgery and MMA embolization group (the combined group) included patients who received the combined treatment during the entire 3-year study period. The medical records of patients in the surgery-only and combined groups were analyzed for ED visits and readmission within 30 days as primary outcomes.

Statistical analysis was performed using SPSS Statistics for Windows, Version 26.0 (IBM). Comparisons of ED visits and readmissions within 30 days were performed using an independent samples t test. The level of significance was set at $P < .05$. Patient data and outcomes are expressed as mean (SD) or as frequency (percentage) or both.

RESULTS

The total study cohort consisted of 137 patients, of whom 109 (80%) underwent surgery only and 28 (20%) underwent combined surgery and MMA embolization. Of the 28 patients in the combined group, 15 (54%) underwent planned elective MMA embolization and 13 (46%) underwent unplanned MMA embolization after surgical failure. No significant differences were found in age or sex between the 2 groups (Table 1). The mean age was 70 (SD, 12.8) years in the surgery-only group and 71 (SD, 10.2) years in the combined group. Most patients in both groups were men (81 of 109 [74%] in the surgery-only group and 21 of 28 [75%] in the combined group). Both groups of patients had a mean GCS score of 14 at both admission and discharge. No significant differences were found in comorbid conditions between the 2 groups. Comorbid conditions for the 2 groups are presented in Table 1.

The mean size of the cSDHs at presentation was not significantly different in the surgery-only group (20.5 [SD, 6.9] mm) compared with the combined group (18.7 [SD, 4.5] mm; $P = .16$). The overall rate of ED visits within 30 days for the entire cohort was 24% (33 of 137 patients). This rate was significantly higher in patients who underwent surgery only (29%, 32 of 109) compared with those who underwent MMA embolization with surgery (7%, 2 of 28; $P = .02$) (Table 2).

The overall rate of readmission within 30 days was 12% (17/137 patients). The readmission rate was higher in the surgery only group (15%, 16/109) compared with the combined group (4%, 1/28), but this difference could not be compared statistically because of the small number of ED presentations in each group and because of the small sample size of the combined group. Most readmissions (59%, 10/17) were due to reaccumulation or residual cSDH. Only 1 patient who underwent both surgery and MMA embolization was readmitted for reaccumulation or residual cSDH compared with 9 in the surgery-only group. In the 10 patients with reaccumulated/residual SDH, the mean cSDH diameter was 12.3 (SD, 2.2) mm.

DISCUSSION

MMA embolization has emerged as a promising minimally invasive procedure to treat primary and refractory cSDH.[3,8,9,12-15] Compared with surgery alone, it has been associated with fewer treatment failures and a reduced rate of hematoma reaccumulation in patients with cSDH.[9,12] To examine this association, we compared the 30-day ED use and readmission rates among patients with surgery only with those among patients with surgery combined with MMA embolization during a 3-year study period at a single institution. We found significantly less ED use in the combined treatment group than in the surgery-only group ($P = .02$).

In this era of continually increasing health care costs, institutions are under pressure to identify ways to reduce expenditures while maintaining and improving the quality of care. Returns to the hospital within 30 days can be devastating for both patients and the health care system. Federal policies and insurance payors

even penalize hospitals for unplanned readmissions. To our knowledge, this study is the first to demonstrate that MMA embolization for SDHs decreases the likelihood of ED visits and hospital readmissions. Our results indicate that the recurrence of cSDH is the most common reason for readmission. However, only 1 patient who underwent MMA embolization was readmitted for recurrence. These findings suggest that MMA embolization may reduce hospital readmissions and their associated cost to both the patient and the health care system. A previous analysis of the National Surgical Quality Improvement Program database similarly found that recurrent SDH was the most common reason for hospital readmission within 30 days for patients who had undergone cSDH evacuation.[16]

Previous estimates of readmission rates after treatment of cSDH are limited. The lack of a specific billing code for cSDH has hindered analyses of nationwide administrative databases. Lakomkin et al[16] reported a 30-day readmission rate of 7.7% (45 of 585) in patients who underwent surgery for SDH. However, several limitations minimize the generalizability of this and other reported readmission rates. Their study was conducted using an administrative billing database, and cSDH was defined by International Classification of Disease, Ninth Revision (https://www.cdc.gov/nchs/icd/icd9cm.htm) billing code 432.1 for "nontraumatic" SDH. This code has not been validated against institutional records to accurately detect cSDH. Furthermore, the National Surgical Quality Improvement Program does not have a specific code for burr- hole evacuation, which is the criterion standard surgical approach for evacuating cSDHs. In addition, their readmission rates were calculated without consideration of how many patients died before discharge, possibly leading to further underestimates.

Previous studies have demonstrated the safety and efficacy of MMA embolization for cSDH. A recent meta-analysis and systematic review by Srivatsan et al[2] identified 3 two-arm studies (embolization versus conventional surgery) and 6 single-arm case series. The authors' pooled analysis showed that hematoma recurrence was significantly less common among patients who underwent embolization (2.1%) than among those who underwent conventional surgical treatment (27.7%; $P < .001$). In our study, only 1 of 28 patients who underwent MMA embolization was readmitted for cSDH recurrence, a finding consistent with that of Srivatsan et al. In addition to the outstanding efficacy of MMA embolization for cSDHs, the procedure has been found to be relatively safe, largely because of the recent advent of newer endovascular techniques (eg, transradial access).[17-25]

Limitations to the study include those inherent in all retrospective analyses. Additionally, the study included only 28 patients in the combined group, limiting its power, and the patients were treated at a single institution by multiple neurosurgeons who ultimately decided which patients underwent surgery with no standardized guidelines.

CONCLUSIONS

Our results show that surgical evacuation combined with MMA embolization in patients with cSDH is associated with decreased ED visits within 30 days compared with surgery alone. Most readmissions after cSDH treatment were due to hematoma recurrences, which were markedly decreased in patients who underwent MMA embolization. These findings warrant the design of future prospective, large-cohort studies to substantiate our data and expand on this preliminary research.

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REFERENCES

1. Catapano JS, Nguyen CL, Wakim AA, et al. **Middle meningeal artery embolization for chronic subdural hematoma.** *Front Neurol* 2020;11:557233 CrossRef Medline
2. Srivatsan A, Mohanty A, Nascimento FA, et al. **Middle meningeal artery embolization for chronic subdural hematoma: meta-analysis and systematic review.** *World Neurosurg* 2019;122:613–19 CrossRef Medline
3. Link TW, Boddu S, Paine SM, et al. **Middle meningeal artery embolization for chronic subdural hematoma: a series of 60 cases.** *Neurosurgery* 2019;85:801–07 CrossRef Medline
4. Balser D, Farooq S, Mehmood T, et al. **Actual and projected incidence rates for chronic subdural hematomas in United States Veterans Administration and civilian populations.** *J Neurosurg* 2015;123:1209–15 CrossRef Medline
5. Foreman P, Goren O, Griessenauer CJ, et al. **Middle meningeal artery embolization for chronic subdural hematomas: cautious optimism for a challenging pathology.** *World Neurosurg* 2019;126:528–29 CrossRef Medline
6. Miranda LB, Braxton E, Hobbs J, et al. **Chronic subdural hematoma in the elderly: not a benign disease.** *J Neurosurg* 2011;114:72–76 CrossRef Medline
7. Mehta V, Harward SC, Sankey EW, et al. **Evidence based diagnosis and management of chronic subdural hematoma: a review of the literature.** *J Clin Neurosci* 2018;50:7–15 CrossRef Medline
8. Catapano JS, Ducruet AF, Nguyen CL, et al. **Middle meningeal artery embolization for chronic subdural hematoma: an institutional technical analysis.** *J Neurointerv Surg* 2021;13:657–60 CrossRef Medline
9. Catapano JS, Ducruet AF, Nguyen CL, et al. **A propensity-adjusted comparison of middle meningeal artery embolization versus conventional therapy for chronic subdural hematomas.** *J Neurosurg* 2021 Feb 26. [Epub ahead of print] CrossRef Medline
10. Chan DY, Chan DT, Sun TF, et al. **The use of atorvastatin for chronic subdural haematoma: a retrospective cohort comparison study.** *Br J Neurosurg* 2017;31:72–77 CrossRef Medline
11. Jiang R, Zhao S, Wang R, et al. **Safety and efficacy of atorvastatin for chronic subdural hematoma in Chinese patients: a randomized clinical trial.** *JAMA Neurol* 2018;75:1338–46 CrossRef Medline
12. Ban SP, Hwang G, Byoun HS, et al. **Middle meningeal artery embolization for chronic subdural hematoma.** *Radiology* 2018;286:992–99 CrossRef Medline
13. Shapiro M, Walker M, Carroll KT, et al. **Neuroanatomy of cranial dural vessels: implications for subdural hematoma embolization.** *J Neurointerv Surg* 2021;13:471–77 CrossRef Medline
14. Rajah GB, Tso MK, Dossani R, et al. **Transradial embolization of the left middle meningeal artery and accessory middle meningeal artery for treatment of subacute-chronic subdural hematoma.** *J Neurointerv Surg* 2020;12:436 CrossRef Medline
15. Fiorella D, Hirsch JA, Arthur AS. **Embolization of the middle meningeal artery for the treatment of chronic subdural hematoma: considerations for pragmatic trial design.** *J Neurointerv Surg* 2021;13:295–97 CrossRef Medline

16. Lakomkin N, Graffeo CS, Hadjipanayis CG. **Specific causes and predictors of readmissions following acute and chronic subdural hematoma evacuation.** *J Clin Neurosci* 2020;75:35–39 CrossRef Medline
17. Majmundar N, Wilkinson DA, Catapano JS, et al. **Reaccessing an occluded radial artery for neuroendovascular procedures: techniques and complication avoidance.** *J Neurointerv Surg* 2021;13:942–45 CrossRef Medline
18. Luther E, Chen SH, McCarthy DJ, et al. **Implementation of a radial long sheath protocol for radial artery spasm reduces access site conversions in neurointerventions.** *J Neurointerv Surg* 2021;13:547–51 CrossRef Medline
19. Luther E, Burks J, Abecassis IJ, et al. **Navigating radial artery loops in neurointerventions.** *J Neurointerv Surg* 2020;13:1027–31 CrossRef Medline
20. Kuhn AL, de Macedo Rodrigues K, Singh J, et al. **Distal radial access in the anatomical snuffbox for neurointerventions: a feasibility, safety, and proof-of-concept study.** *J Neurointerv Surg* 2020;12:798–801 CrossRef Medline
21. Khan NR, Peterson J, Dornbos Iii D, et al. **Predicting the degree of difficulty of the trans-radial approach in cerebral angiography.** *J Neurointerv Surg* 2021;13:552–58 CrossRef Medline
22. Dossani R, Waqas M, Tso MK, et al. **Navigating a proximal loop in the radial artery and avoiding the recurrent radial artery.** *J Neurointerv Surg* 2020;12:724 CrossRef Medline
23. Catapano JS, Fredrickson VL, Fujii T, et al. **Complications of femoral versus radial access in neuroendovascular procedures with propensity adjustment.** *J Neurointerv Surg* 2020;12:611–15 CrossRef Medline
24. Catapano JS, Ducruet AF, Nguyen CL, et al. **Propensity-adjusted comparative analysis of radial versus femoral access for neurointerventional treatments.** *Neurosurgery* 2021;88:E505–09 CrossRef Medline
25. Catapano JS, Ducruet AF, Koester SW, et al. **Propensity-adjusted cost analysis of radial versus femoral access for neuroendovascular procedures.** *J Neurointerv Surg* 2021;13:752–54 CrossRef Medline