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Comparison of hydrogel coils versus bare platinum coils for the treatment of anterior communicating artery aneurysms

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Abstract:

INTRODUCTION: While endovascular coiling has been shown to be a safe treatment option for intracranial aneurysms, there remains concern regarding increased recurrence and retreatment rates. Preliminary studies evaluating hydrogel coated coils have demonstrated decreased recurrence rates compared to bare metal coils.

METHODS: A retrospective chart review was done on all patients with anterior communicating artery aneurysms (ACoAAs) treated with endovascular coiling between 2014 and 2018. Treatment groups were divided into hydrogel coated coils or bare metal coils. Patients were categorized into the hydrogel group when ≥ 70% of the coil length was hydrogel coated.

RESULTS: Eighty-four ACoAAs were treated with coil embolization between 2014 and 2018. Postoperative imaging was available for 68 patients. Twenty-six patients were categorized into the hydrogel treatment group. Aneurysm recurrence was seen in 7.7% (2/26) of patients treated with hydrogel coated coils compared to 33.3% (14/42) of those treated with bare metal coils ($P = 0.03$). Subanalysis of patients with ruptured aneurysms revealed decreased recurrence rates in patients treated with hydrogel coated coils at 5.9% (1/17) compared to patients treated with bare metal coils at 39.4% (13/33) ($P = 0.01$).

CONCLUSIONS: Hydrogel-coated coils may reduce recurrence rates in the treatment of both ruptured and unruptured ACoAAs.

Keywords:

Aneurysm, anterior communicating artery, hydrogel coils, recurrence

Introduction

Endovascular coiling has been shown to be a safe treatment option for patients with intracranial aneurysms, but there remains concern regarding potential higher recurrence and retreatment rates with up to 20.8% of patients experiencing aneurysm recanalization by 38 months posttreatment.[1] In an effort to reduce recurrence rates, researchers have turned their focus to hydrogel-coated coils. Hydrogel is an expansile polymer and theoretically results in improved volumetric filling of the aneurysm lumen.[2] This is believed to reduce thrombus formation and therefore decrease inflammation thought to contribute to arterial wall weakening. Preliminary results from the hydrogel endovascular aneurysm treatment (HEAT) trial demonstrated a statistically significant reduction in aneurysm recurrence in patients treated with hydrogel-coated coils compared to bare metal coils.[3] While these results are promising, it is unclear whether

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they vary by aneurysm characteristics such as location, rupture status, and maximal dimension.

Approximately 85% of intracranial aneurysms occur in the anterior circulation with anterior communicating artery aneurysms (ACoAAs) accounting for 30%–37% of all intracranial aneurysms.[4,5] These aneurysms are associated with high recurrence rates with up to 30% of patients requiring retreatment.[2] In addition, the anterior communicating artery is the most common location of subarachnoid hemorrhages (SAH).[6] Microsurgical clipping of ACoAAs has a higher risk of postoperative complications compared to other intracranial aneurysms, secondary to the proximity of vital perforating arteries, as well as the olfactory and optic nerves.[6] The risk of recurrence and retreatment has yet to be elucidated with this specific treatment modality.

The primary endpoint of this study was to determine if treatment with hydrogel-coated coils (MicroVention: Terumo, Tusin, California) decreases recurrence rates in ACoAAs when compared to noncoated coils. We performed a subgroup analysis on patients presenting with ruptured ACoAAs treated with either hydrogel-coated coils or bare metal coils to determine if recurrence rates were reduced in this population.

Methods

A retrospective chart review was done on all patients with an ACoAA treated with endovascular coiling between 2014 and 2018. Patients were excluded if they were <18 years of age or if follow-up imaging was not available. Follow-up imaging included either magnetic resonance angiography (MRA) or cerebral angiography. All MRAs were performed on a 1.5 Tesla (1.5T) scanner. Aneurysm recurrence was defined as any progress on the Raymond-Roy Occlusion Classification scale on postoperative imaging. Treatment groups were divided into hydrogel-coated coils or bare metal coils. Patients were categorized into the hydrogel group when ≥70% of the coil length was hydrogel-coated (in keeping with the HELPS trial criteria).[7] Patients with <70% hydrogel-coated coils were placed in the bare metal coil treatment group. Fisher's exact test was used to determine statistical significance.

Ethical approval

This study was approved by the Albany Medical Center Institutional Review Board (5693, 3/13/2020). Given the retrospective, de-identified nature of this study, informed written consent was not required based on IRB evaluation.

Results

Eighty-four ACoAAs were treated with coil embolization between 2014 and 2018. Follow-up duration ranged from 2 months to 69 months with a mean of 26 months. Posttreatment imaging was available for 68 patients. Average aneurysm size was 5.5 mm in widest diameter (range, 2–9.7 mm). Wide neck aneurysms were classified as a dome: neck <2. Out of the 68 patients, 37 (54%) presented with wide neck aneurysms which were evenly represented in the hydrogel coated coil and bare metal group at 38% (P = 0.975). Patients presenting with wide neck aneurysms experience recurrence rates of 16.2% (6/37) compared to a rate of 32.3% (10/31) in patients without a wide neck aneurysm (P = 0.16). Twenty-six patients were categorized into the hydrogel treatment group and 42 into the bare metal treatment group. Of patients in the bare metal coil group, 57% (24/42) were female and 43% (18/42) were male [Table 1].

Ages ranged from 27 to 75 with a mean age of 54. Aneurysm maximal dimension ranged from 2–12 mm with a mean of 5 mm. 19% required device-assisted coiling with either a balloon or stent and 10% of patients had a prior history of SAH related to an ACoAA rupture which was subsequently treated. Of patients in the hydrogel group, 69% were female and 31% patients were male. Ages ranged from 41 to 81 with a mean of 59 years. Aneurysm maximal dimension ranged from 2 mm to 10 mm with a mean of 6 mm. 19% of patients required device-assisted coiling and 4% of patients had a prior SAH and ACoAA. Of the 68 patients, 50 (74%) presented with aneurysm rupture. Sixty-five percent (17/26) of patients in the hydrogel group and 79% (33/42) of patients in the bare metal group presented with SAH (P = 0.26). Aneurysm recurrence was seen in 7.7% (2/26) of patients treated with hydrogel-coated coils compared to 33.3% (14/42) of those treated with bare metal coils (P = 0.03) [Table 2]. Subanalysis of patients presenting with aneurysm rupture revealed decreased recurrence rates in patients treated with hydrogel coated coils at 5.9% (1/17) compared to patients treated with bare metal coils at 39.4% (13/33) (P = 0.01).

Interestingly, immediate postembolization angiography demonstrated that 69% of those treated with <70%

Table 1: Demographic information

	Bare metal coil (*n*=42)	Hydrogel (*n*=26)	*P*
Male	43% (*n*=18)	31% (*n*=8)	0.319
Mean age	54 (SD 14.4)	59 (SD 10.5)	0.192
Mean aneurysm maximal dimension	5 mm (SD 2.0)	6 mm (SD 2.7)	0.248
Dome: neck <2	38% (*n*=16)	38% (*n*=10)	0.976
Ruptured aneurysm	79% (*n*=33)	65% (*n*=17)	0.26
Device assisted coiling	19% (*n*=8)	19% (*n*=5)	0.985
Prior SAH	10% (*n*=4)	4% (*n*=1)	0.383
Prior ACoAA treatment	12% (*n*=5)	4% (*n*=1)	0.255

SAH: Subarachnoid hemorrhages, ACoAA: Anterior communicating artery aneurysm, SD: Standard deviation

Table 2: Aneurysm recurrences

	Number of aneurysms	Ruptured (%)	Average number of coils	Recurrence rate	Retreatment rate
<70% hydrogel	42	78.6	3.2	33.3% (14/42)	11.9% (5/42)
>70% hydrogel	26	65.4	2.7	7.7% (2/26)	7.7% (2/26)

hydrogel coil lengths had a final Raymond-Roy Occlusion Classification of 1 or 2, compared to only 38% of those in the >70% hydrogel coil length cohort.

Discussion

In this retrospective chart review, 68 patients presenting with ruptured and unruptured ACoAAs treated with either hydrogel-coated coils or bare metal coils between 2014 and 2018 were analyzed for aneurysm recurrence. Patients in the bare metal coil group experienced higher rates of recurrence at 33.3% compared to 7.7% of those patients treated with hydrogel-coated coils ($P = 0.03$). Subanalysis of patients with ruptured aneurysms similarly revealed decreased recurrence rates in patients with hydrogel-coated coils at 5.9% compared to 39.4% of those with bare metal coils. This result is in spite fewer patients having a Raymond-Roy Occlusion Classification score of 1 or 2 in the hydrogel group.

In 2014, McDougall *et al*. released the Matrix and Platinum Science (MAPS) trial comparing target aneurysm recurrence (TAR) in bioactive versus bare platinum coils.[8] The hypothesis was that coils coated with bioabsorbable polymeric material would accelerate clot organization and fibrosis, which would allow for intraluminal stabilization. In this study, a TAR was defined as three possible events: aneurysm hemorrhage, aneurysm retreatment, or death from unknown cause. After following the patients for 455 days, they found that TAR for bioactive coils was 13.3% and 14.6% for bare platinum coils.[8]

Results of the MAPS trial were disappointing and brought into question the underlying pathophysiology of aneurysm wall healing. Marbacher *et al*. published a study comparing aneurysm wall healing in endovascularly treated aneurysms compared to those treated with clipping.[9] They concluded that healing from clipping is a result of mechanical occlusion, while healing after endovascular treatment is a biological response that requires thrombus formation. Previously, it was believed that thrombus formation promoted scar formation and stabilized the aneurysmal wall. Marbacher *et al*. argued that the aneurysm wall may actually undergo continuous remodeling, leading to impaired healing and destruction of the luminal wall. This may explain why there was no change in aneurysm recurrence with bioactive coils. Bioactive coils may result in continuous remodeling rather than scar formation and increase the risk of recurrence in these patients.

If this theory of luminal wall healing holds true, aneurysm recurrence is more likely to be reduced by limiting thrombus formation. This would lessen inflammation in the aneurysm lumen and reduce the amount of luminal wall destruction. Hydrogel-coated coils are expansile, allowing for improved volumetric filling.[2] This is believed to reduce thrombus formation and therefore reduce inflammation. The Hydrocoil Endovascular Aneurysm Occlusion and Packing Study (HELPS trial) compared HydroCoil endovascular treatment to bare platinum coils.[7] In this study, they found that treatment with HydroCoils resulted in reduced recurrence, but was technically limited by coil stiffness preventing clinical use.[10] These results were promising and led to the GREAT trial-a Randomized Controlled Trial Comparing Hydrosoft/HydroFrame and Bare Platinum Coils for Endovascular Aneurysms Treatment which evaluated the procedural safety and postsurgical angiographic results of softer, second-generation hydrogel coils.[10] The authors found similar rates of residual aneurysms and 14 day mortality in both second-generation HydroCoils and bare platinum coils; however, the authors believed these results underreport negative outcomes as they were unable to obtain informed consent from many patients with ruptured aneurysms and WFNS Scores of 2 and 3.[11]

The HEAT trial is a multicenter randomized control trial comparing aneurysm recurrence rates in hydrogel-coated coils to bare platinum coils.[3] A total of 600 patients were enrolled between 2011 and 2016 across 46 centers. The primary endpoint in this trial is aneurysm recurrence over a 24-month period based on the Raymond-Roy Occlusion Classification scale. Preliminary results from this study have been promising, showing aneurysm recurrence rates of only 4% in the hydrogel group compared to 15% in the bare platinum coil group in patients enrolled in 2014 and 2015 ($P < 0.001$). These recurrence rates are comparable to our findings in ACoAAs where we observed recurrence rates of 7.7% in patients treated with hydrogel-coated coils compared to 33.3% in those treated with bare metal coils.

A multicenter randomized control trial evaluating a composite outcome that included major aneurysm recurrence, aneurysm retreatment, and any death during treatment or follow-up in patients treated with second-generation hydrogel-coated coils compared to those treated with bare metal coils found that hydrogel coils reduced the rate of unfavorable outcome events in patients with small and medium sized intracranial aneurysms.[10] It is additionally difficult to determine the

effects of hydrogel-coated coils on composite outcomes as patients in the hydrogel arm of the study could have as low as 51% of total coil length coated in hydrogel. In addition, patients were followed for a maximum of 18 months following treatment and 18% of patients met the minimum follow-up time of 6 months, making it difficult to determine the true risk of recurrence in this population. Assist devices were additionally used in up to 60% of patients treated with hydrogel coils and 54% of patients in the bare metal stent group.

A retrospective chart review done by Lee *et al*. compared 401 patients with 430 aneurysms treated with second-generation hydrogel coils to 221 patients with 253 aneurysms treated with bare platinum coils and similarly found no difference in initial angiographic outcomes postoperatively.[12] They did however find that the use of HydroSoft (Microvention: Terumo, Tusin, California) coils resulted in a higher mean packing density when compared to bare platinum coils and that coil embolization with HydroSoft coils reduced retreatment rates at 12-month follow-up. Although these results are promising, there are some significant limitations to this study. Over half of the patients in the HydroSoft coil group had <50% of deployed coils coated with hydrogel, making it difficult to determine if reduced recurrence could be attributed to the coated coils versus a higher mean packing density. In addition, around 50% of the patients in the HydroSoft group were lost to follow-up at 12 months compared to 12% in the bare platinum coil group, making it difficult to rule out selection bias.

Limitations to our study include variable follow-up times which ranged from as short as 2 months to as long as 69 months with a mean of 26.4 months. Finally, this is a retrospective chart review, which has a higher risk of selection bias compared to randomized control trials.

Conclusions

Patients treated with hydrogel-coated coils (>70% coil length) had reduced risk of aneurysm recurrence defined as progression on the Raymond-Roy Occlusion Classification when compared to those treated with bare metal coil ($P = 0.03$). Subanalysis of patients presenting with aneurysm rupture similarly revealed decreased recurrence rates in patients treated with hydrogel-coated coils compared to bare metal coils ($P = 0.01$).

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Conflicts of interest

There are no conflicts of interest.

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