Long-Term MRI Findings of Muslin-Induced Foreign Body Granulomas after Aneurysm Wrapping

A Report of Two Cases and Literature Review

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Summary

Muslin-induced foreign body granulomas are rare delayed complications after wrapping of intracranial aneurysms. Few small case series have been reported, with a paucity of documented MRI findings. In addition, there are no reports on long-term radiological appearances or temporal evolution of conservatively managed patients. We thus report on the long-term radiological and clinical follow-up of two patients with asymptomatic muslin-induced foreign body granulomas after wrapping of recurrent middle cerebral arterial aneurysms. Both patients were successfully managed conservatively and remain asymptomatic three and six years after diagnosis of their granulomas. A literature review confirms that MRI features of muslin-induced foreign body granuloma are typical. Features include focal areas of elevated T2 signal with increased diffusion-weighted signal and thin rim enhancement. To the best of our knowledge, this is the first report to confirm that there is a corresponding reduction in apparent diffusion coefficient, as typical in an intracranial abscess.

Thus a history of aneurysm wrapping is critical for diagnosis. Accurate clinical recognition of this exuberant inflammatory response will avoid misdiagnosis as pyogenic abscess or tumor and prevent unnecessary or invasive treatment.

Introduction

Foreign body granulomas are rare delayed complications after wrapping of intracranial aneurysms. In the three largest series in the literature of wrapped aneurysms with a long-term clinical follow-up – 63, 60 and 47 patients followed for a mean of 3.7, 10 and 13.7 years respectively – no post operative foreign body granulomas were reported¹⁻³. Nonetheless, there have been case reports and small case series of granuloma formation after wrapping, particularly after use of muslin. Even fewer have described MRI findings and none have reported on long-term radiological findings or clinical outcomes for conservatively managed patients. We aim to provide insight into the temporal evolution of neuroimaging findings by reporting on two patients with three and six-year clinical and serial MRI follow-up for conservatively managed muslin-induced foreign body granulomas after middle cerebral arterial aneurysm wrapping. We also review the literature on MRI findings of muslin-induced granulomas after aneurysm wrapping to identify imaging findings to facilitate accurate clinical rec-

Abbreviations

MRI Magnetic resonance imaging
MRA Magnetic resonance angiography
DW Diffusion-weighted
ADC Apparent diffusion coefficient
MCA Middle cerebral artery
ACA Anterior cerebral artery
DSA Digital subtraction angiography

Figure 1 MRI imaging course of the granuloma in patient 1. A) Axial fluid attenuated inversion recovery (FLAIR) and coronal contrast enhanced T1-weighted MRI. At diagnosis, 7 months post muslin wrapping, there is edema in the right temporal operculum adjacent to the wrapped aneurysm (arrow in top image), and a ring-enhancing mass centered on the wrapped aneurysm (arrow in bottom image). B) Axial FLAIR MRI and right internal carotid artery (ICA) DSA. Six months after diagnosis, there is increased peri-aneurysmal brain parenchymal edema (arrow in top image) and by the second year after diagnosis, there is prominent peri-aneurysmal vascular narrowing in the M1 and M2 branches of the MCA (bottom image). C) Axial FLAIR, right ICA MRA and coronal contrast-enhanced T1 MRI. Six years after diagnosis, there is a reduced but persistent peri-aneurysmal T2 signal (arrow in top left), peri-aneurysmal vascular narrowing (bottom left) and a ring-enhancing mass (arrow in bottom right).

ognition, and avoid misdiagnosis as pyogenic abscess or tumor, thus preventing unnecessary or invasive treatment.

Case 1

A 53-year-old female presented with an asymptomatic recurrence of a previously coiled incidental 8 mm right MCA aneurysm. Endovascular treatment had been performed four years previously. This was complicated by aneurysm recanalization managed with two further episodes of endovascular treatment. Upon the third recurrence, microsurgical obliteration was planned. Satisfactory primary clip occlusion was not feasible due to insufficient space to

place the clip beneath the coil mass without compromising the MCA branches. Thus the aneurysm was wrapped with muslin. Routine surveillance MRI imaging seven months after wrapping, demonstrated a ring-enhancing mass centred on the wrapped aneurysm and a small amount of abnormal T2 signal in the right temporal operculum adjacent to the coil mass (Figure 1A). The patient had no infective or new neurological symptoms referable to the mass.

There was neither leucocytosis nor neutrophilia on laboratory investigations. The absence of clinical features suggesting intracranial infection or symptoms referable to the mass lead to a presumptive diagnosis of muslin-induced foreign body granuloma. No treatment was instituted, and serial clinical and neuroim-

Figure 2 MRI imaging course of the granuloma in patient 2. A) Axial FLAIR MRI. Twelve months after muslin wrapping, there is new edema in the right temporal operculum and external capsule (arrow in top image) adjacent to the wrapped aneurysm (arrow in bottom image). B) DW, ADC map, axial FLAIR and contrast enhanced axial T1-weighted MRI 28 months after muslin wrapping. There is now marked abnormal peri-aneurysmal brain parenchymal T2 signal with mass effect (arrow in top right) with a large lobulated enhancing mass around the wrapped aneurysm. There are focal round areas of elevated T2 signal with elevated DW signal (arrow in top left) and ADC reduction (arrow in bottom left) with ring enhancement (arrow in bottom right). These are imaging features typically seen with intracranial abscess formation. C) Axial FLAIR and contrast-enhanced axial T1-weighted MRI. During 3 years of follow-up after diagnosis, there is improvement, but persistent abnormal peri-aneurysmal T2 signal and a ring-enhancing mass.

aging follow-up planned. Six months after diagnosis of intracranial granuloma, there was increasing peri-aneurysmal brain parenchymal T2 signal with a slight increase in the size of the ring-enhancing mass (Figure 1B). By the second year after diagnosis, prominent adjacent vascular narrowing in the adjacent M1 and M2 branches of the MCA was noted (Figure 1B). These were hemodynamically significant with a shift of the MCA-ACA watershed towards the MCA territory. Nonetheless, the patient did not report any ischemic symptoms, and there was no evidence of asymptomatic infarction on MRI, presumably due to good collateral support from ACA leptomeningeal collaterals. Over the remaining four years, there was a reduction in the peri-aneurysmal brain parenchymal

T2 signal and size of the ring-enhancing mass. At last neuroimaging follow-up at six years after diagnosis, there remains abnormal peri-aneurysmal T2 signal, peri-aneurysmal vascular narrowing and a ring-enhancing mass (Figure 1C). The patient remained asymptomatic throughout the clinical course.

Case 2

A 70-year-old female presented with an asymptomatic recurrence of a previously coiled 11-mm right MCA aneurysm. Four years previously she had presented with an unruptured right parietal arteriovenous malformation with a 19-mm right MCA flow related aneurysm.

The arteriovenous malformation was completely excised. The 19 mm flow related aneurysm reduced in size to 11-mm over two years, but persisted, so was treated endovascularly. An initial post treatment recurrence was treated again with endovascular techniques. Upon a second recurrence, microsurgical obliteration was planned. Satisfactory primary clip occlusion was not feasible due to insufficient space to place the clip beneath the coil mass without compromising the middle cerebral artery branches. The aneurysm was wrapped with muslin. The patient made an uneventful recovery, with no new neurological deficits. Routine surveillance MRI imaging 12 months later demonstrated a small amount of abnormal T2 signal in the right temporal operculum and external capsule adjacent to the wrapped aneurysm (Figure 2A). Repeat MRI 16 months later revealed marked abnormal peri-aneurysmal brain parenchymal T2 signal with a large lobulated enhancing mass around the wrapped aneurysm. There were focal round areas of elevated T2 signal with diffusion restriction and ring enhancement typically seen with intracranial abscess formation (Figure 2B). The patient had no infective or neurological symptoms. There was neither leucocytosis nor neutrophilia on laboratory investigations. The absence of clinical features suggesting intracranial infection or symptoms referable to the mass lead to a presumptive diagnosis of muslin-induced foreign body granuloma. No antibiotics or steroids were administered, and serial clinical and neuroimaging follow-up planned.

During three years of clinical and neuroimaging follow-up, there was a progressive reduction in the peri-aneurysmal brain parenchymal T2 signal, extent of local mass effect and the size of the ring-enhancing mass. There was no adjacent vascular narrowing. At last neuroimaging follow-up, there remains an abnormal peri-aneurysmal T2 signal and a ring-enhancing mass (Figure 2C). The patient remained asymptomatic throughout the clinical course.

Discussion

In the current case report we have described the temporal evolution and long-term MRI findings of conservatively managed muslin-induced foreign body granulomas after wrapping of a cerebral aneurysm. Importantly, markedly abnormal MRI findings may persist for many

years, as demonstrated in these patients with three and six-year clinical and neuroimaging follow-up after diagnosis.

Wrapping of cerebral aneurysms is uncommon in the post microsurgical era, reserved for aneurysms deemed unsuitable for endovascular treatment or primary microsurgical clipping. There are a variety of materials available in the neurosurgical armamentarium for wrapping, which include muslin, cotton sheet or autologous muscle. The ideal wrapping material is unknown. Limited inflammatory reaction produced by the wrapping material in contact with the aneurysm is desirable as this produces local thickening of the media and the adventitia from vessel wall fibrosis that theoretically results in a reduced likelihood of aneurysm rupture. However, an exuberant inflammatory reaction in response to wrapping may result from the type of material used or the host response, and can extend beyond the aneurysm and into the adjacent brain parenchyma. This rare inflammatory response has been termed foreign body granuloma and is familiar to neurosurgeons from small case series and case reports in the literature. Although no post-operative foreign body granulomas were reported in the three largest series (170 patients total) of wrapped aneurysms with long-term clinical follow-up, only six patients were reported to have undergone MR imaging¹⁻³. In a more contemporary series reporting on patients wrapped with muslin wrapping of a cerebral aneurysm between 2005 and 2008, foreign body granulomas occurred in five of 57 patients (8.8%) within two to 16 months⁶.

Including the present study, MRI features of muslin-induced foreign body granulomas have been described in 18 patients (Table 1). After aneurysm wrapping, these granulomas are characterized by the presence of a peri-aneurysmal brain parenchymal edema and a peri-aneurysmal enhancing mass. Adjacent vascular narrowing may occur in some cases, which in turn can lead to vessel occlusion and subsequent infarction.

We corroborate Yoon et al.'s findings that granulomas can be accompanied by adhesive arachnoiditis or an intracranial abscess. This is characterized as a focal area of elevated T2 signal with elevated DW signal and thin rim enhancement. To the best of our knowledge, this is the first report to demonstrate that the elevated DW signal is due to true diffusion restriction with a corresponding reduction in ADC

Table 1 Summary of MRI features upon initial diagnosis of muslin-induced foreign body granulomas reported in the literature.

Authors and Year	Case No	Peri-aneurysmal edema	Peri-aneurysmal mass	Contrast enhancing mass	Diffusion restriction typical of abscess	Adjacent vascular stenosis or occlusion (MRA or DSA)	Histology	Clinical follow-up or time to resection after initial diagnosis (nearest month)	MRI follow-up if conservative treatment or prior to any resection (nearest month)	Persistent changes on MRI
Felsberg et al., 1993	1	Yes	Yes	Yes	na	na	Yes	na	na	na
Prabhu et al., 1994	2	Na	Yes	Yes	na	na	No	na	na	na
Lee et al., 1997	2	na	Yes	Yes	na	na	Yes	26	na	na
Bhatti et al., 2000	4	Yes	Yes	Yes	na	No	No	1	na	na
	5	Yes	Yes	Yes	na	No	No	2	2	Yes
Berger et al., 2003	6	na	Yes	Yes	na	No	No	12	12	Yes
Brochert et al., 2003	7	Yes	Yes	Yes	na	No	Yes	Yes*	Yes*	Yes
Subramanian et al., 2005	8	na	Yes	Yes	na	na	No	26	3	Yes
Taravatii et al., 2006	9	Yes	Yes	Yes	na	na	No	10	na	na
Andres et al., 2007	10	Yes	Yes	Yes	Yes	Yes	Yes	0	0	na
Yoon et al., 2010	11	Yes	Yes	Yes	Yes	No	No	na^	1	Yes
	12	Yes	Yes	Yes	Yes	Yes	No	na^	24	Yes
	13	Yes	Yes	Yes	No	Yes	No	22-24	23	Yes
	14	Yes	Yes	Yes	No	na	No	22-24	11	Yes
	15	Yes	Yes	Yes	No	No	No	na^	1	Yes
Lee et al., 2012	16	na	Yes	Yes	na	Yes	No	6	na	na
Slater et al (present article)	17	Yes	Yes	Yes	No	Yes	No	72	72	Yes
	18	Yes	Yes	Yes	Yes	No	No	36	36	Yes

^ The mean clinical follow-up period ranged from 13-42 months; individual follow-up periods after initial diagnosis could not be calculated.

* The time interval to repeat MRI prior to partial resection was not reported

signal, as typical in an intracranial abscess. Most histopathological reports in the literature confirm the presence of acute and chronic inflammation within an area of fibrosis, generally without any organisms identified on Gram stains or cultures. However, there have been two reports in the literature of *Staphylococcus epidermidis* and *Candida parapsilosis* isolated via microbiological cultures⁷⁻¹⁰.

In patients with MRI confirmed granulomas managed conservatively (with no treatment or steroids only) and with follow-up MRI imaging, a persistent granuloma was identified in all patients (Table 1). In this small cohort, there was clinical improvement while imaging findings remained stable or improved. Notably, two patients demonstrated a repeat episode of inflammation after a latent period of initial clinical and radiological improvement⁶.

All previous reports of muslin-induced foreign body granulomas have been in symptomatic patients. The majority presented with visual symptoms related to inflammation affecting the optic apparatus from wrapping of paraclinoid and anterior communicating aneurysms. Our cases are unique in that they were discovered on routine surveillance MRI after aneurysm wrapping. The absence of clinical symptoms from parenchymal edema in the

right cerebral hemisphere is not unusual. This may indicate that muslin-induced foreign body granulomas may occur more frequently than expected from the current literature, as there is a paucity of MR imaging follow-up reported after wrapping of cerebral aneurysms.

Conclusion

We have described the temporal evolution and long-term MRI findings of conservatively managed muslin-induced foreign body granulomas after wrapping of a cerebral aneurysm. Typical MRI features are peri-aneurysmal brain parenchymal edema and an enhancing mass centred on the wrapped aneurysm. There may be adjacent vascular narrowing or features suggesting an intracranial abscess —focal area of elevated T2 signal, with central diffusion restriction (elevated DW signal/reduced ADC signal) and thin rim enhancement. Serial neuroimaging reveals improvement, but overall persistence of abnormal findings. Thus a history of aneurysm wrapping is critical for diagnosis. Accurate clinical recognition of this exuberant inflammatory response will avoid misdiagnosis as pyogenic abscess or tumor and prevent unnecessary or invasive treatment.

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