ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.surgicalneurologyint.com

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Neurovascular

Editor
Kazuhiro Hongo, MD
Shinshu University, Matsumoto, Japan

SNI
Open Access

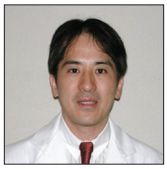
Case Report

Reversible and multiphasic parenchymal changes in MRI after coil embolization for a ruptured cerebral aneurysm

Shinya Miyamoto, Hajime Nishido, Yasushi Ino, Katsumi Hoya

Department of Neurosurgery, Teikyo University Chiba Medical Center, Ichihara, Japan.

E-mail: *Shinya Miyamoto - shinyamiyamoto@hotmail.com; Hajime Nishido - haj.nish@gmail.com; Yasushi Ino - yino-nsu@umin.net; Katsumi Hoya - khoya@med.teikyo-u.ac.jp



***Corresponding author:**
Shinya Miyamoto,
Department of Neurosurgery,
Teikyo University Chiba
Medical Center, Ichihara, Japan.

shinyamiyamoto@hotmail.com

Received : 15 February 2023
Accepted : 30 March 2023
Published : 21 April 2023

DOI
10.25259/SNI_160_2023

Quick Response Code:

ABSTRACT

Background: Reversible and multiphasic parenchymal changes in magnetic resonance imaging (MRI) are exceedingly rare. The authors experienced a case of reversible and multiphasic parenchymal changes in MRI after coil embolization for a ruptured cerebral aneurysm.

Case Description: A 48-year-old woman had a sudden onset of severe headaches and was referred to us for coil embolization. She was alert-oriented and had no neurologic deficits. Her medical history was atopic dermatitis and metal allergy. A head computed tomography (CT) scan demonstrated subarachnoid hemorrhage, and three-dimensional-CT angiography revealed a left internal carotid artery-posterior communicating artery aneurysm. Coil embolization was performed on the next day and seven coils made by three different manufacturers were used for the embolization. Despite no neurologic deficits after the surgery and no abnormal findings in MRI 7 days after the coil embolization, an MRI 2 weeks after embolization demonstrated delayed multiple white matter high intense lesions on T2-weighted image and fluid-attenuated inversion recovery in the left hemisphere. Repeat MRI scans showed multiple high intense lesions at various locations and at different timings. The blood test revealed the elevation of the proportion of EOS up to 9.7%, strongly indicating some allergic response. The MRI scan obtained 3 months after the onset confirmed the complete disappearance of the lesions.

Conclusion: Given her history of metal allergy, and the reversible and multiphasic lesions in the non-vascular territories of the treated aneurysm, metal allergic encephalitis was most likely despite no clear evidence.

Keywords: Metal allergy, Coil embolization, Parenchymal changes, Multiphasic and reversible, Cerebral aneurysm

INTRODUCTION

Delayed leukoencephalopathy (DLE) after coil endovascular surgery is a rare complication but has occasionally been reported.[5,10] The etiologies of the DLE were assumed to be foreign body emboli, contrast media, and hypersensitivity reactions to foreign bodies.[5] Among DLE, reversible and multiphasic parenchymal changes in magnetic resonance imaging (MRI) after cerebral coil embolization are exceedingly rare and only a few cases have been reported.[8] One of the suspected causes for these lesions is the metal in the coils. Metal allergy by itself is not rare, and an estimated 15–20% of the western population is hypersensitive to at least one metal allergen.[13] Sensitization rates for metallic haptens by far outnumber those reported for other common triggers of allergic contact dermatitis.[13] However, metal-induced encephalopathy is extremely rare after coil embolization for cerebral aneurysm. Dermatitis after coil embolization

without a stent deployment[17] and nickel-associated delayed white matter lesion after stent-assisted coil embolization have previously been reported.[9] The authors recently experienced an extremely rare case of reversible parenchymal lesions after simple coil embolization for the ruptured cerebral aneurysm. Herein, we report our case with some discussion.

CASE DESCRIPTION

A 48-year-old Japanese woman had a sudden onset of severe headaches early in the morning during work and was transported to a local hospital. She was alert-oriented and had no neurologic deficits. She had a medical history of atopic dermatitis and metal allergy that had discouraged her from wearing any jewels.

A head computed tomography (CT) scan demonstrated a subarachnoid hemorrhage (SAH) around the basal cistern with predominant SAH in the left sylvian cistern. A three-dimensional-CT angiography revealed a left internal carotid artery (ICA)-posterior communicating artery (Pcom) aneurysm. Although an emergent aneurysm clipping surgery was scheduled, the patient preferred a coil embolization rather than an open surgery so that she was referred to us for a coil embolization.

On the next day after the onset, a coil embolization was performed using a simple technique under the general anesthesia. The left ICA angiogram confirmed an irregular-shaped aneurysm measuring 7.7 mm in the maximum diameter at the left ICA-Pcom junction. Besides the ICA-Pcom aneurysm, aneurysms at the bilateral middle cerebral artery (MCA) bifurcations and at the top of the right ICA were also revealed. Given the distribution of SAH as well as the size and the shape of the aneurysm, the left ICA-Pcom aneurysm was believed to be the cause of the SAH.

A guiding sheath (Flexor shuttle 7F × 90 cm ST 0.100”/2.54 mm) was advanced to the pre-petrous portion of the left ICA. A microcatheter (Excelsior SL-10 pre-shaped 90°) was placed in the aneurysm using a manual-shaped intermediate catheter (TACTICS 120 cm STR). Seven coils were used for the complete obliteration of the aneurysm (Raymond-Roy occlusion classification class I) and are listed in Table 1. The patient recovered well without any neurologic deficits. The head CT scan right after the embolization showed no abnormal findings, as shown in Figure 1.

Despite no neurologic deficits after the surgery and no abnormal findings on a MRI 7 days after the coil embolization, an MRI study performed 24 days after the embolization demonstrated a round lesion beside the posterior horn of the left lateral ventricle, as shown in Figure 2. The lesion showed homogeneously moderately high intensity on the T2-weighted image (T2WI) and the fluid-attenuated inversion recovery (FLAIR) sequence, mildly high intensity on the apparent diffusion coefficient (ADC) map but isointensity on diffusion-weighted imaging (DWI). An MRI taken 44 days after the surgery showed multiple patchy lesions at separate locations of the left frontal and parietal lobes. The lesions demonstrated high intensity on FLAIR as the previous one. An MRI obtained 70 days after the surgery still demonstrated an even larger high intense lesion on T2WI, FLAIR, and ADC map and an isointensity on DWI in the left frontal lobe, though the previous lesion had disappeared. An MRI taken 146 days after the surgery showed complete disappearance of the abnormal high intense lesions finally.

Meanwhile, the ratio of eosinophils (EOS) among the leukocytes was 3.0% (0.0–7.0%) before the surgery, and it elevated up to 9.7% 16 days after the coil embolization and got back to 2.6% 147 days after the surgery, as shown in Figure 2.

Despite the MRI findings, the patient showed no neurologic deficits and complained of only mild headaches throughout the course. No specific treatments were performed, and the headaches gradually subsided and finally resolved completely.

The patient subsequently underwent a metal skin patch test that showed positive against only zinc though the patch test covered neither titanium, tungsten, nor molybdenum, as shown in Table 2.

DISCUSSION

Coil embolization has emerged as the mainstay treatment for cerebral aneurysms. The prognosis and outcome after a coil embolization has proved to be as favorable as those after a clipping surgery in SAH patients. Nowadays, a wide range of coils for cerebral aneurysms have been produced and provided from many manufacturers worldwide.

Small scattered cerebral infarcts are not rare on a post-surgical MRI after a coil embolization. High intense lesions on DWI and FLAIR of the MRI study after coil embolization are mostly cerebral infarcts related to the surgery. First, we suspected scattered embolization associated with the surgery, though the patient had only headaches. However, we found that one of the presented high intense lesions showed atypical appearance such as a round and homogeneously high intensity located near the posterior horn that was in the non-vascular territory of the treated aneurysm. Moreover, those lesions disappeared in a few weeks without any treatments, and similar lesions appeared at separate locations in the same hemisphere. The patient never had neurologic deficits and had only mild headaches throughout the course, but these lesions continued for a few months after the surgery.

Delayed atypical white matter lesions after coiling have been documented. Metal allergy, acute disseminated encephalomyelitis (ADEM)-like reaction due to contrast

medium,[3] polyglycolic-polylactic acid (PGLA) coil allergy,[15] polyvinylpyrrolidone (PVP) embolism, and PVP allergy have been reported to be the cause for the delayed white matter lesions.

ADEM is mostly seen in young children who are infected with viruses or after vaccination shots. Since symptoms of ADEM are acute and severe, ADEM-like reactions due to contrast medium are unlikely to have occurred in our patient.

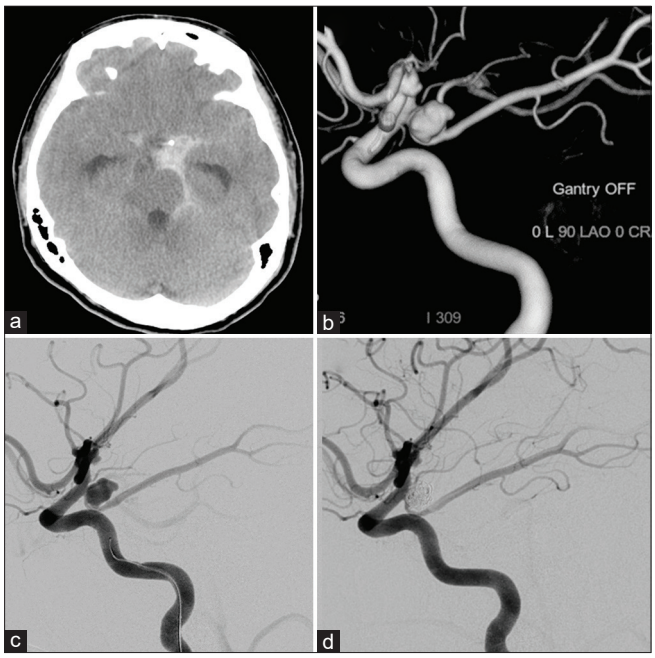


Figure 1: (a) Head computed tomography (CT) scan revealing subarachnoid hemorrhage in the basal cistern and in the left ambient cistern, (b) pre-operative three-dimensional CT angiography depicting the left internal carotid-posterior communicating (IC-PC) aneurysm, (c) pre-operative cerebral angiogram confirming the left IC-PC aneurysm, and (d) post-operative cerebral angiogram showing the complete obliteration of the aneurysm (Raymond-Roy occlusion classification class I) by simple coil embolization.

Although PGLA coils were not used for our patient, PVP is used in most of the catheters for hydrophilic coating. The detachment of PVP from the surface of a catheter has recently been reported to occur due to the friction between a catheter and a guidewire,[1,14] which may cause cerebral artery embolism or granulation tissue following the local inflammation.[6] PVP microembolism frequently manifested severe complications such as altered metal status, paresis, and even death, whereas our patient had no specific symptoms. Furthermore, the DWI did not show any high signals and that the FLAIR showed high intense areas at various places every time even in the non-vascular territories of the treated aneurysm, the microembolisms due to PVP detachment were very unlikely.

A few past articles reported PVP allergies; however, they were all anaphylaxis.[12,18] Delayed PVP allergies can be induced by a fragmentation of PVP that has been detached from the surface of the PVP-coated catheters. In order for a PVP fragment to cause multiphasic delayed allergies, it must stay in the vessel for an extended period of time. In addition, it should cause high intense lesions on the DWI in the vascular territories of the treated aneurysm like the previous case.[8] Our patient showed no high intense lesions on DWI but showed delayed multiphasic high intense lesions even in the non-vascular territories of the treated aneurysm on FLAIR. Hence, metal allergies due to coils are more likely to have happened in our patient considering her medical history of metal allergies.

Many symptomatic patients received a corticosteroid regimen and recovered almost fully after treatment.[10] Early high dose followed by low dose ongoing corticosteroid treatment was recommended for timely remission.[10] However, a few mildly

Table 1: The list of the coils for the embolization.

	Manufacturer	Name of coil	Size	Composition in coil	Core wire
#1	Stryker	Target 360 SOFT	6 mm×20 cm	Platinum, tungsten	Stainless steel (SUS316L: Iron, Chromium 18%, Nickel 12～15%, Molybdenum 2.5%, Carbon), polyimide
#2	Stryker	Target 360 ULTRA	4 mm×8 cm	Platinum, tungsten	Stainless steel (SUS316L: Iron, Chromium 18%, Nickel 12～15%～Molybdenum 2.5%, Carbon), polyimide
#3	Stryker	Target 360 ULTRA	4 mm×8 cm	Platinum, tungsten	Stainless steel (SUS316L: Iron, Chromium 18%, Nickel 12～15%～Molybdenum 2.5%, Carbon), polyimide
#4	Medtronic	AXIUM Prime 3D	3 mm×6 cm	Platinum, tungsten, stainless steel, polypropylene	Platinum, tungsten, stainless steel, polytetrafluoroethylene, polyethylene terephthalate
#5	Stryker	Target 360 ULTRA	2.5 mm×4 cm	Platinum, tungsten	stainless steel (SUS316L: Iron, Chromium 18%, Nickel 12～15%, Molybdenum 2.5%, Carbon), polyimide
#6	Kaneka Medics	i-ED COIL SS	2.5 mm×4 cm	Platinum, tungsten	Stainless steel, polyimide, polyvinyl alcohol, fluorocarbon polymers
#7	Kaneka Medics	i-ED COIL SS	2.5 mm×4 cm	Platinum, tungsten	Stainless steel, polyimide, polyvinyl alcohol, fluorocarbon polymers

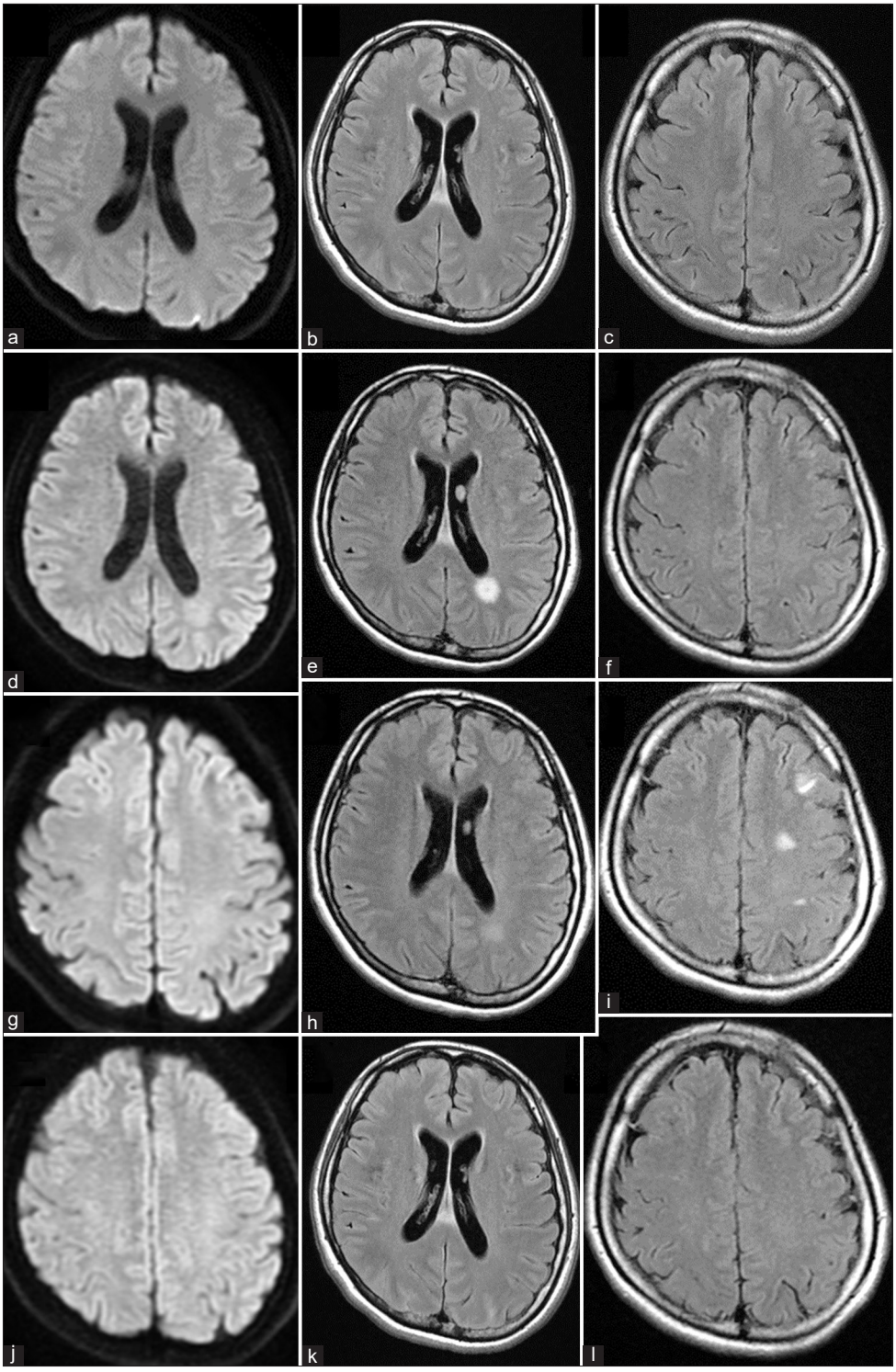


Figure 2: (a) Diffusion-weighted imaging (DWI) on postoperative day (POD) 7 showing no high signals, (b and c) fluid-attenuated inversion recovery (FLAIR) on POD7 showing no abnormal findings, (d) DWI on POD24 showing no high intense lesions, whereas (e and f) FLAIR on POD24 demonstrating a strange round high intense lesion beside the posterior horn of the left lateral ventricle. (g) DWI on POD44 showing no high signals, whereas, (h and i) FLAIR on POD44 depicting scattered small high intense lesions in the left frontal lobe, (j) DWI on POD146 showing no abnormal findings, and (k and l) FLAIR on POD146 confirming the complete disappearance of the high intense lesions.

Table 2: The result of the metal patch test.

S. No.	Metal	%	Base	Day2	Day3	Day7
1.	Al^{3+}	2.0	A	-	-	-
2.	Au^{3+}	0.2	A	-	-	-
3.	Sn^{4+}	1.0	A	-	-	-
4.	Fe^{3+}	2.0	A	-	-	-
5.	Pt^{2+}	0.5	A	-	-	-
6.	Pd^{2+}	1.0	A	-	-	-
7.	In^{3+}	1.0	A	-	-	-
8.	Ir^{4+}	1.0	A	-	-	-
9.	Zn^{2+}	2.0	P	Only erythema	Only erythema	Erythema and edema
10.	Mn^{2+}	2.0	P	Only erythema	Only erythema	-
11.	Ag^{+}	2.0	P	-	-	-
12.	Cr^{3+}	0.5	A	-	-	-
13.	Co^{2+}	2.0	A	-	-	-
14.	Cu^{2+}	1.0	A	-	-	-
15.	Hg^{2+}	0.1	A	-	-	-
16.	Ni^{2+}	5.0	A	-	-	-
	Vaseline			-	-	-

A: Purified water, P: White petrolatum, Al: Aluminum, Au: Gold, Sn: Tin, Fe: Iron, Pt: Platinum, Pd: Palladium, In: Indium, Ir: Iridium, Zn: Zinc, Mn: Manganese, Ag: Silver, Cr: Chromium, Co: Cobalt, Cu: Copper, Hg: Mercury, Ni: Nickel

symptomatic patients were observed without any specific treatment like our patient and recovered well.[10] Therefore, we believe that a steroid regimen is not always needed, especially for asymptomatic DLE patients.

Metal hypersensitivity reactions are usually manifested as a T-cell-mediated delayed type 4 reaction with characteristic cutaneous pruritic lesions.[13] Eosinophilia defined as a peripheral blood eosinophil count >450 cells per microliter, is associated with numerous disorders including allergies, drug reactions, and helminth infections.[4] Hence, given her medical history of atopic dermatitis and metal allergy, elevation of EOS during the course, and the atypical appearances of the lesions, we strongly suspected that high intense lesions were encephalitis due to coil metal allergy, and elected to forgo a brain biopsy and not to give any additional treatments for the lesions.

A delivery wire is generally made of stainless steel that is an alloy of iron, nickel, and molybdenum plus some plastic, even though the wire is only used during a surgery. Although a minute amount of nickel ion is released when the coils are detached from the delivery wire, the amount should be far below the acceptable level of safety.[7]

Coils for cerebral aneurysms are generally made of an alloy that contained 92% platinum and 8% tungsten. Platinum is a precious metal that is widely used for jewels and its allergy is rare. However, dermatitis caused by metal allergy after coil embolization for unruptured cerebral aneurysm was reported.[17] Although our patient showed a negative patch-test reaction to platinum, platinum allergy cannot be completely denied because the patient had jewelry allergies.

Tungsten is known to have some metabolic and toxicity profiles. Despite this, tungsten and its compounds are not considered very toxic for humans. Most existing human toxicology information comes from chronic occupational exposure. However, in a previous case of urticaria after percutaneous varicocele coil embolization, the patient was found to be allergic to tungsten on the immunological tests.[2] As the patch test did not cover tungsten, whether our patient had allergy to tungsten was unknown.

As far as the coil embolization systems that we used are concerned, it is notable that only the axium prime detachable coil system uses the stainless steel for coils, which means nickel stays in the body even after a simple coil embolization without stent-assistance. As most stents are made of nitinol that is an alloy made of 45% of titanium and 55% of nickel in general, there has been a great deal of concern regarding the release of nickel.[16] The mean serum nickel level significantly increased at 24 h, had a maximum level at 1 month, and declined to the baseline at 12 months.[11] Reversible intracranial parenchymal changes in MRI after an MCA aneurysm treatment with stent-assisted coiling technique was reported.[16] Thus, the possibility of nickel allergies in our patient cannot be totally excluded irrespective of no use of stents and the negative patch-test reactions to nickel.

CONCLUSION

The authors experienced a rare case of reversible parenchymal changes in the MRI after coil embolization for the ruptured cerebral aneurysm. Despite no clear evidence, given the medical history of metal allergies, no high signals on DWI,

and delayed, reversible, and multiphasic lesions in the non-vascular territories of the treated aneurysm, metal-induced encephalitis was most likely in our case.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Barnwell SL, D'Agostino AN, Shapiro SL, Nesbit GM, Kellogg JX. Foreign bodies in small arteries after use of an infusion microcatheter. AJNR Am J Neuroradiol 1997;18:1886-9.
2. Clague GA, McGann G, Gilbert H. An unusual allergy to platinum embolization coils. Cardiovasc Intervent Radiol 2012;35:215-6.
3. Deus-Silva L, Lum C, De Meulemeester C, dos Santos MP. Severe aggressive acute disseminated encephalomyelitis-like reaction after aneurysm coiling. Neurosurgery 2010;66:E222-3; discussion E223.
4. Fulkerson PC, Rothenberg ME. Targeting eosinophils in allergy, inflammation and beyond. Nat Rev Drug Discov 2013;12:117-29.
5. Ikemura A, Ishibashi T, Otani K, Yuki I, Kodama T, Kan I, *et al*. Delayed leukoencephalopathy: A rare complication after coiling of cerebral aneurysms. AJNR Am J Neuroradiol 2020;41:286-92.
6. Mehta RI, Mehta RI, Solis OE, Jahan R, Salamon N, Tobis JM, *et al*. Hydrophilic polymer emboli: An under-recognized iatrogenic cause of ischemia and infarct. Mod Pathol 2010;23:921-30.
7. Nagaraja S, Di Prima M, Saylor D, Takai E. Current practices in corrosion, surface characterization, and nickel leach testing of cardiovascular metallic implants. J Biomed Mater Res B Appl Biomater 2017;105:1330-41.
8. Nakamizo S, Miura S, Nakamura N, Okada M, Sakagami Y. A case of multiple brain lesions associated with hydrophilic polymer allergy after coil embolization that showed repeated progression and regression. No Shinkei Geka 2019;47:869-75.
9. Park HS, Nakagawa I, Yokoyama S, Wajima D, Wada T, Motoyama Y, *et al*. Nickel-associated delayed multiple white matter lesions after stent-assisted coil embolization of intracranial unruptured aneurysm. BMJ Case Rep 2017;2017:bcr2017013005.
10. Ridwan S, Kandyba JA, Schug A, Malsagov E, Karageorgos N, Hans FJ. Delayed leukoencephalopathy and foreign body reaction after endovascular treatment in patients with intracranial aneurysms and aneurysmal subarachnoid hemorrhage-a systematic review of the literature. Front Surg 2021;8:732603.
11. Ries MW, Kampmann C, Rupprecht HJ, Hintereder G, Hafner G, Meyer J. Nickel release after implantation of the Amplatzer occluder. Am Heart J 2003;145:737-41.
12. Ronnau AC, Wulferink M, Gleichmann E, Unver E, Ruzicka T, Krutmann J, *et al*. Anaphylaxis to polyvinylpyrrolidone in an analgesic preparation. Br J Dermatol 2000;143:1055-8.
13. Schmidt M, Goebeler M. Immunology of metal allergies. J Dtsch Dermatol Ges 2015;13:653-60.
14. Shapiro M, Ollenschleger MD, Baccin C, Becske T, Spiegel GR, Wang Y, *et al*. Foreign body emboli following cerebrovascular interventions: Clinical, radiographic, and histopathologic features. AJNR Am J Neuroradiol 2015;36:2121-6.
15. Skolarus LE, Gemmete JJ, Braley T, Morgenstern LB, Pandey A. Abnormal white matter changes after cerebral aneurysm treatment with polyglycolic-polylactic acid coils. World Neurosurg 2010;74:640-4.
16. Ulus S, Yakupoglu A, Kararslan E, Islak C, Siva A, Kocer N. Reversible intracranial parenchymal changes in MRI after MCA aneurysm treatment with stent-assisted coiling technique; possible nickel allergy. Neuroradiology 2012;54:897-9.
17. Uwatoko T, Tsumoto T, Wada N, Urabe K, Sanbongi Y, Tokunaga S, *et al*. Dermatitis caused by metal allergy after coil embolization for unruptured cerebral aneurysm. J Neurointerv Surg 2016;8:e42.
18. Yoshida K, Sakurai Y, Kawahara S, Takeda T, Ishikawa T, Murakami T, *et al*. Anaphylaxis to polyvinylpyrrolidone in povidone-iodine for impetigo contagiosum in a boy with atopic dermatitis. Int Arch Allergy Immunol 2008;146:169-73.

How to cite this article: Miyamoto S, Nishido H, Ino Y, Hoya K. Reversible and multiphasic parenchymal changes in MRI after coil embolization for a ruptured cerebral aneurysm. Surg Neurol Int 2023;14:147.