Turk Neurosurg 31(4):661-664, 2021

Technical Note

DOI: 10.5137/1019-5149.JTN.31097-20.2

Received: 06.06.2020
Accepted: 19.10.2020

Published Online: 08.04.2021

An Alternative Endovascular Technique for Vein of Galen Aneurysmal Malformation Treatment: Etylene Vinyl Alcohol Co-Polymer Embolization via Double-Lumen Balloon Microcatheter

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ABSTRACT

AIM: To present an alternative endovascular treatment option for the vein of Galen aneurysmal malformation by ethylene-vinyl alcohol copolymer embolization via a double-lumen balloon microcatheter.

MATERIAL and METHODS: A female patient was suspected with the vein of Galen aneurysmal malformation in the prenatal period and diagnosed choroidal type vein of Galen aneurysmal malformation. Once the patient was symptomatic with severe cardiac failure, an endovascular treatment decision was made. In the first step, a mixture of N-butyl cyanoacrylate-lipiodol was used for embolization. In the second session of the treatment, ethylene-vinyl alcohol copolymer was administered through a double-lumen balloon microcatheter.

RESULTS: Complete cure of the aneurysmal malformation was obtained by no filling was observed in arterial feeders, collapsed appearance of the vein of Galen, and arterial-venous shunts at the end of the five-year follow-up period with magnetic resonance imaging and angiography.

CONCLUSION: Ethylene-vinyl alcohol copolymer embolization via double-lumen balloon microcatheter provides an alternative and effective endovascular treatment option for the vein of Galen aneurysmal malformations using less contrast agent in less procedural time. Also, the possibility of spontaneous regression of residual aneurysmal malformations with small feeders should be considered.

KEYWORDS: Aneurysm, Cerebral Veins, Vein of Galen, Ethylene vinyl alcohol, Endovascular embolization

ABBREVIATIONS: VGAM: Vein of Galen aneurysmal malformation, **NBCA:** N- butyl cyanoacrylate, **AVM:** Arterio-venous malformation, **DMSO:** Dimethyl sulphoxide, **EVOH:** Ethylene-vinyl alcohol copolymer, **AVF:** Arterio-venous fistula

INTRODUCTION

Vein of Galen aneurysmal malformation (VGAM) is a malformation that leads to a high-flow arteriovenous fistula; accounts for approximately 1% of all vascular malformations (1). VGAM is characterized by the embryonic origin and can result in severe morbidity and mortality. Surgical treatment is limited, and 80 to 100 % of cases result in death. By the development of endovascular embolization techniques, the outcomes of VGAM are significantly improved. Additionally, persistent heart failure and multiple organ failure can be prevented by the endovascular approach (2,7).

This study aimed to report the following two endovascular treatment sessions for a VGAM case and highlight an alternative endovascular treatment technique as ethylene-vinyl alcohol copolymer embolization via a double-lumen balloon microcatheter, which is relatively little published.

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PROCEDURAL TOOLS and TECHNIQUE

A female patient was suspected of VGAM in the prenatal period by supracerebellar vascular lesion and concomitant hydrocephalus. After birth, cranial magnetic resonance imaging revealed an aneurysmal dilatation of Galen's vein with multiple vascular structures extending to the bilateral inferior perimesencephalic cistern (Figure 1A).

Upon developing severe symptoms of cardiac failure, a 15-day-old patient was admitted to the angiography unit. By biplane angiography device (Artis Zee® biplane, Siemens Healthcare, Erlangen, Germany), pre-procedural angiographic evaluation confirmed choroidal type VGAM had feeding arteries from both posterior cerebral arteries, posterior choroidal arteries, and anterior cerebral arteries (Figure 1B). The feeder originating left posterior cerebral artery was catheterized with 0,012 inch hydrophilic guidewire (Radifocus® Guidewire M Non-Vascular - Guidewire – Terumo Europe)-0.017 inch microcatheter (Echelon 10™, Medtronic, Irvine, USA) and N-butyl cyanoacrylate (NBCA) (Histoacryl®, B. Braun Surgical S.A., Barcelona, Spain) –lipiodol (glue) embolization was performed. Despite using a 70% glue mixture during the procedure, minimal nontarget embolization was observed to the vein of Galen and sinus rectus because of the high rate of flow in the VGAM. The procedure was terminated to continue another session due to the maximum dose of contrast agent used (13 cc for 2800-gram baby). This procedure took about three hours. Medical treatment was regulated, and cardiac symptoms were followed up.

The patient was admitted to the second session 15 days after the first procedure due to worsened cardiac symptoms. Based on the first procedure's experience, the residue multiple feeders of the choroidal VGAM were planned to be embolized with ethylene-vinyl alcohol copolymer (Onyx-18, Medtronic, Irvine, USA), which used in arterio-venous malformation (AVM) treatment. The feeding artery originated from the right posterior cerebral artery was catheterized with a 0.014-inch hydrophilic guidewire (Syncro™, Striker, California, USA) and a double-lumen balloon microcatheter (Scepter C™, Microvention, Terumo Group). Test injection was performed by balloon inflation. Following the dimethyl sulphoxide (DMSO) administration through the balloon microcatheter, ethylene-vinyl alcohol copolymer (EVOH) was injected safely. Feeders from both posterior-anterior cerebral arteries and embryonic choroidal arteries opened into the prosencephalic vein's lateral wall were embolized. Although minimal filling was observed in the left choroidal artery feeders (Figure 2), the flow of the VGAM and straight sinus was reduced, and contrast stagnation began. This procedure was completed with only 7 cc contrast agent usage in one hour.

The cardiac failure symptoms of the patient were improved rapidly after the second session. At the end of the five-year follow-up period with magnetic resonance imaging and angiography, there was no filling observed in arterial feeders and aneurysmal malformation. Collapsed appearance of vein of Galen and arterial-venous collaterals was considered as total recovery from VGAM (Figure 3A-D). On clinical examinations during the follow-up, the patient had no cognitive impairment, and no neurological deficits were detected.

DISCUSSION

VGAM occurs between 6th and 11th gestational weeks, with connections between the median prosencephalic vein (Markowski's vein) and primitive choroidal vessels (1).

VGAM is classified into two groups: The choroidal type (type I) is usually present early in life, is the most common and most complex type. Both anterior and posterior cerebral artery branches and all choroidal arteries with interconnections have contributed. The mural type (type II) usually has a single or multiple direct arterio-venous fistula (AVF) draining to the median prosencephalic vein's inferolateral side. AVF leads to abnormal flow that prevents embryonic venous regression and subsequent VGAM development. Mixed types with choroidal

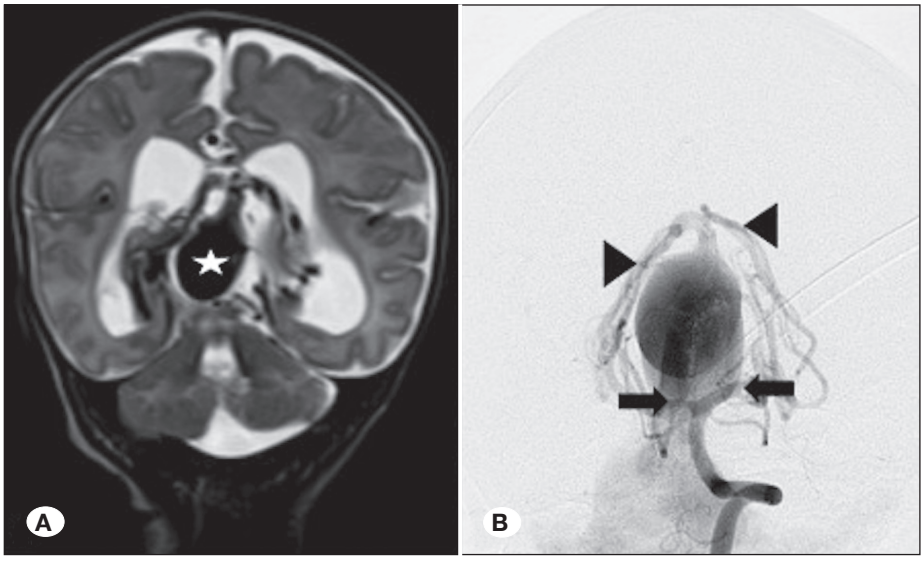

Figure 1: Coronal T2-weighted image **(A)** demonstrated an aneurysmal dilatation of vein of Galen (star) accompanying multiple vascular structures extending to the bilateral inferior perimesencephalic cistern. Anterior-posterior view of left vertebral artery injection **(B)** illustrated multiple fistulous vascular structures (arrowheads) originated from bilateral posterior cerebral arteries (arrows) and draining to the primitive prosencephalic vein that causing aneurysmal malformation.

and mural types are also seen (7). The presented case was a choroidal VGAM (type I).

Despite effective and supportive care, VGAM often results in multisystem failure and death. However, significant improvements have been observed in the treatment of this malformation over the past decade. Successful results have been obtained by reducing the aneurysmal blood flow due to the embolization of the aneurysm' feeding arteries by the endovascular approach (2). Several authors strongly advocate the use of liquid acrylic embolic agents for the treatment of VGAM. The ability to inject these agents through microcatheters in tortuous vascular structures that are generally encountered in VGAM is a benefit of these agents (3). In the first treatment session of the case presented, only one feeder of VGAM was embolized with a mixture of 70% N-butyl cyanoacrylate (NBCA)–lipiodol (glue).

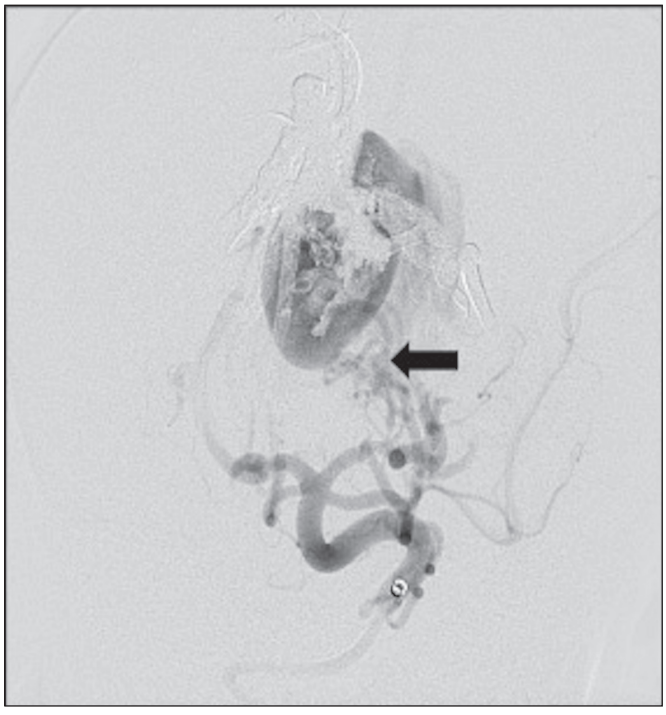

Figure 2: Post-embolization control basilar artery injection revealed retrograde embolization of multiple feeders of VGAM, and minimal residual filling (arrow) was observed in left choroidal artery feeders draining to the left inferolateral side of VGAM.

Ethylene-vinyl alcohol copolymer (EVOH) is a permanent, non-adhesive liquid embolic agent that has shown preferable results compared to NBCA-lipiodol. The ability to stop EVOH injection and evaluate its penetration can minimize nontarget embolization (4). Besides, double-lumen balloon microcatheters have been successfully used for flow control to prevent nontarget embolization. Simultaneous balloon inflation occluded the proximal side of the afferent artery and prevented backflow of the embolic agent. Thus simplified the control precipitation of the EVOH in the feeder artery and the arterial-venous shunt point (8). In the presented case, a feeder originated right posterior cerebral artery was temporarily occluded with balloon inflation as close as possible to the AVF. Then the right side of the feeders was embolized by EVOH injection via a double-lumen balloon microcatheter.

Double-lumen balloon microcatheters may provide embolization of several feeders in the same session in less time using less contrast agent. The shortening of the procedure time reduces the X-ray exposition dose, which is especially important in the pediatric patient population. However, the presented technique has some limitations: This technique has additional risks comparing with NBCA-lipiodol embolization; because double-lumen balloon microcatheters are stiffer than the flow-guided, lower caliber, detachable tip microcatheters which are routinely used for NBCA-lipiodol injection. That is why catheterization of small feeder arteries more difficult in case of prominent tortuosity (8). Especially with the evolution of the technology, the problem of distal navigation in double-

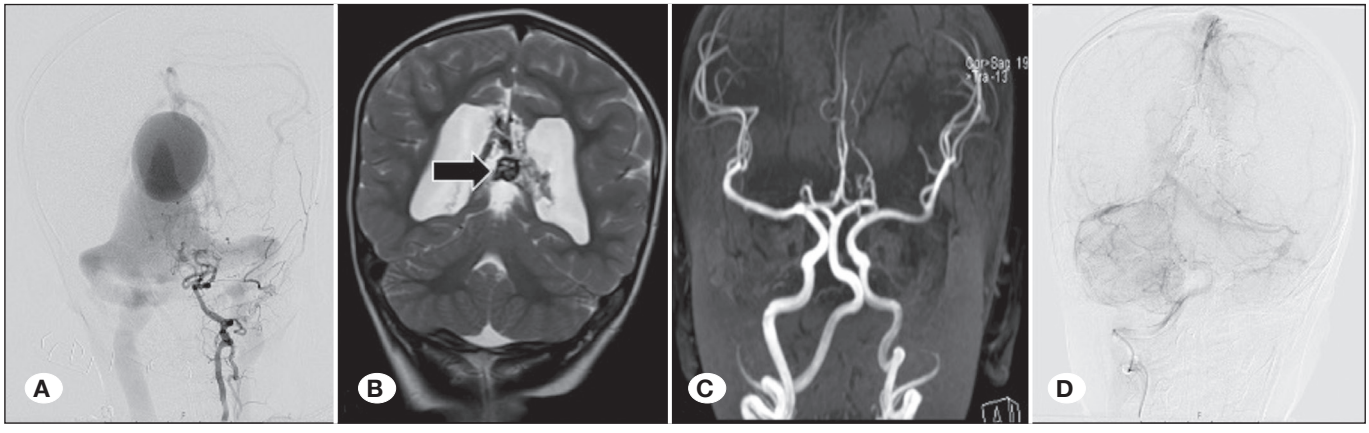

Figure 3: Pre-treatment anterior-posterior view of venous angiogram by left vertebral artery injection **(A)**. Fifth-year control coronal T2-weighted magnetic resonance image **(B)**, cranial MR-angiography **(C)**, and anterior-posterior view of venous angiogram by right vertebral artery injection **(D)** demonstrated complete regression of the vein of Galen aneurysmal malformation and arterial-venous collateral vascular structures. A focal hypointense appearance (arrow) on coronal T2-weighted image **(B)** is compatible with residue ethylene-vinyl alcohol copolymer material.

lumen balloon microcatheters is overcome, and more flexible catheters will provide effective embolization with flow control in patients with cerebral arteriovenous malformations and arteriovenous fistulas.

On the other hand, spontaneous regression of such residual aneurysmal malformations with small feeders should be considered. Several studies in the literature confirm that small aneurysmal malformations can spontaneously regress over time (5,6).

CONCLUSION

Ethylene-vinyl alcohol copolymer embolization via double-lumen balloon microcatheter is an effective and alternative option for endovascular treatment in selected cases with the vein of Galen aneurysmal malformation. This technique enables more vascular structure embolization in less procedural time using less contrast agent with the flow control mechanism.

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