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Endovascular Management of Vein of Galen Aneurysmal Malformations: A Retrospective Analysis over a 15-Year Period

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Abstract

Objectives—This retrospective study was aimed at assessing our results of endovascular management in vein of Galen aneurysmal malformation (VGAM).

Materials and Methods—This is a retrospective study of 26 patients of VGAM who underwent endovascular treatment between 1998 and 2012. All patients underwent trans-arterial embolization. Of 26 patients, 23 were treated using *n*-butyl cyano acrylate (Glue), while 3 out of 26 patients were treated using the ethylene vinyl alcohol (EVOH) copolymer.

Results—Ages of the treated patients ranged from 1 day to 18 years of age. Of the patients treated, 17 were males and 9 were females. Around 15 of the VGAMs were of the mural variety and 11 were choroidal in nature. A good outcome was seen in 22/26 (85%) of the patients. Complications were seen in total in 7/26 patients (26.92%) of which 3/26 (12%) has a fatal outcome.

Conclusion—Endovascular embolization for VGAMs is highly efficacious and has helped create a population of VGAM survivors in this condition, which until only a few decades ago caused high mortality and morbidity.

Keywords

Vein of Galen aneurysmal malformations (VGAMs); glue; EVOH; Onyx; vein of Galen (VOG)

INTRODUCTION

The past three and a half decades have seen a better understanding of the management of vein of Galen aneurysmal malformation (VGAM), which is a congenital vascular malformation that comprises 1% of all pediatric congenital anomalies and about 30% of all pediatric vascular malformations [1–3]. Abnormal embryonic development causes arterial shunting into the median prosencephalic vein (MProsV) of Markowski, which although is a precursor of the vein of Galen (VOG), is a separate entity, making the term VOG malformation a misnomer. These rare malformations are challenging to manage in view of differences encountered in their clinical presentation, physiological effects on various organ systems and their architecture. The initial results of surgical management of this condition were dismal [4,5], and it was the pioneering work of Lasjaunas and colleagues which offered a better understanding of the pathophysiology of this malformation and established endovascular embolization as the modality of treatment for it [6–8].

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Table 1. Clinical features

Clinical feature	No. of patients(1 month–2 years)	No. of patients (2–16 years)
Macrocrania	11/16 (68.75%)	4/8 (50%)
Dysnea on feeding/CCF	1/16 (6.25%)	—
Developmental/neurocognitive delay	5/16 (31.25%)	3/8 (37.5%)
Seizures	2/16 (12.5%)	3/8 (37.5%)
Failure to thrive	1/16 (6.25%)	—
Prominence of scalp veins	3/16 (18.75%)	1/8 (12.5%)
Diminution of vision	—	2/8 (25%)
Focal neurological deficit	—	2/8 (25%)
Headaches	—	1/8 (12.5%)

Table 2. Complications

Complication	No. of patients
None	18/26 (69.2%)
Minor complications with good recovery: Glue granuloma, visual deterioration, Apnoeic spell (ventilated), Transverse sinus thrombosis (anticoagulation done)	(4/26 = 15.4%)1/26 (3.8%)1/26 (3.8%)1/26 (3.8%)1/26 (3.8%)
Major complications (leading to major morbidity/ death): Glue progression into SSS, Cardiac failure, IVH	1/26 (death) (3.8%), infant1/26 (death) (3.8%), neonate2/26 [one death (infant), other had poor recovery, mRS < 2] (7.7%)

MATERIALS AND METHODS

Twenty-six patients with VGAM were treated between 1998 and 2012 and data retrospectively analyzed. There were 17 males and 9 females whose age ranged from 1 day to 18 years. Of these, one was a neonate, 16 were in the infantile age group (1 month to 2 years), eight were children (2–16 years), and one adult (more than 16 years). Infants were selected for embolization typically after six months of age, and in only one case, embolization was performed in the neonatal period. All patients underwent angiography and embolization in the same session on a bi-plane angiography unit (Integris, Allura, Philips). Once the angioarchitecture was studied, the usual approach for transarterial embolization involved using a common femoral arterial access and placement of a 5F or 6F guiding catheter (Envoy, Codman Neurovascular or Guider, Stryker Neurovascular) in the ICA or the vertebral artery. A suitable microcatheter (Marathon, Medtronic/Prowler, Codman Neurovascular/ NeuroRenegade, Boston Scientific) was used over a suitable microwire to access the artery and navigate as close to the fistulous site as possible. After suitability of microcatheter position was ascertained using microcatheter angiograms, embolization was performed using concentrated n-BCA (75%–100%) admixed with either Lipiodol (Guerbet) or Tantalum powder. Of the 26 patients, 23 were embolized using n-BCA, while three patients were embolized using ethylene vinyl alcohol EVOH) (Onyx-34, EV3). The patient population was typically followed up clinically at one month, by MRI at three months, and angiography at 1 year or earlier if required. If multiple sessions of treatment were planned, then subsequent sessions were performed at a 3- to 6-month interval.

Results

Twenty-six patients with VGAM were treated of which 17 were males and 9 were females. Various clinical features at the time of presentation in infants and children are as summarized in Table 1. Only one neonate was treated who had an antepartum diagnosis made in the second trimester of gestation with USG and MRI. There was antenatal Doppler evidence of congestive cardiac failure. Postpartum neonate had a congestive cardiac failure. There were no seizures. No renal or hepatic insufficiency was present. The single patient in the adult (>16 years) group presented with recurrent seizures. There was no macrocrania, neurocognitive delay, or other symptoms.

Morphological type, endovascular treatment outcome and complications

Of the 26 patients treated, 15 were of the mural type and 11 were of the choroidal variety. Transarterial embolization was performed in all patients. The glue was the agent of embolization in the majority (23/26 patients). Transarterial Onyx embolization was performed in 3/26 patients. Total complications were seen in 7/26 patients (26.92%). Complications (Table 2) included minor complications which were seen in 4 out of 26 patients (15.4%). Of these, one patient had glue granuloma formation which resolved after a course of steroids and antibiotics, one child had visual deterioration which required VP shunt placement, another had a sudden apnoeic spell which mandated ventilation, and one had transverse sinus thrombosis which improved after anticoagulation. Major complications were seen in 4 out of 26 patients. Of these, three had a fatal outcome (11.5%) and one had an mRS < 2 at the time of discharge. Therefore, a good outcome was seen in 22/26 (85%) of the patients. A poor outcome was seen in 4/26, i.e., 15.4% of the patients, of which there were 3/26 deaths (11.5%).

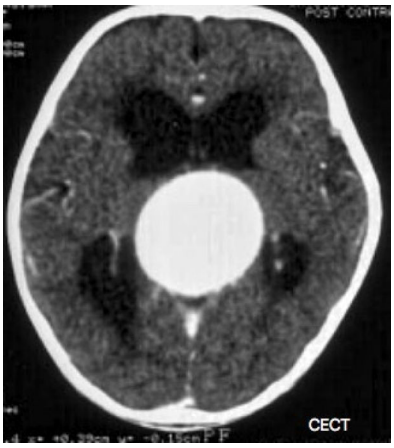

Figure 1. CECT of the brain shows a dilated median vein and hydrocephalus. There is no atrophy or parenchymal calcification present.

ILLUSTRATIVE CASES

Case 1

A nine-month-old male infant presented with h/o progressively increasing head size since birth and delayed milestones. The infant was a full-term normal delivery and cried at birth. There was no history of difficulty in feeding, sweating episodes, or irritability. On examination, the infant was of normal length and weight. Macrocrania was present. In addition, a dark cutaneous patch was present on the lower back. Delayed milestones were present in the form of absence of head holding, inability to sit or grasp objects. Systemic examination was within normal limits. CECT (Figure 1) showed a dilated median vein and hydrocephalus. No features of cerebral atrophy or parenchymal calcification were present.

Angiography showed a mural type of VGAM supplied by medial and lateral posterior choroidal arteries and embolized using concentrated n-butyl cyanoacrylate (glue) [Figure 2(A)–(d)].

On a seven month follow up visit the child had a minor improvement in milestones (motor > mental). Head holding was achieved. There was a positive approach to objects. A control MRI done at this time showed a thrombosed median vein. A control angiogram [Figure 3(A)—(F)] confirmed nonvisualization of the VGAM.

One year later, the child was symptomatically better and fed well. On examination, he had head holding present with a tilt to the right side. There was no hypotonia; however, sitting without support was not yet achieved. MRI (Figure 4) showed successful embolization of the VGAM without recurrence of the aneurysm. The lateral extension of the Glue cast on the right side along the superior surface of the tentorium was present which demonstrated intense homogeneous enhancement associated with vasogenic edema. This was strongly suggestive of a glue granuloma incited by the embolic material. The child was treated with a course of steroids and clinically did well up to four years of age after which he was lost to follow up.

Case 2

An 18-month-old male child presented with a history of progressively increasing the head size and delay in achieving milestones. The child was a full-term normal delivery with a normal immunization history. There was no history of breathlessness, headaches, or seizures. On examination, head circumference measured 52.5 cm. There was bilateral proptosis and prominent periorbital and forehead veins. Milestones were delayed. Systemic examination was WNL. Cardiac evaluation including 2D echocardiography was normal. MRI study (Figure 5) showed a dilated median vein draining into a large falcine sinus. Early parenchymal atrophy and hydrocephalus was present. No parenchymal or subependymal calcifications were present.

Diagnostic cerebral angiogram [Figure 6(A)–(E)] showed a mural type of VGAM supplied by medial and lateral posterior choroidal, thalamo-perforators, anterior choroidal, posterior pericallosal and subependymal arteries. The first session of embolization was performed using concentrated n-BCA (Glue) via posterior choroidal arterial feeders, the second session performed three months after the first session, this time after selectively navigating into feeders from the anterior cerebral artery and the choroidal branches from posterior communicating artery [Figure 6 (F)]. At 2 years, the child had achieved milestones commensurate with age. The prominence of the periorbital veins had also reduced. At 4 years of age, the patient was asymptomatic and clinically doing well with normal intelligence for age. On examination, head circumference was stabilized and no neurological deficits were present.

DISCUSSION

Before the advent of endovascular techniques, surgery was the primary treatment modality although it had exceptionally high mortality. Many series reported mortality reaching 100% in the neonatal population [2,9]. Although there are select reports of good outcomes fol-

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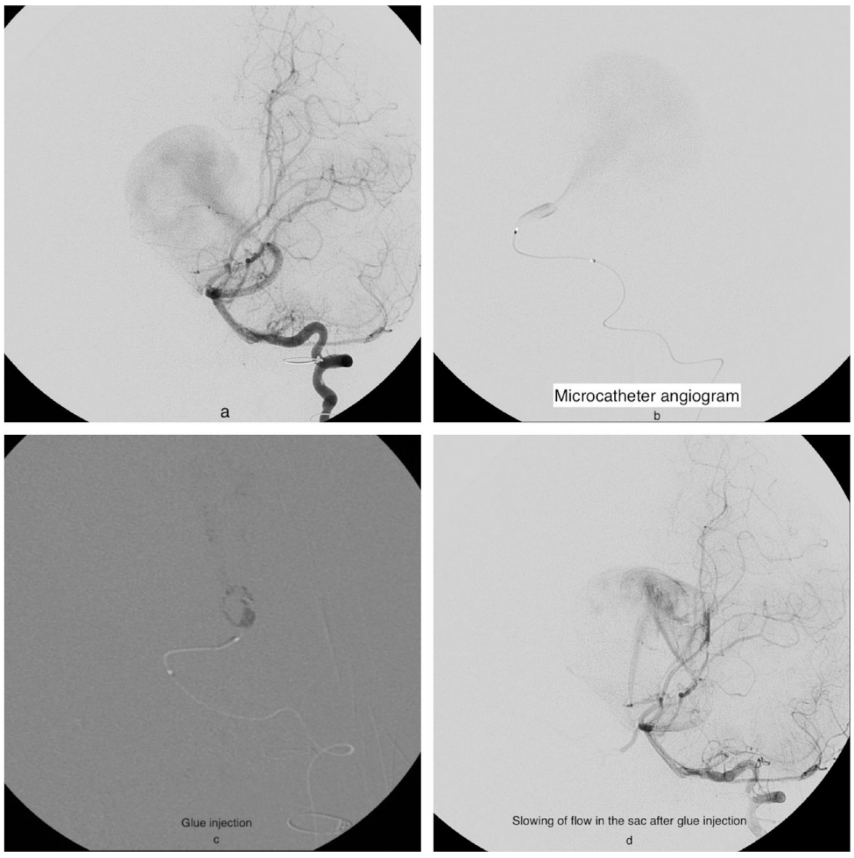

Figure 2. (A) Left Vertebral artery angiogram in lateral projection shows a mural type of VGAM with supply to the dilated median vein from a hypertrophied right lateral posterior choroidal artery. (B) Selective microcatheter angiogram confirms the good distal position of the microcatheter closely approximating the fistula. (C) Glue cast from the injection of concentrated glue. (D) Immediate postprocedure angiogram shows marked slowing of flow within the dilated median vein.

lowing surgery [10], the outcomes of larger series do not compare with the results obtained with endovascular treatment. In 1991, Friedman and colleagues [11] reported a mortality of 50% and mental retardation rate of 37%. With the improvement in endovascular techniques and neonatal intensive care, mortality significantly decreased. In 1993, the same group reported a series of 11 patients with no mortality and a 55% rate of functionally normally patients [11]. Early reports focused on the technical aspects of treating a VGAM with endovascular therapy without emphasis on the neurologic outcome. In selected reports, complete radiographic obliteration was considered a successful outcome, even if the patient subsequently died. In more recent reports, the shift has focused on survival and neurocognitive outcome [11–27].

Analysis of clinical features of the disease in our series reveals a M:F ratio of 1.9:1. Commonest presenting features in infancy were macrocrania (62.5%), developmental delay (31.25%), and prominent scalp veins (18.75%). Seizures and failure to thrive were uncommonly occurring in 12.5% and 6 %, respectively. Common presenting features in children (2–13 years) were macrocrania (50%), neurocognitive delay and seizures (37.5% each). High output cardiac failure was the presenting feature in the single neonate who was treated at one day of life. In 2006, Lasjaunias and colleagues [5] reported a series of 233 patients with VGAM treated with embolization, which is currently the largest reported experience. At the time of diagnosis, ages of patients were as follows: fetus 93 (29.3%), neonates (<1 month) 119 (37.5%), infants (>1 month and <2 years) 82 (25.9%), and children (2–16 years) 23 (7.3%). They reported a 10.6% overall mortality. Our series showed overall mortality of 11.53% which is quite similar to these rates.

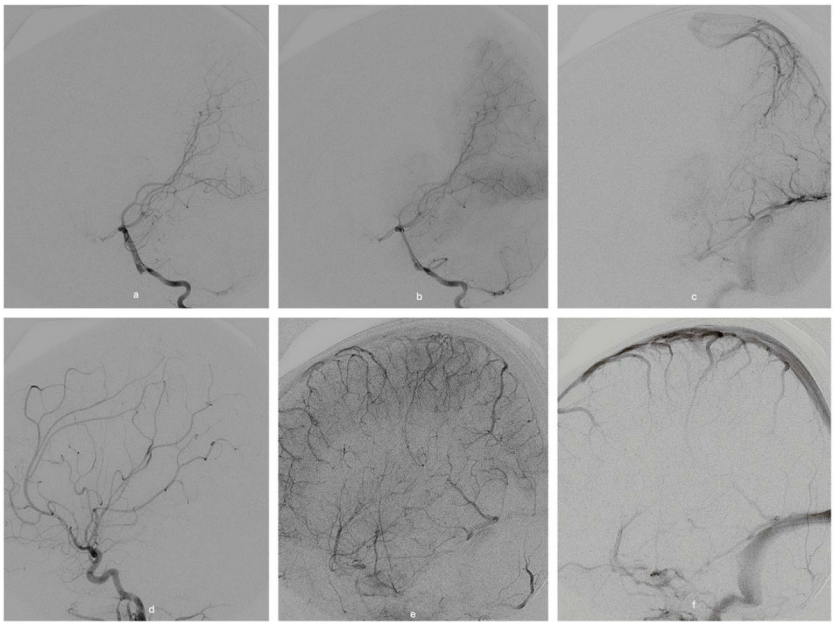

Figure 3. A 7-month control angiogram: (A–C) arterial, parenchymal and venous phases of the left vertebral artery angiogram (D–F) arterial, parenchymal, and venous phases of the right ICA angiogram show nonvisualization of the VGAM.

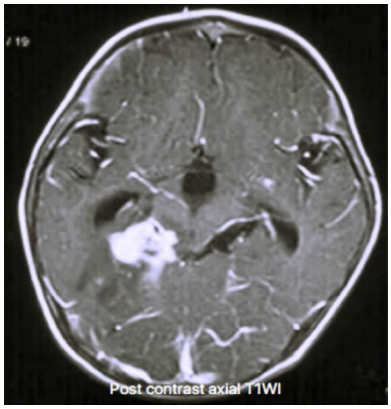

Figure 4. Postcontrast axial T1WI shows the lateral extension of the glue cast on the right side along the superior surface of the tentorium associated with intense homogeneous enhancement. There is perifocal vasogenic edema associated. Findings indicate a foreign body type of reaction/granuloma incited by the embolic material.

In the Lasjaunias' series, neonates had a mortality of 52%, which was significantly higher than the mortality in infants (7.2%) and children (0%) [5]. It is now established that a VGAM associated with antenatal cardiac failure carries 80% mortality [28,29]. In addition, the presence of severe cerebral damage in the antenatal or neonatal period has been associated with irreversible multiorgan failure. The extremely poor outcome in these patients is not improved with radiological obliteration of the VGAM. In our series, we had treated only one neonate who succumbed, leading to 100% mortality in this subgroup.

Our series also shows an overall rate of complications in infants of 31.25% (5/16) and 25% (2/8) in children. However, mortality in infants was 2/16 (12.5%) and in children 0%, which were in keeping with published data from the Lasjaunias group [5]. In our series of endovascular treatment, most children were treated in their infancy (16/26, 61.53%) in keeping with recommended management guidelines. A technically good outcome was seen in 22/26 patients (84.61%). There were three mortalities (11.53%) and one child had a poor recovery (Bicetre outcome score 2).

In addition, in the Lasjaunias series, 74% of surviving patients were neurologically normal, 15.6% were moderately retarded, and 10.4% experienced severe mental retardation during a median follow-up time of 4.4 years. Between 90% and 100%, obliteration was achieved in 55% of patients, further emphasizing that complete obliteration of a VGAM is not necessary in all cases to achieve clinical improvement [5]. Our series had 11/26 patients who had the choroidal type of VGAM, where

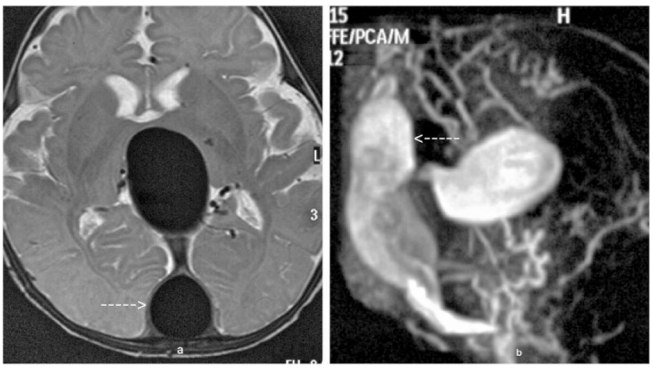

Figure 5. MRI (A) Axial T2WI and (B) MR venography show an aneurysmally dilated median vein which drains into a falcine sinus (arrow).

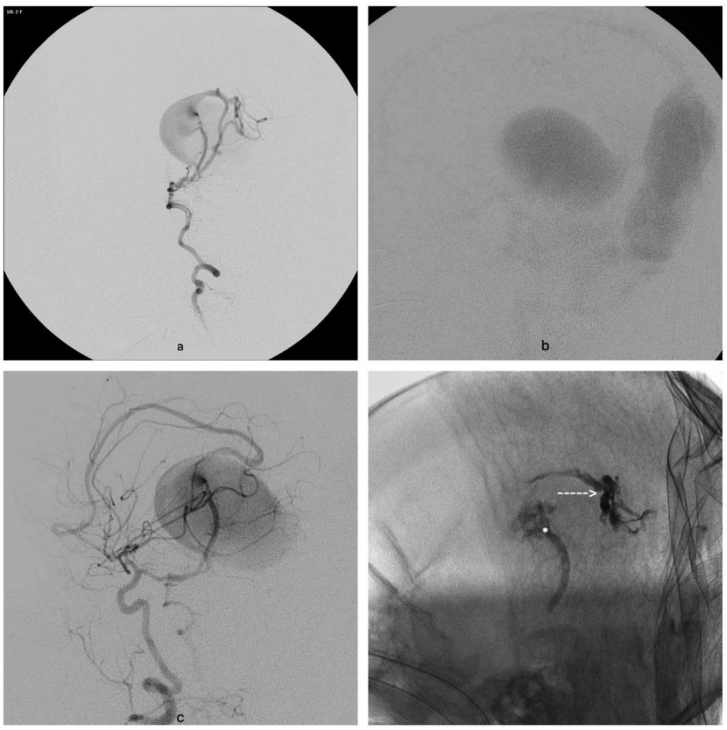

Figure 6. Left vertebral angiogram lateral projection (A) arterial phase, (B) venous phase, and (C) left ICA angiogram arterial phase lateral projection show mural type of VGAM supplied by medial and lateral posterior choroidal, thalamo-perforators, anterior choroidal, posterior pericallosal, and subependymal arteries. It drains into a dilated falcine sinus. Persistent occipital and marginal sinuses are present. (D) A fluoroscopic image demonstrating glue casts after the second session of embolization using the posterior communicating artery (asterisk) and the anterior cerebral artery (dashed arrow).

the goal of treatment was a reduction in flow and not complete obliteration. 9/11 (81.8%) patients had a good recovery reiterating the recommendations of the Bicetre group that complete obliteration was not necessary for the management of these children. Of the 15 patients with the mural type of VGAM, there were two mortalities (2/15, 13.3%).

CONCLUSION

VGAMs are uncommon congenital vascular malformations that are characterized by single or multiple, direct

and/or indirect arterial feeders which have a fistulous connection with a persistent and dilated MProsV of Markowski. It can be detected in the antepartum period on screening ultrasound and further visualized on MRI. Endovascular therapy is the first-line treatment of a VGAM and its associated sequelae. Ideally, the first intervention is performed at 5–6 months of age, although some cases require emergent endovascular treatment. The primary goal of medical management in VGAM treatment is to stabilize cardiac and systemic complications until endovascular intervention can be performed. Given the complex nature of treating patients with a VGAM, a multidisciplinary approach is recommended. Endovascular therapy combined with a multidisciplinary management strategy to treat a VGAM has significantly lowered mortality and can result in normal neurologic development in surviving patients. It is exceedingly important to understand that management of this condition has an aim of restoration of normal neurocognitive and clinical parameters and not angiographic cure.

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REFERENCES

1. Casasco A, et al. Percutaneous transvenous catheterization and embolization of vein of Galen aneurysms. *Neurosurgery* 1991;28:260.

2. Gold A, et al. Vein of Galen malformation. *Acta Neurol Scand Suppl* 1964;40(Suppl. 11):1.

3. Lasjaunias P, et al. Dilatation of the vein of Galen. Anatomoclinical forms and endovascular treatment apropos of 14 cases explored and/or treated between 1983 and 1986. *Neurochirurgie* 1987;33:315.

4. Dandy W. Arteriovenous aneurysm of the brain. *Arch Surg* 1928;17:190.

5. Lasjaunias PL, et al. The management of vein of Galen aneurysmal malformations. *Neurosurgery* 2006;59:S184.

6. Boldrey E, Miller ER. Arteriovenous fistula (aneurysm) of the great cerebral vein (of Galen) and the circle of Willis; report on two patients treated by ligation. *Arch Neurol Psychiatry* 1949;62:778.

7. Silverman BK, et al. Congestive failure in the newborn caused by cerebral A-Vfistula; a clinical and pathological report of two cases. *AMA Am J Dis Child* 1955;89:539.

8. Yasargil MG, et al. Arteriovenous malformations of vein of Galen: microsurgical treatment. *Surg Neurol* 1976;(3):195.

9. Hoffman HJ, et al. Aneurysms of the vein of Galen. Experience at the hospital for sick children, Toronto. *J Neurosurg* 1982;57:316.

10. Friedman DM, et al. Neonatal vein of Galen malformations: experience in developing a multidisciplinary approach using an embolization treatment protocol. *Clin Pediatr (Phila)* 1991;30:621.

11. Friedman DM, et al. Recent improvement in outcome using transcatheter embolization techniques for neonatal aneurysmal malformations of the vein of Galen. *Pediatrics* 1993;91:583.

12. Burrows PE, et al. Urgent and emergent embolization of lesions of the head and neck in children: indications and results. *Pediatrics* 1987;80:386.

13. Lasjaunias P. Vein of Galen malformations. *Neurosurgery* 1989;25:666.

14. Lasjaunias P, et al. The role of dural anomalies in vein of Galen aneurysms: report of six cases and review of the literature. *Am J Neuroradiol* 1987;8:185.

15. Lasjaunias P, et al. Vein of Galen aneurysmal malformations. Report of 36 cases managed between 1982 and 1988. *Acta Neurochir (Wien)* 1989;99:26.

16. Raybaud CA, et al. Aneurysms of the vein of Galen: embryonic considerations and anatomical features relating to the pathogenesis of the malformation. *Neuroradiology* 1989;31:109.

17. Pearl M, et al. Endovascular management of vein of Galen aneurysmal malformations. Influence of the normal venous drainage on the choice of a treatment strategy. *Childs Nerv Syst* 2010;26(10): 1367–1379.

18. Lasjaunias P, et al. Treatment of vein of Galen aneurysmal malformation. *J Neurosurg* 1989;70:746.

19. Yasargil MG. AVM of the brain, clinical considerations, general and special operative techniques, surgical results, nonoperated cases, cavernous and venous angiomas, neuroanesthesia. Vol. III BNew York, NYThieme1988;

20. King WA, et al. Management of vein of Galen aneurysms. Combined surgical and endovascular approach. *Childs Nerv Syst* 1989;5:208.

21. Chevret L, et al. Severe cardiac failure in newborns with VGAM. Prognosis significance of hemodynamic parameters in neonates presenting with severe heart failure owing to vein of Galen arteriovenous malformation. *Intensive Care Med* 2002;28:1126.

22. Pellegrino PA, et al. Congestive heart failure secondary to cerebral arterio-venous fistula. *Childs Nerv Syst* 1987;3:141.

23. Alvarez H, et al. Vein of Galen aneurysmal malformations. *Neuroimaging Clin N Am* 2007;17:189.

24. Krings T, et al. Classification and endovascular management of pediatric cerebral vascular malformations. *Neurosurg Clin N Am* 2010;21:463.

25. Mickle JP, Quisling RG. The transtorcular embolization of vein of Galen aneurysms. *J Neurosurg* 1986;64:731.

26. Jeanty P, et al. In utero detection of cardiac failure from an aneurysm of the vein of Galen. *Am J Obstet Gynecol* 1990;163:50–51.

27. Horowitz MB, et al. Vein of Galen aneurysms: a review and current perspective. *Am J Neuroradiol* 1994;15:1486–1496.

28. Rodesch G, et al. Prognosis of antenatally diagnosed vein of Galen aneurysmal malformations. *Childs Nerv Syst* 1994;10:79.

29. Garcia-Monaco R, et al. Congestive cardiac manifestations from cerebrocranial arteriovenous shunts. Endovascular management in 30 children. *Childs Nerv Syst* 1991;7:48.