Radiological and Clinical Features of Vein of Galen Aneurysmal Malformation in Newborn Infants and, the Results of Endovascular Interventional Treatment: 10-Years Experience

Sinan Tufekci*, Zeynep Ince, Beril Yasa, Meltem Bor, Mehmet Barburoglu, Serra Sencer, and Asuman Coban

Department of Paediatrics, Istanbul Medical Faculty, Istanbul University, New-Born Intensive Care Unit, Monoblok Binası 9. Kat, Şehremini-Capa Fatih, İstanbul, Turkey

Abstract

Aim: To assess the clinical features, diagnosis, treatment and prognosis of newborn infants with a diagnosis of Vein of Galen Malformation (VGAM) during a 10-year period.

Method: Eight patients with a diagnosis of VGAM in the neonatal period were assessed retrospectively in terms of clinical signs, diagnosis, treatment strategies and follow-up. Three of four patients who survived had neurological assessment whereas one was lost to follow-up because of moving to another city.

Results: Seven of 8 patients had an antenatal diagnosis. In all cases, severe heart failure and pulmonary hypertension were present from the first day of life and hypotension, multiorgan failure, hydrocephaly and seizures developed in the following days. VGAM and its feeder arteries were mapped by cranial magnetic resonance imaging and magnetic resonance angiography. Transarterial embolization therapy was performed on 7 patients, of whom four babies survived and three babies died, while one patient died before any intervention.

Conclusion: The mortality and morbidity rates of VGAM is high because of its mixed anatomy, pathophysiology and characteristic features leading to severe neurological sequelae in the survivors. Prognosis in high risk neonates can be improved with aggressive medical support and early endovascular embolization therapy.

Keywords: Vein of Galen aneurysmal malformation; Neonate; Endovascular therapy; High outflow heart failure

Introduction

Vein of Galen Aneurysmal Malformation (VGAM) comprises 1% of all vascular malformations and 30% of vascular malformations in childhood. The patients usually present with severe heart failure in the neonatal period. VGAM is a small, deep venous internal cerebral vessel with a thin wall. The conjunction of choroidal and thalamostriate veins in the interventricular foramen creates internal cerebral veins. VGAM is generated between the 6th and 11th weeks of gestation by the connections between primitive choroidal vessels and median prosencephalic vein (Markowski) [1].

The two widely used classifications of VGAM have been defined by Lasjaunias and Yasargil [2-6]. Lasjaunias classified VGAM in two types: Choroidal type (Type I), which is the most common and the most complicated type, is usually seen in the early stages of life. Multiple supplying arteries penetrate the median prosencephalic vein usually through the anterior wall. All choroidal arteries and their interconnections, anterior cerebral artery, pericallosal artery, thalamoperforating artery and quadrigeminal arteries also support the blood supply. Mural type (Type II), has a single or multiple arteriovenous fistulas (AVF) which drain the median prosencephalic vein at the inferolateral mural side. The shunt is usually fed by collicular and posterior choroidal arteries. The resultant AVF leads to abnormal flow which prevents the regression of the embryonic vein, generating VGAM. There are also mixed types of VGAM carrying the characteristics of both choroidal and mural types. Yasargil classification has four types. In types I, II and III, all lesions have direct fistulous connections with the vein of Galen. In type IV, there is a parachymal arteriovenous malformation which drains into the vein of Galen. In Type I, there is an AVF between vein of Galen and pericallosal branches of leptomeningeal arteries and/or any branch of posterior cerebral artery. In Type II, vein of Galen is fed by two branches of posterior cerebral artery and thalamoperforating vessels. Type III is a mixture of type I and type II and is the most common form. Type IV is known as the secondary type and has three subtypes: In Type IVA an aneurysmal dilatation develops in the vein of Galen by the neighbouring thalamic arteriovenous malformation. Type IVB is similar to type IVA, but arteriovenous malformation is mesencephalic rather than thalamic. In Type IVC thalamomesencephalic or mesodiencephalic plexiform malformation drains into the vein of Galen by a nearby and different cisternal AVF. Yasargil classification is helpful if endovascular intervention is the treatment option [4].

Prenatal diagnosis is made by color Doppler ultrasound examination in the third trimester of pregnancy. Aneurysmatic dilatation localized at the midline and posterior to the third ventricle, venous and arterial turbulent blood flow in hypoechoic structures can be shown [7]. Fetal magnetic resonance imaging (MRI) is needed both to confirm VGAM and to exclude the diagnosis of arachnoidal, prosencephalic and choroid plexus cysts, pineal tumor, choroid papilloma and intracerebral hematoma [8]. The aneurysm leading to a cerebral shunt flow, increases

*Corresponding author: Sinan Tufekci, Department of Paediatrics, Istanbul Medical Faculty, Istanbul University, New-Born Intensive Care Unit Monoblok Binası 9. Kat, Şehremini-Capa Fatih, 34134, Istanbul, Turkey, Tel: 905324417882; Fax: 902124142196; E-mail: sinantufekci28@hotmail.com, tufekci.sinan@gmail.com

Received December 19, 2016; Accepted April 28, 2017; Published May 07, 2017

Citation: Tufekci S, Ince Z, Yasa B, Bor M, Barburoglu M, et al. (2017) Radiological and Clinical Features of Vein of Galen Aneurysmal Malformation in Newborn Infants and, the Results of Endovascular Interventional Treatment: 10-Years Experience. Brain Disord Ther 6: 234. doi: 10.4172/2168-975X.1000234

Copyright: © 2017 Tufekci S, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
blood return to the right ventricle, which may lead to congestive heart failure. Cardiomegaly, tricuspid regurgitation, polyhydramnios, pericardial/pleural effusions, edema and ascites are predictive of a high outflow anomaly which is usually refractory to treatment and carries a poor prognosis [6].

In this report, we reviewed 8 cases of newborn babies with an antenatal diagnosis of VGAM with an emphasis on clinical features, transarterial endovascular treatment and prognosis. There are many case reports about VGAM published previously; but this is the first report of a case series from our country.

**Method**

The newborn patients who were hospitalized in our Neonatal Intensive Care Unit (NICU) between 2005 and 2015, with a diagnosis of VGAM were included. Data about the NICU care, neuroradiological interventions and follow-up were collected from the hospital records retrospectively. Every patient had a cranial MR angiography/venography prior to endovascular intervention, for mapping of the vessels and revealing the type of malformation. Decision for endovascular intervention was made according to the patients cardiovascular and respiratory status. The large feeder vessels were identified and appropriate cases underwent endovascular intervention. The embolizing agents used were N-butyl cyano acrylate (NBCA) (5 patients) and ethylene vinyl alcohol (EVA) (2 patients). During endovascular intervention, maximal doses of radiocontrast material were not exceeded and intervention was stopped when the dose reached maximum values. Except the third case in whom embolization...
patients who can benefit from endovascular intervention, was assessed retrospectively (Table 1).

**Results**

Seven out of eight patients were males. All patients were full term except one, who was born at 36 3/7 weeks of gestational age and all were born with cesarean section. Seven of these patients were diagnosed antenatally except one who was referred from another hospital.

All patients developed severe heart failure in the early days of life. Respiratory failure, tachycardia, hyperdynamic precordial activity, 2-4/6 systolic or continuous murmur heard through the anterior fontanel were the common physical examination findings in all patients. Posteroanterior chest X-rays showed cardiomegaly. Echocardiographic findings were tricuspid regurgitation (TR), cardiomegaly (CM), severe pulmonary hypertension (PH) in all patients and severe right atrium

---

**Figure 1:** Enlarged precursors of VGAM and large feeder arteries at the posterior side of the third ventricle are shown by MRI, MR angiography and DSA imaging.
and right ventricle dilatation in five patients. Additionally, one patient had atrial situs solitus (ASS), left aortic arch, small ventricular septal defect and one other patient had hemodynamically significant patent ductus arteriosus. Cranial ultrasound imaging showed wide VGAM in all patients.

All patients needed ventilatory support due to respiratory failure on the first day of life, either conventional or high frequency oscillatory ventilation. Fluid restriction, digoxin, dobutamine and/or dopamine perfusions and furosemide were used for cardiac failure. Sildenafil (n=3) and inhaled nitric oxide therapy (n=1) were given for severe pulmonary hypertension in 4 patients. Six patients developed refractory hypotension and three of these died because of multiorgan failure. Bicêtre scores of 4 patients who died were 5, 11, 7 and 12 respectively. Seizures developed in six patients (one of them without embolization treatment) and ventriculoperitoneal shunt was needed in two patients with hydrocephaly. Upper gastrointestinal bleeding (n=1), supraventricular tachycardia (n=1), acute renal failure (n=4), cholestasis (n=1) and sepsis (n=3) were the other morbidities. The demographic characteristics, clinical and echocardiographic features, prognosis and neurodevelopmental outcomes are summarized in Table 2.

Vascular mapping of VGAM by cranial MRI and MR angiographic images were assessed by the Department of Neuroradiology (Figure 1). Data about the interventional therapies are shown in Table 3.

**Discussion**

The incidence of VGAM is reported to be 1 in 25,000 live births [10]. The total number of births between the years 2005-2015 in our hospital was 19,835 and the number of cases with VGAM was 7, with a resultant incidence of 1 in 2833 live births. This figure is much higher than the reported incidences which is probably due to the fact that our hospital is a tertiary perinatal-neonatal referral center in Istanbul.

It has been reported that VGAM is seen more frequently in males. In our case series seven out eight patients were males also. However, the reason of this male gender dominance is unknown [11].

VGAM can be a life-threatening situation in newborn infants, especially when it causes severe heart failure. Choroidal and mixed types of VGAM may lead to mild to severe heart failure, cerebral atrophy, and seizures in the early days of life. In infancy, macrocrania and hydrocephalus, asymptomatic cardiomegaly or moderate heart failure; in older children mild heart failure, asymptomatic cardiomegaly, headache and intracranial hemorrhages can be seen. The severity of heart failure in newborns with VGAM differs according to the type and size of the aneurysm [12]. In neonatal patients with choroidal and mixed types of VGAM, severe heart failure and hypotension refractory to treatment, may lead to multiorgan failure which cause ischemia of vital organs [3,8,10,13]. In our patient group, mixed type VGAM was the most frequent type and all the patients had severe heart failure. Three of six patients with refractory hypotension who developed multiorgan failure died.

Bicêtre scoring system has been developed to identify those babies with heart failure who may benefit most from endovascular treatment. The scoring system is performed in patients with high output heart failure looking at the presence or absence of multiorgan failure. This system is beneficial in the decision of early interventional therapy but is not reliable in the early days of life [14]. We did not use the Bicêtre scoring system for treatment decisions in our patient group; however, when evaluated retrospectively Bicêtre scores and the therapeutic management strategies were found to be compatible.

An association between VGAM and congenital cardiac anomalies like sinus venous type atrial septal defect and coarctation of the aorta had been reported [15]. Mc Elhinney et al. also reported the presence of partial pulmonary venous return abnormalities, ventricular septal defect and atrioventricular channel defect in association with VGAM [16]. In our patients, ventricular septal defect, patent ductus arteriosus, patent foramen ovale, atrial situs solitus and left aortic arch anomalies were the associated cardiac findings.

The treatment options for VGAM are open surgery, endovascular and stereotactic radiosurgery, of which endovascular therapy is the most preferred method. The aim of this therapy is to selectively catheterize the feeder arteries and to close the fistulae with liquid (NBCA, EVA) or coil, in order to reduce the high flow in this vascular malformation [17,18]. After multiple embolization procedures, systemic cardiovascular load also decreases with the decreasing flow in the malformation. This intervention in the neonatal period should be done under optimal conditions by an experienced team and risk-benefit ratio should always be kept in mind. The interventional therapy should be delayed to decrease the risks and increase the success of the procedure as long as the baby tolerates the condition. However, early intervention is necessary if there is severe and intractable respiratory or cardiac failure. The advances in interventional neuroradiology resulted in a more favorable prognosis in VGAM cases [19] in recent years. However, mortality and morbidity is still high. Severe heart failure can progress quickly to multiorgan failure and death; can also lead to cerebral venous hypertension, vascular leak, cerebral ischemia and infarction. The patients with high outflow, choroidal and mixed type malformations carry a worse prognosis than the patients with mural type and/or those who can tolerate later intervention. Fullerton et al. reported the mortality rate in 27 children with VGAM (21 newborns) as 15% in 2003. Four of their patients died, all of whom developed symptomatic in the neonatal period [20]. Geibprasert et al. reported the mortality rate as 36% in 25 children (20 newborns) in 2010 [21]. Excluding one patient, who died without having a chance of any intervention, mortality rate in our patients after endovascular treatment was 43%. This high mortality rate was thought to be the result of the type of the malformations (choroidal-mixed type, with multiple feeder vessels) and severe and very early clinical presentation in the newborn period. Neurological sequelae can be seen in 37% to 50% of VGAM patients. When the patients who survive after embolization are assessed neurologically, 66% was found to be normal, 11.5% had moderate neurological problems and 8.5% had irreversible neurological deficits [22]. Patients who develop multiorgan failure, develop cerebral infarction more frequently and has a poorer neurodevelopmental outcome in the long term [10]. In our case series, three out of four patients who survived had a normal neurological development whereas one patient had severe impairment. The small sample size is a limitation of our cases. For this reason, it is difficult to make a statistical interpretation. GVAM is a rare disease, group and treatment comparison is not possible. In conclusion, in neonatal patients with a high output cardiac failure without a cardiac origin, VGAM should always be considered in the differential diagnosis. Prenatally diagnosed patients should be born in a tertiary level perinatal-neonatal center, with experienced neuroanesthesiology and neuroradiology clinics. Although mortality and morbidity is high, endovascular interventional treatment of VGAM in the neonatal period may result in a favorable outcome.
Table 3: The feeding vessels and the embolizing agents used in endovascular treatment of the cases.

| Case | Postnatal age at intervention | Feeding vessels | Embolizing agent |
|------|--------------------------------|-----------------|------------------|
| 1    | 3. day                         | -right ACA 1    | NBCA 2           |
| 2    | 2. day                         | -right ACA, -left PCA, right PMCA, right PLCA | NBCA |
| 4    | 18. day                        | -right ACA, right PCA, right PCLA | NBCA |
| 5    | 1. day                         | -right ACA     | EVA 3           |
| 6    | 2. day, 4. day, 8. day         | -right ACA, -right PCA, -left ACA | EVA |
| 7    | 25. day                        | -right ACA, -left PCA, -left ACA | NBCA |
| 8    | 3. day                         | -left ACA, left TMPA | NBCA |

1ACA: anterior choroidal artery  
2PMCA: posteromedial choroidal artery  
3PLCA: posterolateral choroidal artery  
4PCA: posterior choroidal artery  
5PCLA: pericallosal artery  
6MCA: median choroidal artery  
7PLCA: posterior lateral choroidal artery  
8MOF: multi organ failure  
9EVA: ethylene vinyl alcohol

References
1. Casasco A, Lylyk P, Hodes LE, Kohan G, Aymard A, et al. (1991) Percutaneous transvenous catheterization and embolization of vein of Galen aneurysms. Neurosurgery 28: 260-266.
2. Mullin S, Mojtabahedi S, Jonsson DL, Macdonald RL (1996) Embryological basis of some aspects of cerebral vascular fistulas and malformations. J Neurosurg 85:1-8.
3. Zerah M, Garcia-Monaco R, Rodesch G, Terbrugge K, Tardieu M, et al. (1992) Hydrodynamics in vein of Galen malformations. Childs Nerv Syst 8:111-117.
4. Mortazavi MM, Griesenauer CJ, Foreman R, Bavarsad Shahrpouir R, Shoja MM, et al. (2013) Vein of Galen aneurysmal malformations: Critical analysis of the literature with proposal of a new classification system. J Neurosurg Pediatrics 12:293-306.
5. Yaqargil MG (Ed.) (1993) AVM of vein of Galen region. In: Microneurosurgery: AVM of the brain, clinical considerations, general and special operative techniques, surgical results, nonoperated cases, cavernous and venous angiomata. Neuroanesthesia. Stuttgart: Georg Thieme, III: pp 323-354.
6. Lasjaunias PL, Chng SM, Sachet M, Alvarez H, Rodesch G, et al. (2006) The management of vein of Galen aneurysmal malformations. Neurosurgery 59: S184-S194.
7. Ruan R, Benachi A, Aubry MC, Brunelle F, Durnez Y, et al. (2003) Perinatal three-dimensional color power Doppler ultrasonography of vein of Galen aneurysms. J Ultrasound Med 22: 1357-1362.
8. Deloison B, Chalouhi GE, Sonigo P, Zerah M, Millischer AE, et al. (2012) Hidden mortality of prenatally diagnosed vein of Galen aneurysmal malformation: Retrospective study and review of the literature. Ultrasound Obstet Gynecol 40: 652-658.
9. Goldstein B, Gioirno B, Randolph A (2005) The members of the international consensus conference on pediatric sepsis. International Pediatric Sepsis Conference: Definitions for sepsis and organ dysfunction in pediatrics. Pediatr Crit Care Med 6: 2-8.
10. Frawley GP, Dargaville PA, Mitchell PJ, Tress BM, Loghnan P (2002) Clinical course and medical management of neonates with severe cardiac failure related to vein of Galen malformation. Arch Dis Child Fetal Neonatal Ed 87: F144-9
11. Lasjaunias PL, Wuppalapati S, Alvarez H, Rodesch G, Ozanne A (2005) Intracranial aneurysms in children aged under 15 years: Review of 59 consecutive children with 75 aneurysms. Childs Nerv Syst 21: 437-450.
12. Gupta AK, Varma R (2004) Vein of Galen malformations: Review. Neurology India March 52: 43-53.
13. Chow ML, Cooke DL, Fullerton HJ, Amans MR, Narvid J, et al. (2014) Radiological and clinical features of vein of Galen malformations. J Neurointervent Surg 6:1-6.
14. Heuchan AM, Bhattacharya J (2012) Superior vena cava flow and management of neonates with vein of Galen malformation. Arch Dis Child Fetal Neonatal Ed 97: F344-F347.
15. Karadeniz L, Coban A, Sencer S, Has R, Ince Z, et al. (2011). Vein of Galen aneurysmal malformation: Prenatal diagnosis and early endovascular management. JCM: 74: 134-137.
16. Mc Ehinney DB, Halbach VV, Silverman NH, Dowd CF, Hanley F (1998) Congenital cardiac anomalies with of Galen malformations in infants. Arch Dis Child 78: 548-551.
17. Kleindienst A, Hildebrandt G, Klug N, Schon R (1998) Management of vein of Galen malformations: A review based on five neurosurgically treated cases and literature reports. Zentralbl Neurochir 60: 172-182.
18. Juan SBG, Julio AD, Yoana LC, Carlos AGG, Cecilia SG (2012) Systolic heart murmur as first manifestation of high output heart failure due to the vein of Galen malformation. Arch Cardioil Mexico 82(3): 214-217.
19. Karanam LSP, Baddam SR, Joseph S (2011) Endovascular management of vein of galen aneurysm malformation: A series of two case reports. JPN 8: 32-35.
20. Fullerton HJ, Aminoff AR, Ferriero DM, Gupta N, Dowd CF (2003) Neurodevelopmental outcome after endovascular treatment of vein of Galen malformations. Neurology 61: 1386-1390.
21. Gelibrasred S, Kings T, Armstrong D, Terbrugge KG, Raybaud CA (2010) Predicting factors for the follow-up outcome and management decisions in vein of Galen aneurysmal malformations. Childs Nerv Syst 26: 35-46.
22. Ashida Y, Miyahara H, Sawada H, Mitani Y, Maruyama K (2005) Anesthetic management of a neonate with vein of Galen aneurysmal malformations and severe pulmonary hypertension. Paediatr Anaesth 15: 525-528.