Great vein of Galen malformations in infancy[1]

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Four female infants with large cerebral great vein of Galen malformations were examined at the Cleveland Clinic between 1979 and 1982. All patients had a loud intracranial bruit and pulmonary flow murmurs with bounding peripheral pulses. Computed tomography (CT) scanning with contrast was diagnostic in all cases. A staged surgical procedure was performed in 3 of the 4 patients, and one patient died before surgery could be performed. Arterial feeders were clipped during two staged operative procedures with no surgical mortality. At follow-up 2 infants are developmentally normal. One infant, who had suffered preoperative intracerebral bleeding, continues to have evidence of hemiparesis and developmental delay. Awareness of the clinical signs of great vein of Galen malformations and rapid neurosurgical intervention with the use of a staged surgical approach may result in higher surgical survival rates than previously reported.

Index terms: Aneurysm, great vein of Galen • Arteriovenous malformations, cerebral • Arteriovenous malformations, surgery
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The overall outlook for infants with large great vein of Galen arteriovenous malformations in infancy has been extremely poor. As of 1982 the mortality was 85%.[1–33] Even with early neurosurgical intervention, there is significant postoperative morbidity with only three reports of 4 patients after surgery who are developmentally normal at long-term follow-up.[34–37]

We describe our experience with 4 infants who presented with large cerebral arteriovenous malformations. With a staged surgical approach, all 3 infants survived surgery,

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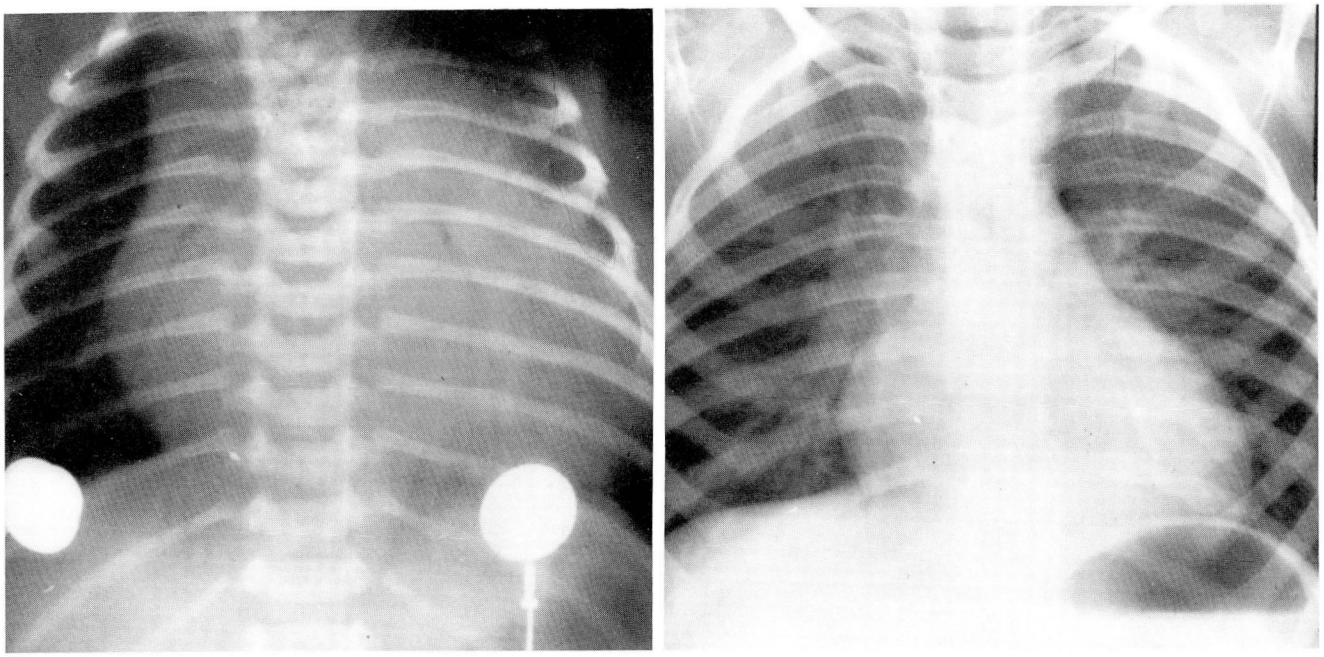

Fig. 1. A. Case 1. Chest radiograph, anteroposterior view prior to surgical clipping, shows marked cardiomegaly. **B.** Anteroposterior view, three years after neurosurgical clipping. Heart size and pulmonary vasculature are normal.

and 2 appear to be developmentally normal at long-term follow-up.

Case reports

Case 1. A 3.5-kg full-term white female infant was noted to have cyanosis, tachypnea, and cold hands and feet at birth. She had been treated with digoxin and diuretics at another institution and transferred to The Cleveland Clinic Foundation. At admission, the six-day-old infant was in mild respiratory distress with signs of congestive heart failure. She weighed 3.5 kg with a head circumference of 36 cm. Blood pressure was 80–90/50–60 mm Hg. The chest was clear. A loud continuous bruit was heard over the cranium. All peripheral pulses were bounding. There was a right ventricular lift with an increased pulmonary component of the second heart sound, and a grade II/VI systolic murmur at the left upper sternal border. The liver was palpable 3–4 cm below the right costal margin. Other physical and neurologic findings were normal.

The chest radiograph revealed marked cardiomegaly (*Fig. 1,A*). The electrocardiogram demonstrated right ventricular hypertrophy, right atrial enlargement, and inverted T waves in leads I, AVR, AVL, V5, and V6. A contrast CT scan showed midline arteriovenous malformation. An intravenous digital subtraction angiogram (DSA) (*Fig. 2*) defined the aneurysm and demonstrated its feeding vessels. An intra-arterial cerebral angiogram definitively outlined the large arteriovenous malformation with its nutrient vessels (*Fig. 3*).

At six days the infant underwent initial clipping of the arterial feeding vessels on one side of the malformation. Two days later, the second surgical clipping was performed on the contralateral side. Postoperatively, seizures and occasional premature ventricular contractions developed, and the infant was given phenytoin (Dilantin). Both seizures and premature contractions resolved within two days.

At long-term follow-up, three years following the initial repair, she is not taking medication and is developmentally normal. Her head circumference is 48.4 cm, which is normal for age, and results of a detailed neurologic examination are normal. A grade I-II/VI innocent pulmonary flow murmur continues. A plain film of the chest (*Fig. 1,B*), is now normal with a marked decrease in cardiac size from the preoperative study. Bilateral soft systolic bruits continue.

Case 2. A full-term white female had murmur and cyanosis at two days of age. Cardiac catheterization at two weeks of age demonstrated the great vein of Galen arteriovenous malformation, and she was transferred to The Cleveland Clinic Foundation.

On physical examination, she was mildly cyanotic at rest with tachypnea. The heart rate was 150–170/min and the respiratory rate 75/min. The infant weighed 2.8 kg. The chest was clear. There was a right ventricular lift with an increased pulmonary component of the second heart sound and an S3 gallop. A grade II/VI systolic murmur was heard at the left upper sternal border. A port wine stain was seen over the anterior calvarium, and a continuous bruit was heard over the calvarium. All peripheral pulses were bounding. Marked hepatomegaly was noted. Other physical and neurologic findings were normal. A plain film of the chest demonstrated cardiomegaly with increased pulmonary vascularity. The electrocardiogram showed right ventricular hypertrophy, right atrial enlargement, right axis deviation for age, and ST and T wave changes (*Fig. 4*).

Digoxin and furosemide (Lasix) were administered in an attempt to manage the congestive heart failure before neurologic investigation. Two days following admission, the

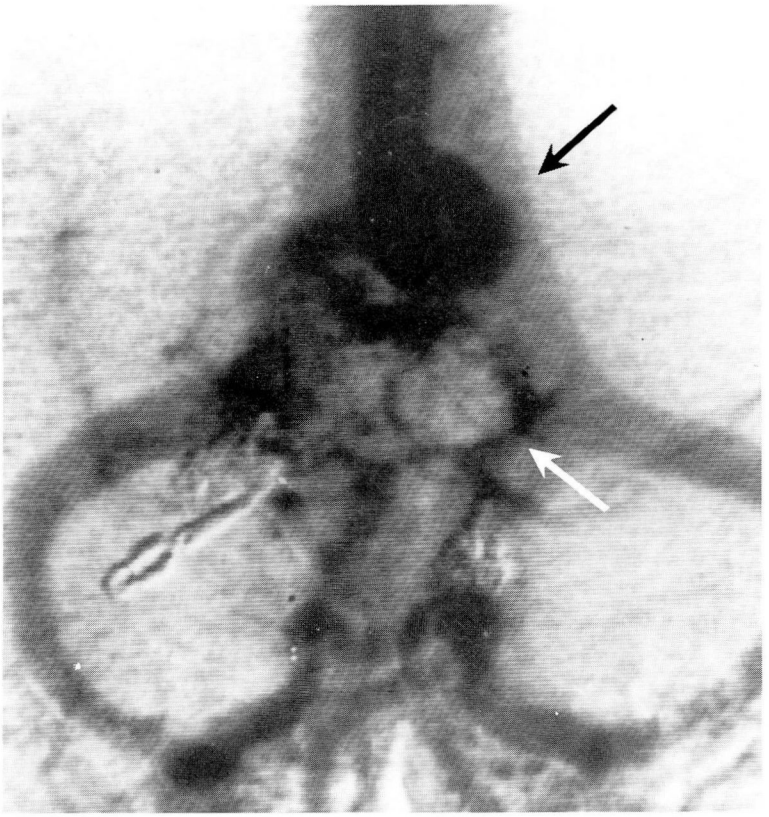

Fig. 2. Case 1. Intravenous digital subtraction angiogram (DSA) of a great vein of Galen aneurysm. *Black arrow* indicates vein of Galen aneurysm and the *white arrow* the posterior cerebral artery.

infant had a cardiac arrest and could not be resuscitated. A postmortem study was not obtained.

Case 3. At four to six weeks of age, a full-term white female was noted to have an enlarging head circumference of 40.5 cm, which is greater than the 95th percentile for age. At six weeks she had undergone ventriculoperitoneal shunting for hydrocephalus, and a great vein of Galen aneurysm was discovered.

On physical examination, she weighed 4.8 kg with a blood pressure of 140/50 mm Hg. Heart rate was 120–140/min. All peripheral pulses were bounding. There was a grade I-II/VI short systolic murmur at the left upper sternal border with an increased pulmonary component of the second heart sound. A grade II/VI bruit was heard over the cranium. The liver was at the right costal margin. Other physical and neurologic findings were normal. A chest radiograph showed cardiomegaly with increased pulmonary vascularity, and an electrocardiogram demonstrated right ventricular hypertrophy.

A CT scan with contrast clearly delineated the arteriovenous malformation, and a cerebral arteriogram defined the arterial feeders. The infant underwent a two-stage surgical clipping. She continues with the VP shunt for hydrocephalus with a head circumference that is now in the 75th percentile for age. Two years after surgery there is a soft pulmonary flow murmur with completely normal neurologic development. A grade II/VI continuous bruit continues to be heard over the head.

Case 4. A ten-month-old white female infant had left hemiparesis secondary to intracerebral bleeding. Developmental delay had been noted at six months of age. A heart murmur and cardiomegaly were noted at that time, but no diagnosis was made. The patient was seen in consultation following a lecture at another hospital and brought back to The Cleveland Clinic Foundation. One week before admission, the patient had had a left-sided seizure and left hemiparesis. She had been a full-term baby with no perinatal problems.

On examination at The Cleveland Clinic Foundation, she weighed 7.2 kg, which is less than the 5th percentile for age. Head circumference was 48 cm, which is greater than the 95th percentile for age. A small hemangioma was seen on the forehead, and a grade III/VI continuous bruit was noted over the calvarium. A grade II/VI systolic murmur was heard at the left upper sternal border with an increased pulmonary component of the second heart sound. An electrocardiogram demonstrated right ventricular hypertrophy. Cardiomegaly and increased vascularity were noted radiographically.

A CT scan demonstrated the arteriovenous malformation with a large right-sided intracerebral bleed (*Fig. 5*), confirmed by intracerebral angiography. The infant underwent a two-stage surgical clipping. At long-term neurologic follow-up about 18 months after surgery, she continues to have left-sided weakness, which had been noted preoperatively secondary to preoperative intracerebral bleeding. In addition, significant developmental delay is evident. The electro-

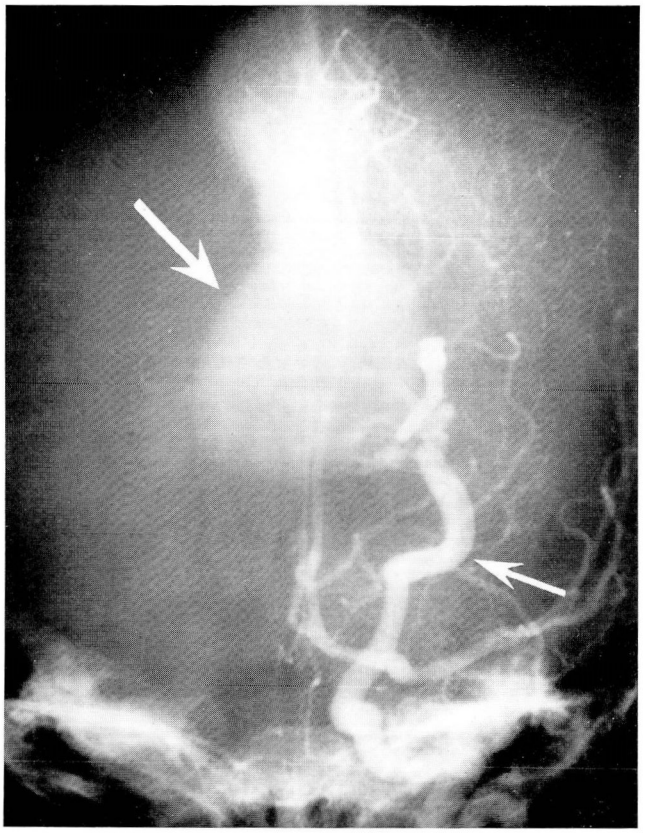

Fig. 3. Case 1. Cerebral arteriogram, early filling, demonstrating a large vein of Galen aneurysm (*large white arrow*). *Small white arrow* indicates large posterior cerebral artery.

encephalogram is abnormal, and head circumference is greater than the 95th percentile for age. No bruit could be auscultated.

Discussion

Pathophysiology: Infants with large great vein of Galen arteriovenous malformations have increased cardiac output secondary to a markedly increased stroke volume. The superior vena cava is usually significantly dilated, and the patients present with high output congestive heart failure. Most patients will have both tachycardia and increased stroke volume. Peripheral resistance is decreased with a widened pulse pressure, secondary to the large arteriovenous runoff. Increased cardiac volume contributes to the congestive heart failure. We have been particularly impressed with the right ventricular and right atrial volume overload with signs of right-sided congestive heart failure. Because of increased right-sided volumes, the pulmonary artery, right ventricular, and right atrial pressures may increase. An increased right atrial pressure, a dilated right atrium, and a stretched foramen ovale secondary to elevated atrial pressures can induce a right-to-left shunt via the patent foramen ovale, thereby causing clinical evidence of cyanosis. All of our patients demonstrated cardiac abnormalities in infancy, consistent with biventricular volume overload and congestive heart failure. Treatment

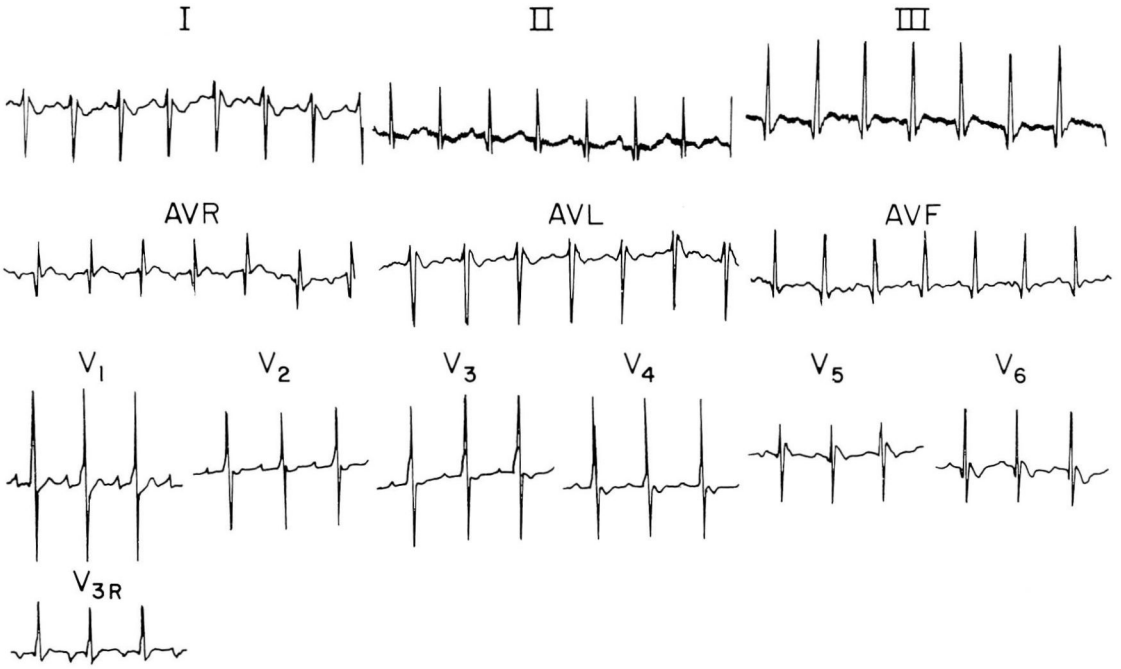

Fig. 4. Case 2. Preoperative 12-lead electrocardiogram demonstrating right ventricular hypertrophy, right atrial enlargement, with inverted T waves at leads I, II and III, AVR, AVL, V5, and V6.

of secondary cardiac problems in the patients with large cerebral arteriovenous malformations is difficult, accounting for the high mortality encountered in these patients.[1–31] One patient died of severe heart failure before surgery could be performed.

Even with aggressive neurosurgical management, mortality for infants with cerebral arteriovenous malformations has been 85%. As of 1982, there were 319 cases reported in the literature with 263 deaths.[1–33] Thirty-two patients are alive with severe neurologic abnormalities at follow-up.[1–33] Ten patients have been described who are alive and believed to be neurologically normal, but follow-up consisted only of the immediate postsurgical hospitalization.[1–33] There are only three reports[34–37] of 4 infants who are alive and neurologically normal at three months postoperatively (1 patient), one year postoperatively (2 patients), and three years postoperatively (1 patient). Thus, even with early neurosurgical intervention, few patients are neurologically normal postoperatively. The neurologic abnormalities may be present preoperatively and may be secondary to intrauterine cerebral damage as a result of the significantly reduced local tissue perfusion to the brain secondary to shunting of blood through the aneurysm with pronounced cerebral damage, or due to hemorrhage or associated cerebral malformations.

Half the cerebral venous malformations reported in the literature have involved the middle and posterior cerebral arteries, the vertebral artery, and the great vein of Galen. In our patients, the arteriovenous malformation was supplied by the posterior cerebral arteries bilaterally in 2 patients, a left posterior cerebral and right thalamoperforator in one, and by a left vertebral artery in one patient.

As the vein of Galen is markedly dilated, the flow of cerebrospinal fluid through the aqueduct of Sylvius may be obstructed, giving rise to hydrocephalus. Thus, the size and complications of the arteriovenous malformation account for the three major presentations in infancy and childhood. Infants with extremely large arteriovenous malformations present in early infancy primarily with cardiovascular effects and congestive heart failure (cases 1 and 2). Other children present in later infancy with hydrocephalus (case 3) and also may have congestive heart failure. A third group present in later infancy and childhood with an intracerebral bleed and also may have hydrocephalus (case 4). One of our patients died in severe congestive heart failure prior to any attempt at surgical correction, which reemphasizes that congestive heart failure in these patients may be severe, unrelenting, and unresponsive to conventional therapy. We feel that diagnosis should be based on clinical findings and angiographic review, with surgical therapy instituted as soon as possible. In reviewing the electrocardiograms of our 4 patients, we found the ST and T wave changes suggestive of subendocardial ischemia in two. This finding has recently been reported by the group from Toronto Sick Children's Hospital.[14] These two patients were the youngest in our series.

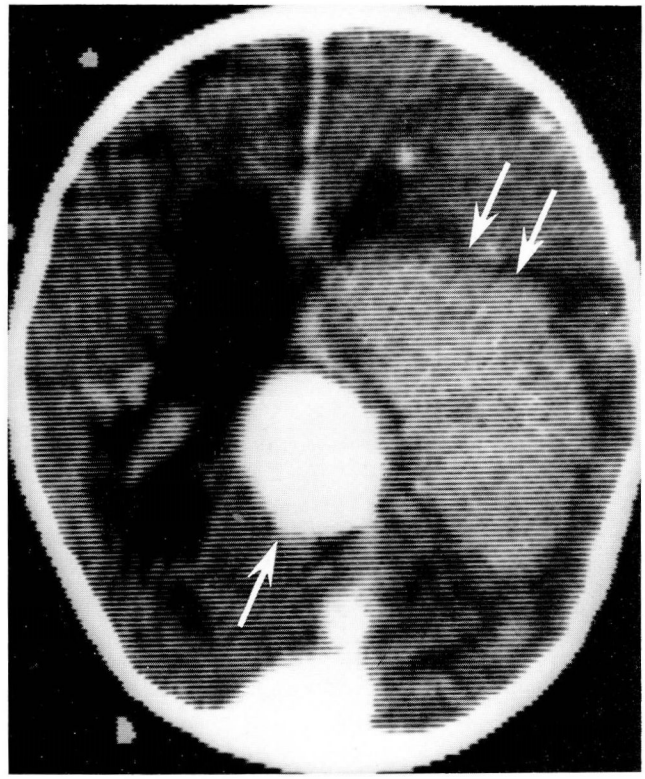

Fig. 5. Case 4. Contrast computed tomography demonstrating a large vein of Galen aneurysm (*large arrow*). Note right temporal intracerebral hemorrhage (*double arrows*).

The CT scan with contrast material is diagnostic in these patients and, indeed, was definitive in all of our patients in whom it was performed (3 of 4 patients). Not only could the arteriovenous malformation be visualized (*Fig. 5*), but accompanying central nervous system abnormalities, such as an intracerebral bleed (*Fig. 5*), could also be demonstrated. Modic et al[38] first described the use of peripheral intravenous DSA in our case 1 in the demonstration of an arteriovenous malformation. Digital subtraction angiography outlines the malformation clearly, and appears to be a useful procedure to follow contrast and

hence CT scanning, and should precede arteriography in patients with suspected arteriovenous malformations. We do not feel at present that DSA sufficiently defines all arterial feeders, so we perform selective arteriography in all patients to accurately demonstrate the feeding vessels (*Fig. 3*). Digital subtraction angiography may also be useful in infants and children with significant intracranial bruits and negative CT scans.

After accurately defining the feeding vessels, a staged surgical approach can be used in which the vessels are clipped on one side. The patient can then return a few days to a few weeks later for surgical ablation of the feeders on the contralateral side. During the intervening period, congestive heart failure decreases, and the patient is more easily managed from a cardiac standpoint.

Despite the high surgical mortalities reported in the literature,[1-37] all 3 of our infants survived a staged neurosurgical procedure. In addition, with prompt recognition and surgical intervention, 2 of our 3 patients are developmentally normal at long-term follow-up. The one patient not neurologically normal had suffered significant central nervous system bleeding prior to surgical correction. With awareness of the clinical signs of arteriovenous malformations, diagnosis may be made quickly and easily in the newborn. Rapid surgical intervention with staged surgical procedures may result in higher surgical survival rates with improved neurologic function. Arteriovenous malformation is still present in these infants, but its hemodynamic effects have been alleviated. All of our infants had normal cardiovascular examination with merely an innocent pulmonary flow murmur. Long-term prognosis in these infants remains to be defined.

References

1. Quero Jimenez M, Acerete Guillen F, Castro Gussoni MC. Arteriovenous fistulas. [In] Moss AJ, Adams FH, Emmanouilides C, eds. Heart Disease in Infants, Children, and Adolescents. Baltimore: Williams and Wilkins, 1977, pp 470–482.
2. Amacher AL, Shillito J Jr. The syndromes and surgical treatment of aneurysms of the great vein of Galen. J Neurosurg 1973; **39:**89–98.
3. Knudson RP, Alden ER. Symptomatic arteriovenous malformation in infants less than 6 months of age. Pediatrics 1979; **64:**238–241.
4. Cumming GR. Circulation in neonates with intracranial arteriovenous fistula and cardiac failure. Am J Cardiol 1980; **45:**1019–1024.
5. Watson DG, Smith RR, Brann AW. Arteriovenous malformation of the vein of Galen. Am J Dis Child 1976; **130:**520–525.
6. Schum TR, Meyer GA, Grausz JP, Glaspey JC. Neonatal interventricular hemorrhage due to an intracranial arteriovenous malformation: a case report. Pediatrics 1979; **64:**242–244.
7. Sapire DW, Casta D. Aneurysmal bulging of the intratrial septum in a newborn infant with arteriovenous fistula and congestive heart failure. Chest 1982; **82:**649–651.
8. Boynton RC, Morgan BC. Cerebral arteriovenous fistula with possible hereditary telangiectasia. Am J Dis Child 1973; **125:**99–101.
9. Berant M, Chaim S. Cerebral arteriovenous fistula causing congestive heart failure in infancy. JCE Pediatrics 1978; **28:**32.
10. Beatty RA. Surgical treatment of a ruptured intracerebral arteriovenous malformation in a newborn. Pediatrics 1974; **53:**571–572.
11. Montoya G, Dohn DF, Mercer RD. Arteriovenous malformation of the vein of Galen as a cause of heart failure in hydrocephalus in infants. Neurology 1971; **21:**1054–1058.
12. Proesmans W, Van Damme B, Casaer P, Marchal G. Autosomal dominant polycystic kidney disease in the neonatal period: association with a cerebral arteriovenous malformation. Pediatrics 1982; **70:**971–975.
13. Schum TR, Meyer GA, Grausz GP, Glaspey JC. Neonatal interventricular hemorrhage due to an intracranial arteriovenous malformation: a case report. Pediatrics 1979; **64:**242–244.
14. Jedeikin R, Rowe RD, Freedom RM, Olley PM, Gillan JE. Cerebral arteriovenous malformation in neonates. The role of myocardial ischemia. Pediatr Cardiol 1983; **4:**29–35.
15. Stanbridge RD, Westaby S, Smallhorn J, Taylor JFN. Intracranial arteriovenous malformation with aneurysm of the vein of Galen as the cause of heart failure in infancy. Echocardiographic diagnosis and results of treatment. Br Heart J 1983; **49:**157–162.
16. Long DM, Seljeskog EL, Chou SN, French LA. Giant arteriovenous malformations of infancy and childhood. J Neurosurg 1974; **40:**304–312.
17. Trumpy JH, Eldevik P. Intracranial arteriovenous malformations: conservative or surgical treatment? Surg Neurol 1977; **8:**171–175.
18. Ventureyra ECG, Ivan LP, Nabavi N. Deep seated giant arteriovenous malformations in infancy. Surg Neurol 1978; **10:**365–370.
19. Yasargil MG, Antic J, Laciga R, Jain KK, Boone SC. Arteriovenous malformations of vein of Galen: microsurgical treatment. Surg Neurol 1976; **6:**195–200.
20. Snider AR, Soifer SJ, Silverman NH. Detection of intracranial arteriovenous fistula by two-dimensional ultrasonography. Circulation 1981; **63:**1179–1185.
21. Sivakoff M, Nouri S. Diagnosis of vein of Galen arteriovenous malformation by two-dimensional ultrasound and pulsed Doppler method. Pediatrics 1982; **69:**84–86.
22. Parkinson D, Bachers G. Arteriovenous malformations. Summary of 100 consecutive supratentorial cases. J Neurosurg 1980; **53:**285–299.
23. Aube M, Tenner MS, Brown J, Sher J. Arteriovenous malformation of the vein of Galen. Acta Radiol 1975; 347:(suppl): 23–30.
24. Wilson CB, Sang H, Domingue J. Microsurgical treatment of intracranial vascular malformations. J Neurosurg 1979; **51:**446–454.
25. Menezes AH, Graft CJ, Jacoby CG, Cornell SH. Management of vein of Galen aneurysms. J Neurosurg 1981; **55:**457–462.

26. Iannucci AM, Buonanno F, Rizzuto N, Mazza C, Vivenza C, Maschio A. Arteriovenous aneurysm of the vein of Galen. A clinical, angiographic CT scan and neuropathological study. J Neurol Sci 1979; **40:**29–37.
27. Norman MG, Becker LE. Cerebral damage in neonates resulting from arteriovenous malformation of the vein of Galen. J Neurol, Neurosurg Psychiatry 1974; **37:**252–258.
28. Kelly JJ, Mellinger JF, Sundt TM. Intracranial arteriovenous malformations in childhood. Ann Neurol 1978; **3:**338–343.
29. Alvarez-Garijo JA, Mengual MV, Gomila DT, Martin AA. Giant arteriovenous fistula of the vein of Galen in early infancy treated successfully with surgery. J Neurosurg 1980; **53:**703–706.
30. Jones RWA, Allan LD, Tynan MJ, Joseph MC. Ultrasound diagnosis of cerebral arteriovenous malformation in the newborn. Lancet 1982; **1:**102–103.
31. Swischuk LE, Crowe JE, Mewborne EB. Large vein of Galen aneurysms in the neonate. A constellation of diagnostic chest and neck radiologic findings. Pediatr Radiol 1977; **6:**4–9.
32. Pasqualin A, Mazza C, Da Pian R, Bernardina BD. Midline giant arteriovenous malformations in infants. Acta Neurochir 1982; **64:**259–271.
33. So SC, Ngan H, Ong GB. Intracranial arteriovenous malformations in the Chinese. Surg Neurol 1979; **12:**41–45.
34. Lakier JB, Milner S, Cohen M, Levin SE. Intracranial arteriovenous fistulas in infancy—haemodynamic considerations. S Afr Med J 1982; **61:**242–245.
35. Lillquist K, Haase J, Thayssen P. Operative treatment of cerebral arteriovenous aneurysm of vein of Galen complicated by congestive heart failure. Br Heart J 1979; **42:**738–741.
36. Cunliffe PN. Cerebral arteriovenous aneurysm presenting with heart failure. Report of three cases. Br Heart J 1974; **36:**919–923.
37. Holden AM, Fyler DC, Shillito J Jr, Nadas AS. Congestive heart failure from intracranial arterial venous fistula in infancy. Clinical and physiological considerations in eight patients. Pediatrics 1972; **49:**30–39.
38. Modic MT, Weinstein MA, Chilcote WA, et al. Digital subtraction angiography of the intracranial vascular system: comparative study in 55 patients. AJR 1982; **138:**299–306.