Interventional Neuroangiography in Neonates

M. KOMIYAMA, H. NAKAJIMA, M. NISHIKAWA, S. KITANO*, H. SAKAMOTO*

*Departments of Neurosurgery and *Pediatric Neurosurgery; Osaka City General Hospital; Osaka*

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Summary

Two neonates with either vein of Galen aneurysmal malformation or dural sinus malformation (congenital dural arteriovenous fistula at the torcular herophili) are reported. In neonatal interventional neuroangiography, special attention should be paid to body temperature, contrast material, infusion fluid, heparin, and angio-equipment. In the neonatal period, the umbilical approach provides unique access routes to both arterial and venous sides of the cerebral circulation. Among them, transumbilical venous, transcardiac approach through the foramen ovale allows transarterial intervention from the venous side.

Introduction

It is extremely rare to require interventional neuroangiography for the neonates. Only the neonates with vein of Galen aneurysmal malformation and dural sinus malformation are the candidates for such interventional angiography. We have already reported two neonates either with vein of Galen aneurysmal malformation or dural sinus malformation elsewhere in detail [1,2]. In this communication, we report these two neonates briefly and focus on several important points specific to the neonatal interventional neuroangiography.

Case Presentation

Case 1: Vein of Galen aneurysmal malformation

Antenatal Doppler sonography at a gestation period of 32 weeks had disclosed an intracranial cystic vascular lesion. Because progressive fetal cardiac failure was found at 37 weeks, an emergency cesarean section was performed. Apgar scores were 2/8 with a birth weight of 2860 g and a head circumference of 33.4 cm. The patient (boy) was transferred to us 5 hours after birth. At admission, no apparent motor weakness was observed, but loud cranial bruit was present everywhere over the head. He developed generalized seizure and cyanosis, requiring controlled ventilation. Chest x-ray demonstrated marked cardiomegaly. Computed tomography (CT) showed intraventricular and subependymal hemorrhage and a slightly high density midline structure, which was homogeneously enhanced by the contrast material.

On day 4, transfemoral (arterial) cerebral angiography was performed using a biplanar digital subtraction equipment, which revealed a large choroidal vein of Galen aneurysmal malformation fed by the bilateral pericallosal arteries of the anterior cerebral arteries, bilateral distal middle cerebral arteries, many feeders from the bilateral posterior cerebral arteries including the posterior choroidal arteries, and the left posterior inferior cerebellar artery (figure 1).

Due to progressive heart failure refractory to medical treatment, interventional neuroangiography was required. The microcatheter (FasTracker-18 catheter; Target Therapeutics Inc., Fremont, CA) and microguidewire (0.014 inch) were difficult to navigate into the target vessels without a guiding catheter because the microcatheter system was unstable and easily fell into the aorta. Then 3 F vascular sheath was exchanged for a 4 F sheath and a 4F guiding catheter. This 4 F system markedly facilitated the interventional procedures. The left posterior inferior cerebellar artery and the right lateral posterior choroidal artery were occluded with interlocking detachable coils (Target Therapeutics Inc.). The femoral sheath was left in place.

On day 6, the second intervention was carried out using the same femoral sheath. The right medial posterior choroidal artery was occluded in the same manner. Final angiography revealed marked reduction of the shunted flow and reduced diameter of the aneurysmal sac from 18 mm to 9 mm. The patient's congestive heart failure improved markedly, but his general condition gradually deteriorated, probably due to persistent pulmonary hypertension. On day 9, the patient developed a pulmonary hemorrhage, which caused respiratory failure and the patient died on day 12.

Case 2: Dural sinus malformation (congenital dural arteriovenous fistula)

An intracranial vascular anomaly had been prenatally diagnosed by Doppler sonograms at a gestation period of 38 weeks. Due to fetal distress, a cesarean section was carried out under spinal anesthesia at 39 weeks. A boy was born with a birth weight of 2,801 g. Apgar scores were 4/9. Except for cardiac failure and bruits heard over the cervical and occipital regions, the patient was neurologically normal. Since there was no apparent brain damage revealed by CT performed the day following birth, treatment of heart failure was warranted. For possible neurointervention, we cannulated the umbilical vein using a 4 F nutritional tube.

On the fourth postnatal day, the first transumbilical venous, transarterial diagnostic and therapeutic angiography was carried out. The 4 F nutritional tube was replaced by a 5 F vascular sheath with a length of 6 cm. This vascular sheath was finally removed on the seventeenth postnatal day, following the fourth intervention. A 5 F double-lumen balloon catheter (Arrow International, Reading, PA) was navigated from the umbilical vein to the inferior vena cava through the ductus venosus, to the right atrium, then to the left atrium through the foramen ovale, to the left ventricle, and finally to the ascending aorta.

Using a long guidewire, the balloon catheter was exchanged for a Tracker-38 catheter (Target Therapeutics, Fremont, CA), which was introduced into the ascending aorta and then into the brachiocephalic vessels. Angiography revealed dural sinus malformation at the torcular herophili. The main feeding arteries were the bilateral middle meningeal arteries, bilateral occipital arteries, bilateral tentorial arteries, bilateral superior cerebellar arteries, and bilateral anterior inferior and posterior inferior cerebellar arteries (figure 2). The occipital and marginal sinuses were patent bilaterally.

We first attempted transumbilical, transarterial embolization, but due to elongation and coiling of the common carotid and extracranial internal carotid arteries and their small sizes, embolization was accomplished only on the right occipital artery and bilateral middle meningeal arteries, using platinum coils, and to the left anterior inferior cerebellar artery, using polyvinyl alcohol particles through a microcatheter. Progressive heart failure prompted us to undertake proximal coil placement over three sessions, viz., on the fourth, tenth, and twelfth postnatal days. Due to progressive heart failure even after three sessions, transvenous embolization of the huge venous lake through the umbilical venous route was required on the seventeenth postnatal day. A 4 F Berenstein catheter was advanced from the umbilical vein, to the inferior vena cava through the ductus venosus, to the right atrium, to the superior vena cava, and then finally to the right internal jugular vein. A microcatheter was introduced into the right occipital sinus and then into the huge venous pouch without difficulty.

We undertook coil occlusion on the belief that even partial reduction of shunt flow might improve clinical symptoms. Platinum Galen coils and interlocking detachable coils (Target Therapeutics, Fremont, CA) of a total length of 590 cm were introduced loosely into the venous pouch. After this procedure, the umbilicus was ligated. This transvenous embolization improved heart failure to such a dramatic degree that we were soon able to discontinue controlled ventilation and markedly reduce the dose of diuretics, while the patient's body weight gradually began to increase. Chest x-ray showed marked improvement of cardiomegaly. The patient was discharged at 3 month-old. At the last follow-up, the patient was 11 month-old with mild heart failure, which was well controlled with medication. He remained neurologically normal.

Discussion

Vein of Galen aneurysmal malformation is a rare disease and only less than 30 such patients have been reported till 1996 in Japan [3]. Dural sinus malformation is even rarer than vein of Galen aneurysmal malformation [4]. Basic techniques in the interventional neuroangiography for the neonates are similar to those in children and adults. However, definite differences exist in their management and angiographic routes.

General management

Several important points should be stressed: body temperature, contrast material, infused fluid, heparin, and angio-equipment. It is crucial to keep the body temperate of the neonates adequately especially outside the incubator. In order to keep the

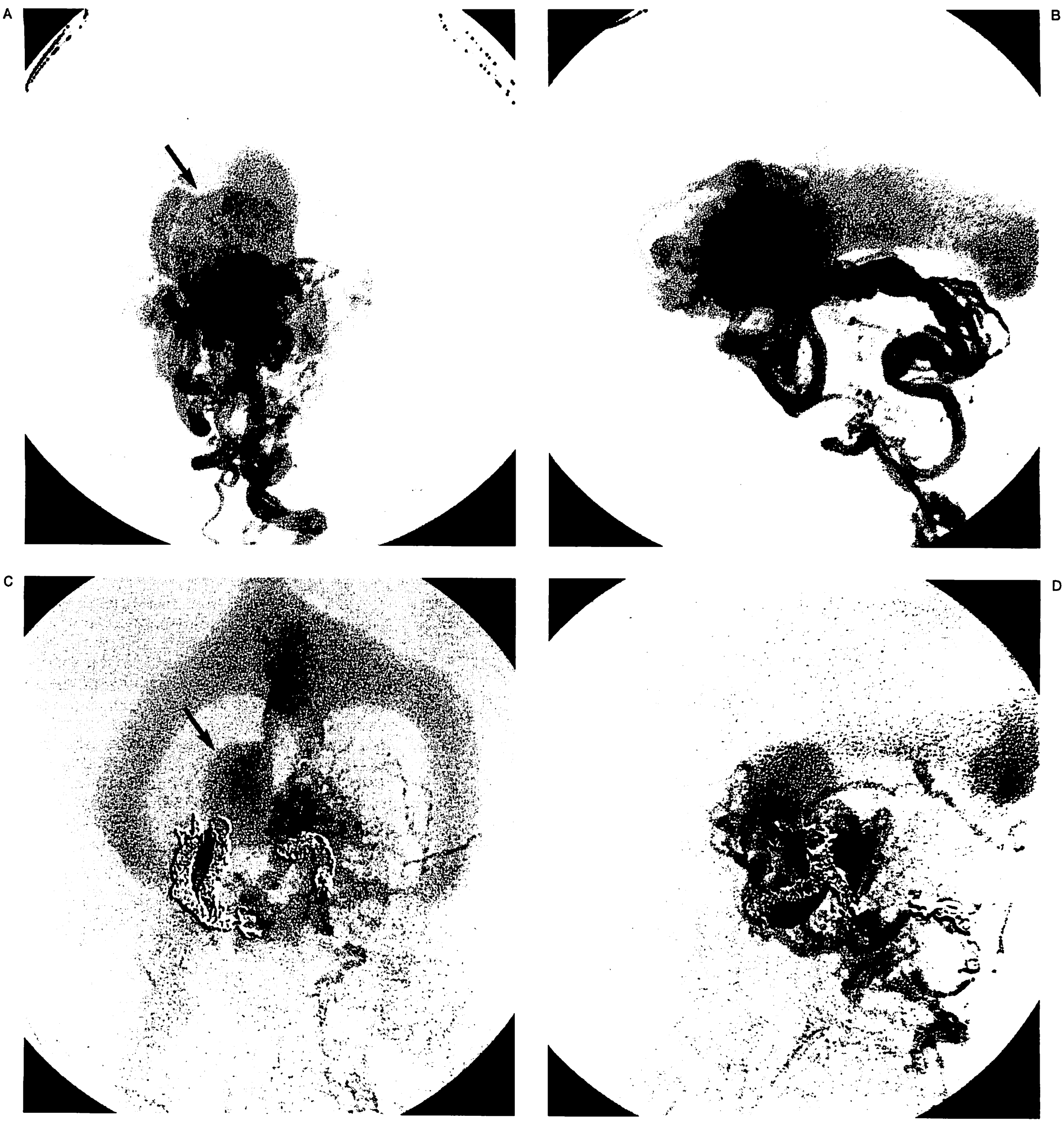

Figure 1 Case 1: Vein of Galen aneurysmal malformation. Pre-embolization left vertebral angiograms, anteroposterior (A) and lateral views (B), showing vein of Galen aneurysmal malformation. Post-embolization left vertebral angiograms, anteroposterior (C) and lateral views (D), revealing marked reduction of the shunted flow. The diameter of the aneurysmal sac (arrow) has been reduced from 18 mm to 9 mm.

temperature, we lapped the extremities with aluminum sheet during angiography. Total dose of the non-ionic contrast material is limited up to 6 ml/kg[5], but the neonates have usually cardio-renal dysfunction and the contrast materiel is more strictly limited. Normal saline should be replaced by dextrose infusion because large amount of sodium in saline would cause serious electrolyte imbalance. Heparin should be strictly used because large amount of heparin would cause serious hemorrhagic complications. One unit of heparin in the one ml of saline or dextrose is an adequate dose to keep the infusion line or fluid used during angiography. We believe that biplane and digital subtraction angio-equipment

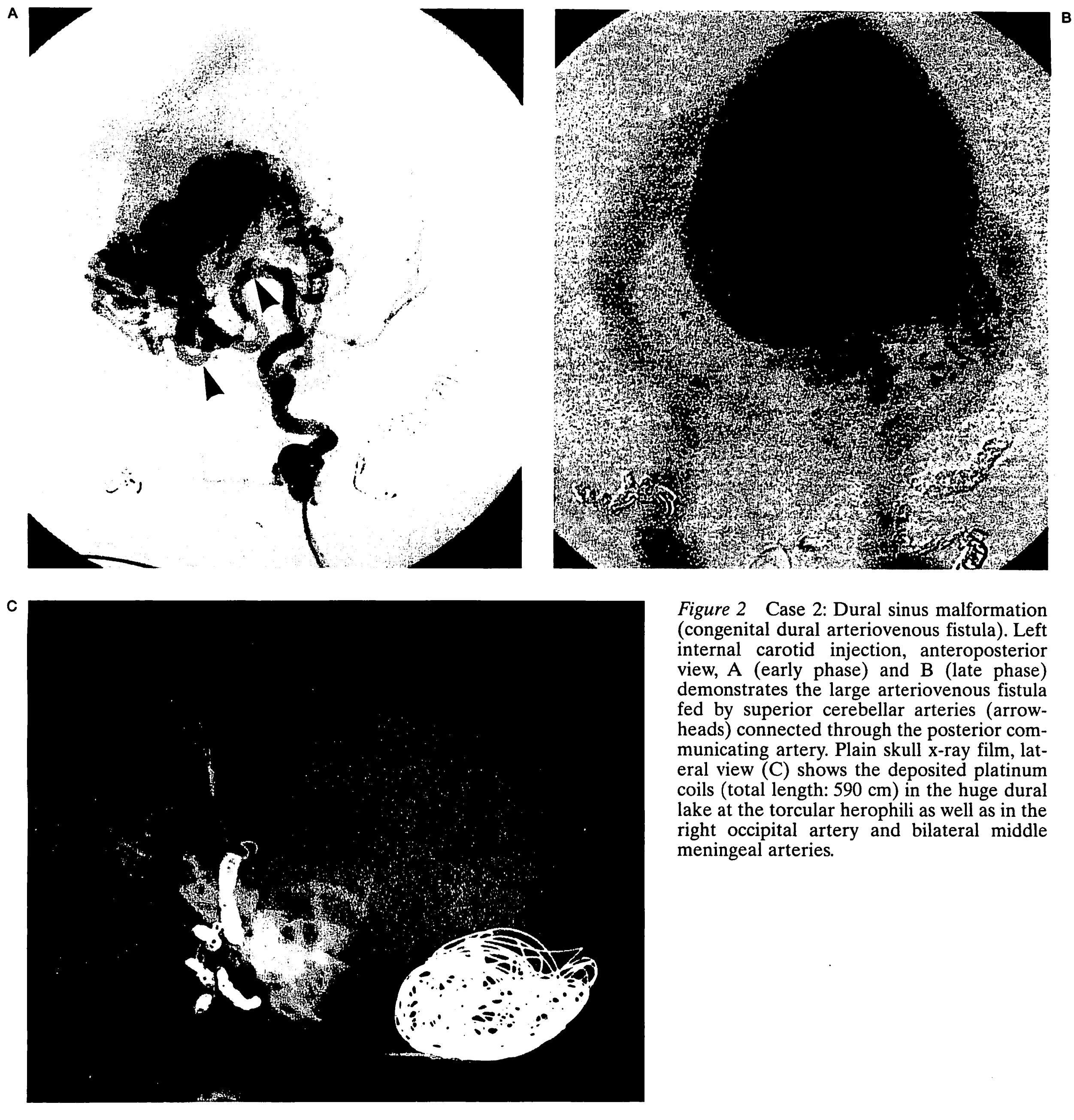

Figure 2 Case 2: Dural sinus malformation (congenital dural arteriovenous fistula). Left internal carotid injection, anteroposterior view, A (early phase) and B (late phase) demonstrates the large arteriovenous fistula fed by superior cerebellar arteries (arrowheads) connected through the posterior communicating artery. Plain skull x-ray film, lateral view (C) shows the deposited platinum coils (total length: 590 cm) in the huge dural lake at the torcular herophili as well as in the right occipital artery and bilateral middle meningeal arteries.

is essential for neonatal intervention to reduce the dose of the contrast material and time required for the procedures.

Angiographic routes

In the neonatal periods, access routes to the cerebral circulation are transfemoral route, transcervical or jugular route, transumbilical route, and direct approach to the lesion. Transfemoral routes include transfemoral arterial and transfemoral venous routes to the cerebral arterial and venous circulation. It is impossible to perform neurointervention without a guiding catheter because of instability of the microcatheter. Transfemoral venous, transcardiac route provides another way to reach from the venous side to the arterial side through the foramen ovale. Transcervical arterial route by direct puncture to the carotid artery is invasive and risky, thus not appropriate for neonatal neuroangiography. Tran-

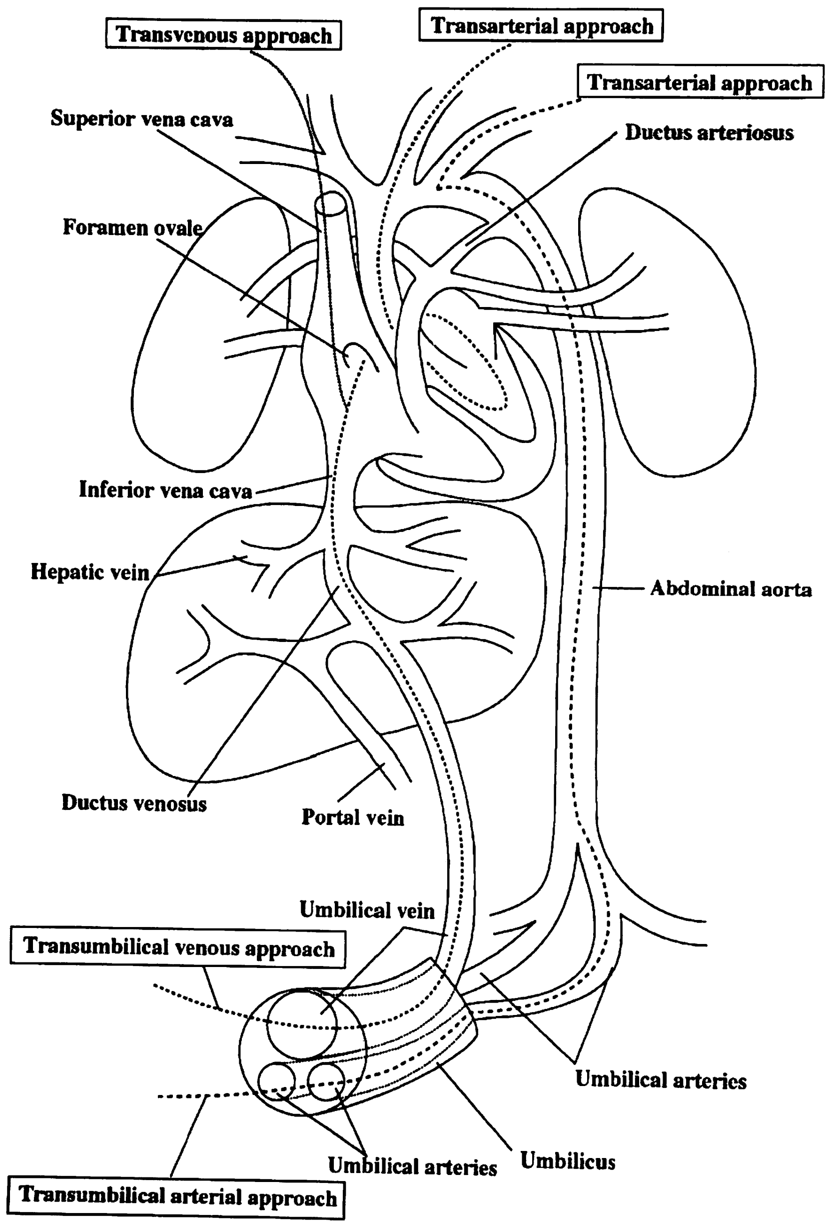

Figure 3 Transumbilical routes to the arterial and venous sides of the cerebral circulation in neonatal neurointervention.

sjugular venous route by direct puncture to the cerebral venous circulation is another option.

Transumbilical routes provide unique routes only available in the neonatal periods (figure 3). The umbilical cord has two thick-walled, round umbilical arteries and one larger thin-walled, oval umbilical vein [6]. The umbilical arteries originate from the internal iliac arteries and run caudal along the sides of the bladder and then turn cephalad along the abdominal wall to the umbilicus. The umbilical arteries constrict rapidly after birth in normal neonates while they remain patent for longer periods in hypoxic-ill newborns [7].

The umbilical vein is located at the 12 o'clock position at the level of the abdominal wall and runs cephalad to the left portal vein, and then through the ductus venosus, connecting to the inferior vena cava [7,8].

Cannulation to the umbilical artery should be carried out immediately after birth because it is almost impossible after postnatal day 4[6]. Since the direction of the artery near the umbilicus is caudal, this approach is not convenient for manipulation of catheters for angiography or intervention. Berenstein et Al[9] reported in 1997 diagnostic and therapeutic angiography for vein of Galen aneurysmal malformations using this approach.

Cannulation to the umbilical vein is easier than that to the umbilical artery and may be performed up to at least 7 days after birth[7]. Since the direction of the vein is cephalad, this approach is convenient for diagnostic and interventional procedures. Placement of the catheter in the umbilical vein may be tolerated over a longer period than that in the umbilical artery. In a transarterial approach, the catheter must pass through the heart, from the right atrium to the left atrium through the foramen ovale, then to the left ventricle.

There is a risk of inducing arrhythmia during intracardiac catheter manipulation, but this is usually tolerated when a gentle maneuver is employed. Both a transjugular venous cerebral approach and a transcardiac, transarterial cerebral approach can be made through the umbilical venous route. We believe that intracardiac catheter manipulation should be performed by pediatric cardiologists who are familiar with transfemoral, transcardiac procedures.

Conclusions

General management in neurointervention for neonates differs from those for children and adults. During the neonatal period, umbilical arterial and venous routes provide unique vascular access in diagnostic and therapeutic neuroangiography.

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Dr Masaki Komiyama, M.D.
Department of Neurosurgery
Osaka City General Hospital
2-13-22, Miyakojima-Hondouri
Miyakojima, Osaka 534-0021 Japan
E-mail: komiyama@japan-mail.com