

# The application of preoperative computed tomography angiogram for hemispherectomy

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## Abstract

Hemispherectomy is an established neurosurgical procedure for unilateral refractory epilepsy. Even though the surgical approach has evolved greatly, prevention of catastrophic intraoperative bleeding is a challenge. It is important that surgeons know the abnormal blood vessel before surgery. Herein, we report our experience with two patients in whom computed tomographic angiography (CTA) was used in the preoperative evaluation for hemispherectomy. CTA allowed for precise anatomical delineation of the hemispheric vascular abnormalities. Preoperative CTA showed that the specific cerebral arteries and their branches ipsilateral to the lesion were slender. Elaborate preoperative planning for the surgical approach helped prevent catastrophic intraoperative bleeding. Favorable outcomes were achieved in both children. CTA appears to confer a considerable advantage in the preoperative vascular and anatomical delineation in patients scheduled for hemispherectomy. To our knowledge, this is the first report about the application of CTA for hemispherectomy preoperative planning.

## Introduction

Resective epilepsy surgery has become an established treatment modality for appropriately selected children and infants with symptomatic focal seizures.<sup>1</sup> Hemispherectomy is an effective treatment for unilateral refractory epilepsy.<sup>2,3</sup> In 1938, McKenzie provided the first description, and in 1950, Krynauw reported the first positive results in seizure outcome.<sup>4,5</sup> Although the surgical approach has greatly evolved, preventing catastrophic intraoperative bleeding is still challenging. Uncontrollable intraoperative blood loss is one of hemispherectomy complications.<sup>6</sup>

The indications for hemispherectomy

include frequent seizures, status epilepticus, and hemiparesis due to cortical dysplasia, perinatal stroke, hemiconvulsion-hemiplegia-epilepsy syndrome, Rasmussen encephalitis, and Sturge-Weber syndrome.<sup>3</sup> Some patients may develop into cerebral atrophy and have variant vascular anatomical structures.<sup>7</sup> Vascular abnormalities of brain atrophy and malformations of vessels increase the risk of blood loss in the hemispherectomy. Additionally, perioperative blood transfusion can cause a variety of complications.<sup>8</sup> Because surgeons do not know about vessel malformation before surgery, they could not correctly identify abnormal blood vessels in the surgery.

A strong understanding of the complicated anatomical structures and early identification of vascular abnormalities and focal developmental malformations are essential prerequisites to the prevention and control of intraoperative bleeding.

Herein, we report two cases in whom we performed CTA for preoperative evaluation for hemispherectomy. CTA scan allowed for precise anatomical delineation of hemispheric vascular abnormalities.

## Case Reports

### Case #1

A 17-year-old boy presented with a 4-year-long history of epileptic seizures, which was controlled unsatisfactorily with antiepileptic drugs. He was born at 42 weeks of gestation by breech delivery and had sustained neonatal stroke. At the age of 14, he was diagnosed with complex partial seizures. His seizures semiology generally consisted of an aura, unconsciousness, and jerks in both upper and lower limbs. His partial status epilepticus occasionally lasted for up to 1 min. Occasionally, he sustained a more prolonged, secondarily generalized tonic-clonic seizure, which lasted for 2 to 3 min. His seizures were refractory to several trials of antiepileptic medication under supervision.

The brain magnetic resonance imaging (MRI) showed cystic porencephaly in the right cerebral hemisphere (Figure 1A and B). Preoperative CTA scan needed 2 min and completed when the patient was awake. It showed attenuation of ipsilateral anterior cerebral artery (ACA) and middle cerebral artery (MCA) and their branches (Figure 2A and B). A diagnosis of refractory epilepsy was made, and a right anatomical hemispherectomy was scheduled.

The operation involved removal of the entire right hemisphere, with preservation of the basal ganglia, thalamus. The surgeon

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divided the ACA and MCA distal to the origin of the deep perforators, and preserved the vessels that provide blood supply to the basal ganglia. Complete resection of the right hemisphere was performed.

The patient lost blood less than 200 mL. He did not receive packed red blood cells and received 1500 mL of crystalloid in the surgery. The anesthesiologist maintained blood pressure at 90/60 mmHg. Surgical time from skin to skin was 8.5 h. Preoperative hemoglobin level was in the normal range. Hemoglobin values immediately after surgery was 105 g/L (normal range 115-150 g/L). Over the first day after surgery, hemoglobin levels keep up in 100 g/L. Postoperative computed tomography (CT) scan confirmed the complete removal of the right hemisphere (Figure 3A). After surgery, all motor and sensory functions were preserved. Compared with his preoperative condition, no motor deficit was observed in the left limbs. The average number of antiepileptic drugs taken before surgery was 3, which was reduced to 1 after surgery. The boy was discharged 12 days later. During a follow-up period of 24 months, the boy was Engle and could perform simple tasks.

## Case #2

A 9-year-old girl was admitted to our department for intractable epilepsy. She experienced coma a few days after birth and was diagnosed as a case of neonatal stroke. She woke up 7 days later from the coma, but developed left-sided hemiparesis. At 2.5 years of age, she developed simple partial seizures. Later, the seizures aggravated to complex partial seizures. The brain MRI showed a diffuse lesion in the right cerebral hemisphere, asymmetric skull, and a large porencephalic cyst (Figure 1C and D). Preoperative CTA scan needed 3 min and completed smoothly when the patient was awake. Preoperative CTA scan showed parameters similar to those in case 1, which showed ipsilateral attenuation of middle cerebral artery and its branches (Figure 2C and D). A right anatomical hemispherectomy was planned. The right hemisphere was totally resected after preservation of vascular supply to the basal ganglia. Postoperative CT scan confirmed complete removal of the right hemisphere (Figure 3B).

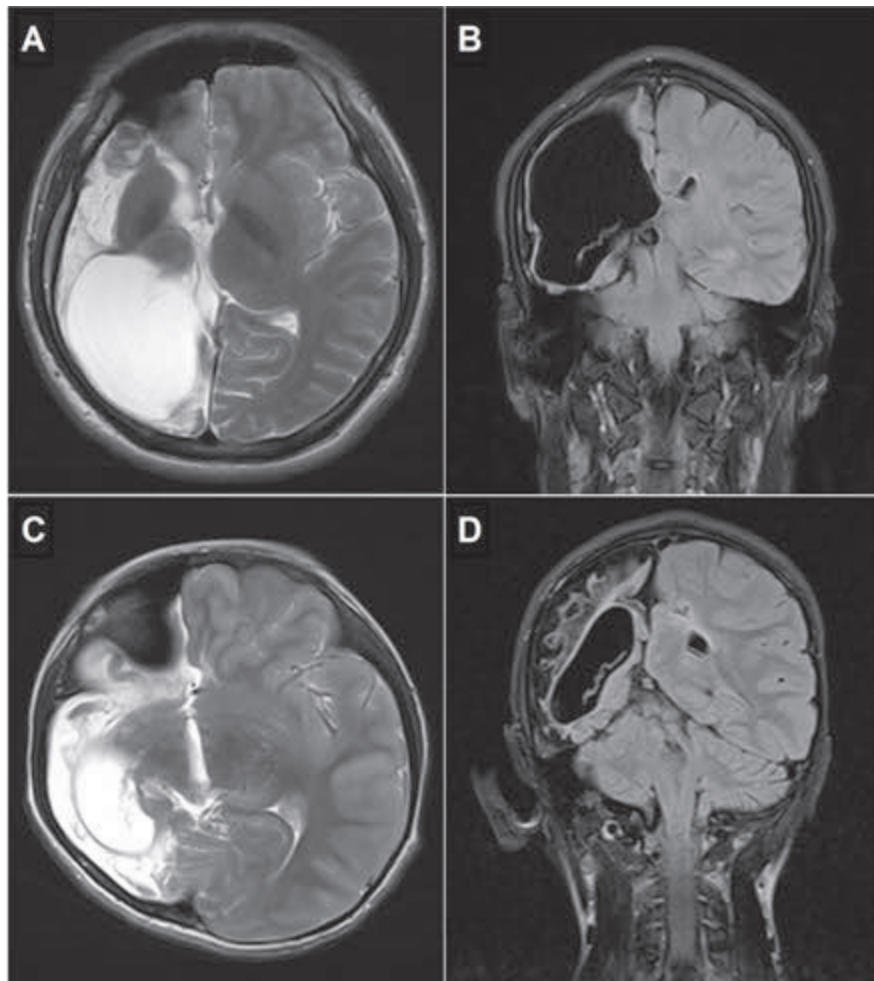
Blood loss was less than 250 mL. The patient did not receive packed red blood cells in the surgery. Blood pressure was at 80/50 mmHg. Surgical time from skin to skin was 9.2 h. Preoperative hemoglobin level was in the normal range. Hemoglobin values immediately after surgery was 102g/L (normal range 115-150 g/L). Over the first day after surgery, hemoglobin levels keep up in 95 g/L.

After surgery, her sensory and motor functions recovered. Compared to her preoperative status, no change in motor activity was evident on the left side. The girl was discharged 15 days later. During a follow-up period of 36 months, the girl was able to attend school and she was Engle.

## Discussion

Hemispherectomy, originally described as the anatomical removal of unilateral cerebral hemisphere, has been the treatment of choice for patients with pharmacologically intractable epilepsy attributed to congenital or acquired hemispheric pathology including Rasmussen encephalitis, Sturge-Weber disease, hemimegalencephaly, and extensive hemispheric infarct. As per the available literature, the complete control rate for epileptic seizure, seizure free outcome, has ranged from 65% to 95%.<sup>9,10</sup>

Anatomical hemispherectomy is a technically challenging procedure with unmanageable potentially intraoperative bleeding being the most common complication.<sup>11</sup>



**Figure 1. Case 1: Preoperative axial T2-weighted (A) and coronal T1-weighted (B) magnetic resonance imaging (MRI) showing cystic porencephaly in the right hemisphere. Case 2: Preoperative axial T2-weighted (C) and coronal T1-weighted (D) MRI showing the diffuse lesion in the right hemisphere, an asymmetric skull and a large porencephalic cyst.**

The identification of right MCA and ACA amidst the vascular abnormalities or focal developmental malformations is critical to successful outcomes.<sup>12</sup> This report illustrates the potential of preoperative CTA imaging as an aid to the precise identification of these variant anatomical structures in patients undergoing pre-hemispherectomy. The methods for detection of vessel malformation include CTA, magnetic resonance angiography (MRA) and intra-arterial digital subtraction angiography (IADSA).

Abnormal blood vessels can be identified more precisely and directly with angiography. The traditional golden standard for diagnosing vessel malformations is catheter intra-arterial digital subtraction angiography (IADSA). The doctor injects contrast dye from the catheter into the cerebral artery. Vessel images taken during injection can be evaluated the arterial and the venous system of brain.

However, IADSA must use ionizing radiation (up to four times as much as CTA)

and iodinated contrast agents. They have the risk of contrast-induced nephropathy.<sup>13</sup> IADSA is associated with a risk of stroke and puncture site complications of thrombus. IADSA is invasive and expensive<sup>14</sup> and needs an experienced radiologist to perform the procedure.

CTA and MRA are modern noninvasive neurovascular imaging techniques. CTA scan time is shorter than MRA. Our CTA is high-speed multislice, dual-source CT scanners, which allows examining the brain vessel less than 3 min, obviating the need for sedation in young children. While MRA in our hospital need more than 10 min. Because some patients have cognitive impairment,<sup>15</sup> they can not follow the commands of doctors for a long time.

Though MRI is routinely performed, MRA must be performed separately and some children cannot endure long-time examination. Sedation for preoperative evaluation is harmful to children. CTA may be better than MRA. MRA can display large vessels. And small blood vessels can be

shown in CTA. It is important to preserve blood supply of the basal ganglia, thalamus.

Using post-processing programs, a radiologist allows arterial and venous reconstructions with subtraction of the bony structures. CTA create high-resolution images of the arteries of the brain and may directly reveal the abnormal blood vessel.<sup>16</sup>

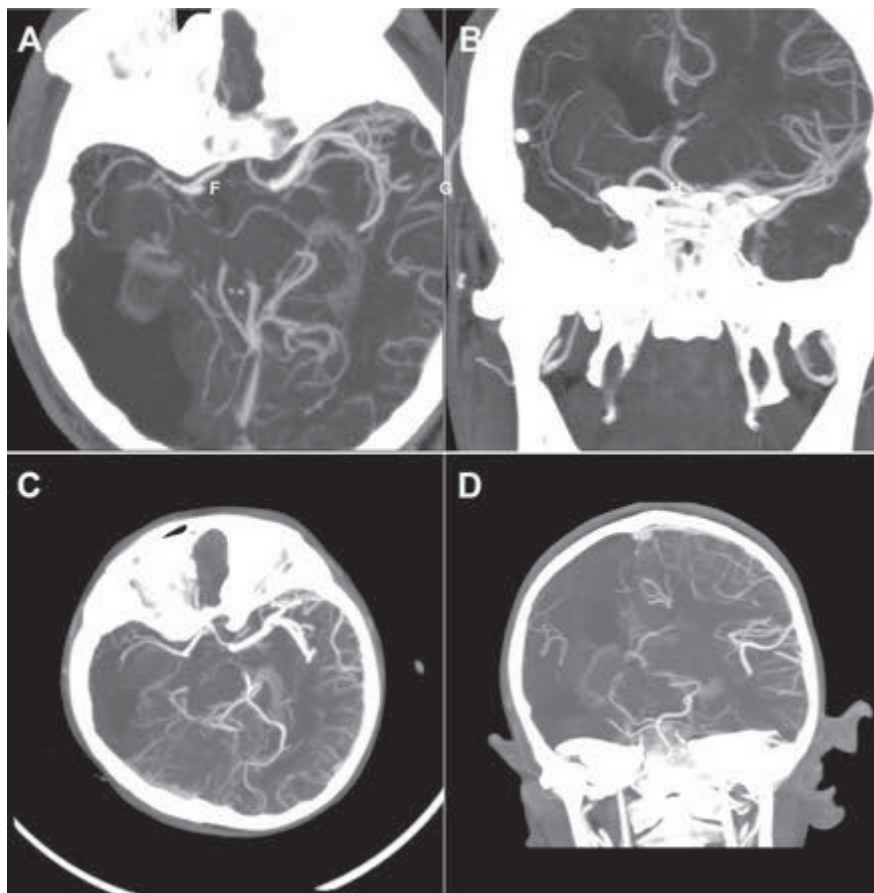
Using axial, coronal imaging and three-

dimensional reconstruction of CTA, precise delineation of the vascular anatomy is possible. Using CTA, the surgeon knows the information of attenuation of ipsilateral ACA and MCA.

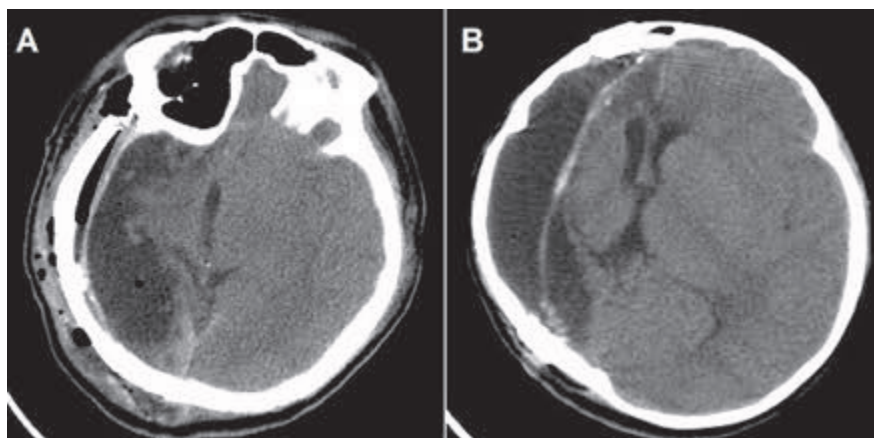
Blood loss volume, hemoglobin levels and surgery time from skin to skin are less than before in our hospital. They may be equal to the published paper abroad.<sup>17</sup>

Above all, MRA and IADSA have been widely used, but both of these modalities should not be recommended as the first line option in patients undergoing hemispherectomy.

CTA, which is cheaper and less invasive than many other techniques and can be easily modified from contrast-enhanced CT, may confer a considerable advantage in the preoperative evaluation for hemispherectomy.



**Figure 2.** Preoperative head computed tomographic angiogram showing vascular abnormalities. (A and B: Case 1; C and D: Case 2).



**Figure 3.** Postoperative computed tomographic scan confirmed the complete removal of the right hemisphere (A: Case 1; B: Case 2).

## Conclusions

A strong understanding of the complicated anatomical structures and early identification of vascular abnormalities and focal developmental malformations is key to the prevention and control of intraoperative bleeding in patients undergoing hemispherectomy. CTA allows for precise vascular and anatomical delineation in patients undergoing hemispherectomy.

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