Intracranial Aneurysms Mimicking Third Ventricular and adjoining parts Masses Associated with Obstructive Hydrocephalus: Diagnosis and Treatment

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Abstract

Objective: Intracranial aneurysms presenting as third ventricular and adjoining parts masses are rare, and always associated with obstructive hydrocephalus. It is vital to provide precise diagnostics, and prompt treatment for such patients since endovascular or microsurgical operations remain challenging. This study aimed to discuss differential diagnosis tactic based on collected cases and the current literature on intracranial aneurysms mimicking third ventricular masses, and a treatment regimen based on the available data is proposed.

Methods: We collected a case series of intracranial aneurysms presenting as third ventricular masses with hydrocephalus from our hospital database. Literature reports related to aneurysms adjoining the third ventricle since 1979 were also included.

Results: Twenty-seven cases of this disease were collected. The average age of the patients was 62 years (range, 14–82 years). The female-to-male ratio of the patients was 14:13. Eight of the 27 patients died during hospitalization. Basilar artery aneurysm was the most common type (21 of 27 cases). One aneurysm from our cases was considered as a craniopharyngioma according to MRI report. There are false negative angiography reports for aneurysms from our cases and literature review. Strategies for the diagnosis and treatment of these aneurysms have changed over time. The uniqueness of our cases sheds light on the use of CT angiography, which has proven to be an appropriate test for diagnosis and reexamination but was not wildly applied in previous reports.

Conclusions: Thrombosed aneurysms should be considered a differential diagnosis in patients with third ventricular masses. Application of CTA and VW-MRI can be beneficial. Aneurysm coil occlusion might be a favorable treatment for cases with mass effect. Further studies should be conducted to confirm our observations.

Introduction

Third ventricular and adjoining parts masses, including various tumors such as germ cell tumors, glial cell tumors, craniopharyngiomas,[1] meningioma, ependymomas, choroid plexus tumors,[2–4] epidermoid cysts,[5, 6] and various vascular malformations[7] can cause obstruction of cerebral spinal fluid (CSF) flow and result in hydrocephalus. Identifying the pathological histology of this area is of great clinical importance, especially for rare intracranial aneurysms[8–26]. These intracranial aneurysms are usually giant, sometimes with thrombogenesis inside, which makes a portion of these aneurysms resemble brain tumors on magnetic resonance imaging (MRI) and computed tomography (CT). Mass effect, thrombosis and calcification can appear in intracranial aneurysms, causing compression of important surrounding structures such as cranial nerve compression paralysis and limb paralysis to varying degrees or increased intracranial pressure due to occupying. CT showed the focal point accompanied by calcification, with uneven internal density and large patchy edema density around. MRI also showed manifestation of intracranial mass with mixed signals. And angiography may have false negative results because of the thrombosis. Intracranial aneurysms can be misidentified due to atypical symptoms, which are more common in brain tumors. Neuroimaging error reporting occurs in our cases and the literature because of the scarcity of this situation. Craniotomy for those “tumor resection” could be dangerous when aneurysms are not considered. To avoid this unexpected intraoperative situation, preoperative examinations should be performed to detect potential aneurysms. CT is the most commonly used neuroimaging method in neurosurgical disease due to the convenience and excellent sensitivity for acute hemorrhage. Also, the superiority of showing calcification makes CT scan valuable in identification of calcific aneurysm wall. MRI has high specificity in the diagnosis of large intracranial aneurysms, especially in the manifestation of aneurysm lumen and lumenal thrombus. Typical thrombus signals in aneurysms are mixed signals with high and low alternating layers or vortexes. In addition, irregular flowing blood vortices in the aneurysm lumen can cause blood flow artifacts in the phase code direction of MRI. These flow artifacts are favorable in diagnosing aneurysms. Besides, MRI can provide important information about the relationship between aneurysm location and surrounding structures. Digital subtraction angiography (DSA) is considered the gold standard for diagnosing aneurysms and is widely used in cerebrovascular diseases. All cases of third ventricular and adjoining parts masses associated with obstructive hydrocephalus from previous case reports, and this study applied DSA as a diagnostic criterion. There is no doubt that DSA is reliable in diagnosing intracranial aneurysms, but it is an invasive procedure that is usually not considered a preferred inspection method. In addition, DSA may result in false-negative or imprecise results in aneurysms with thrombosis. Computed tomographic angiography (CTA) and magnetic resonance angiography (MRA) are also commonly used angiography, with greater safety and convenience, but DSA is always needed as golden standard. Optimizing neuroimaging tactics is imperative in treating this particular intracranial space-occupying lesion.

Even with detailed information of a case, how to cope with aneurysms adjoining the third ventricle associated with obstructive hydrocephalus remains to be determined. This may be because the change in intracranial pressure after surgery or the generally giant size of the aneurysm and the high risk of hemorrhage, aneurysm rupture, and cerebral infarction render the prognosis of the patient as usually unfavorable. Aneurysm rupture during surgery is the most likely cause of death.[8, 10, 11, 13, 25, 26] The surgical approach has developed, and with a view of the history of this situation, better treatment strategies may emerge.

This study aimed to assess different neuroimaging methods in revealing aneurysms adjoining the third ventricle with obstructive hydrocephalus through our cases and a literature review. Furthermore, we wanted to investigate the appropriate treatments for this situation.

Methods

This case series was conducted with ethical approval from the Ethical Institutional Review Board, and informed consent was obtained from all patients. Here, we present a case series of four patients with aneurysms adjoining the third ventricle and a case of an anterior cranial fossa that could oppress the third ventricle. All data were collected by retrospective review of patients from a single-institution database over a six-year period (2015–2021). A systematic search was conducted using the Embase and PubMed databases. The search terms were “aneurysm” and “third ventricular mass” with no language restriction. To specify differential diagnosis between aneurysms and different kinds of tumor, cases with aneurysms adjoining the third ventricle associated with obstructive hydrocephalus were included from literature. Previous case reports and case series since 1979, which provided complete information on neuroimaging, treatment options, and follow-up outcomes, were included. One of our cases was a giant anterior cranial fossa aneurysm that was not directly associated with the third ventricle (case 3), but the mass was close to the third ventricle, and the lesion also caused hydrocephalus. VW-MRI (vessel wall MRI) was conducted in this case to estimate the risk of aneurysm rupture. We believe that this case can also inform us of the proper diagnostic and surgical strategies for aneurysms adjoining the third ventricle. All Basic information of aneurysms present as lesions of the third ventricle and hydrocephalus in the literature and the database is preset in Table 1.

Table 1
Basic information of cases in the literature and the database.

Author	Age/Sex	Site	Rupture	Treatments	Neuroimaging	Outcome
Babu et al.	52/M	Acomm	No	VP shunt, ligation	CT, DSA	death
Koga et al.	65/F	BA	No	VP shunt	CT, DSA	good
Piek et al.	60/F	BA	No	VP shunt	CT, DSA	good
Bose et al.	55/F	BA	No	VP shunt, resection	CT, DSA	death
Borrie et al	72/F	BA	No	VP shunt	CT, DSA	good
	70/M	MCA	No	VA shunt	CT, DSA	good
Ishibashi et al	63/M	BA	No	VP shunt	CT	ICA occlusion
Smith et al.	60/F	Pcomm	Yes	EVD/VP shunt, clipping thrombectomy	MRI, DSA	good
Koyama et al.	67/F	BA	No	EVD	CT, MRI, DSA	death
Hongo et al.	70/F	BA	Yes	ETV, coil occlusion	CT, MRI, DSA	death
Ishihara et al	72/F	BA	No	ETV, coil occlusion	CT	not reported
Gelal et al	58/M	BA	No	VP shunt	CT, MRI, MRA, DSA	good
Nabika et al	58/M	BA	Yes	VP shunt	CT, DSA	death
Liu JK et al	55/M	BA	No	clipping	MRI, MRA, DSA	good
Tsutsumi et al	58/M	BA	No	VP shunt, coil occlusion	CT, MRI, MRA, DSA	hydrocephalus
Stachura et al	82/M	BA	/	ETV	/	good
Oertel et al	80/M	BA	No	ETV	CT, MRI	good

Author	Age/Sex	Site	Rupture	Treatments	Neuroimaging	Outcome
	55/M	BA	No	ETV, coil occlusion	MRI	death
	32/F	BA	No	ETV	MRI, DSA	death
Castro et al	67/M	ACA	No	VA shunt	CT, MRI, DSA	good
Sato et al	76/F	BA	No	ETV, coil occlusion	MRI, MRA, DSA	development
Kalousek et al	62/F	BA	No	EVD, coil occlusion	CT, MRI, DSA	good
Case 1	14/F	BA	No	coil occlusion	CT, CTA, MRI, DSA	good
Case 2	61/F	BA	No	clipping	CT, CTA, MRI, DSA	coma
Case 3	53/M	Acomm	Yes	clipping, resection	CT, CTA, MRI, DSA	death
Case 4	60/F	BA	No	Stenting, coil occlusion	CT, CTA, DSA	good
Case 5	67/M	Acomm	Yes	clipping	CT, CTA, DSA	good

Case Presentation

Case 1

A 14-year-old girl presented, having had a headache, nausea, and blurring of vision for a few days. Ataxia, temporal hemianopia of the right eye, and nasal hemianopia of the left eye were found on physical examination with impaired vision in both eyes. Hormone tests revealed declines in adrenocorticotropic hormone (ACTH) and cortisol levels (Table 2). MRI of the sellar region revealed a 41 × 24 × 23 mm solid-cystic lesion located in the suprasellar region (Fig. 1). According to the MRI examination report, the lesion was considered a craniopharyngioma. Supratentorial hydrocephalus and interstitial cerebral edema were observed. CT scanning revealed annular calcifications at the inferior margin of the lesion. On CTA, the lesion located in the suprasellar region was found to be connected with the basilar artery apex, and the lesion was considered a thrombosed basilar apex aneurysm, which was later confirmed by DSA. The patient underwent an exploration surgery via the right subfrontal approach for diagnosis and CSF diversion. Lamina terminalis fenestration was performed to further release the CSF and explore the intracranial mass. The mass was determined to be bulging in the region behind the optic chiasm. An injector was used to poke the mass, and arterial blood was observed in the injector, so the mass was determined to be a thrombosed giant intracranial aneurysm, which was identical to the result of CTA. The aneurysmal neck was unclear, so the patient was transferred to the interventional operating room for aneurysm coil occlusion. The angiography revealed the thrombosed aneurysm, with a dimension of 22.0 × 12.0 × 4.0 mm diameter, located in the basilar apex, and an aneurysm coil occlusion was performed. The postoperative examination result of visual acuity remained the same as before the surgery. Hormone tests after surgery showed significant recovery in ACTH and cortisol (ACTH: 0.987 pmol/L; cortisol: 296 nmol/L). The patient recovered fairly,, clinical and radiological follow-ups with brain CT scanning and CTA were performed four months and 19 months after the operation. CT scanning and CTA demonstrated that the thrombosed basilar aneurysm was stable, without evidence of recanalization. The hydrocephalus was relieved, and the ventricles had diminished in size during the 19-month follow-up (Fig. 2), and the patient's neurological function recovered completely to normal levels.

Hormone Tests Before Surgery Of Case

Hormone	Result	Measurement	Reference Range
Free Triiodothyronine (FT3)	3.3	pmol/L	2.8–7.1
Free Thyroxine (FT4)	17.25	pmol/L	12–22
Thyroid Stimulating Hormone (TSH)	2.12	mUI/L	0.27–4.2
Cortisol	60.43	nmol/L	172–497
Follicle-Stimulating Hormone (FSH)	7.16	IU/L	follicular phase: 3.89–6.71
Luteinizing Hormone (LH)	3.59	IU/L	follicular phase: 2.07–7.47
Estradiol (E2)	72.71	pmol/L	follicular phase: 45.4–854
Prolactin (PRL)	32.1	ng/ml	4.79–23.3
Testosterone (TESTO)	0.552	nmol/L	≤2.9
Progesterone (PROG)	0.175	nmol/L	follicular phase: 0.181–2.84
Growth Hormone (GH)	0.69	ng/mL	0.14-9.9ng/mL
Adrenocorticotropic Hormone (ACTH)	□0.220	pmol/L	1.1-11.0pmol/L

Case 2

A 61-year-old female patient who had suffered from headaches for four years suddenly developed limb inertia. The CT scan revealed a lesion located in the third ventricle and hydrocephalus (Fig. 3). MRI revealed a 25 × 25 × 24 mm lesion in the interpeduncular cistern, estimated to be an aneurysm. DSA and CTA showed that the aneurysm originated from the basilar apex. The patient underwent aneurysm clipping surgery via the right subfrontal approach. The aneurysmal neck was clear between the oculomotor nerve and the internal carotid artery. After temporary basilar and posterior cerebral artery occlusion, two long straight clips were used to clamp the aneurysmal neck parallel to the direction of the basilar artery. When the aneurysm collapsed, one long straight clip and one short curving clip were used to clamp the aneurysm. DSA angiography confirmed that the aneurysm was completely clipped. Three days after surgery, the patient was in a coma, and an immediate CT scan showed massive cerebral infarction in the right frontal, temporal lobe, and basal ganglia region with a small accumulation of blood in the ventricular system (Fig. 4). After a few days of expectant treatment, CT revealed less blood in the ventricular system and operation area. The patient was still in a coma with a Glasgow Coma Scale (GCS) score of 5, with pupillary response to light, when she discharged.

Case 3

A 53-year-old male patient with diabetes experienced mild headaches and blurred vision for half a year. According to the patient, he suffered an intense headache six years ago and went to a hospital where an aneurysm was detected, but he refused further treatment. Diminution of bilateral vision was observed on physical examination. MRI showed a prefrontal mass with few enhancements and was estimated as an intracranial cavernous angioma in the report. CT and CTA revealed a 22 × 28 mm giant anterior communicating artery aneurysm with thrombosis and discontinuous calcification surrounding the rim of the aneurysm (Fig. 5, 6). DSA revealed an aneurysm of 6.1 × 4.7 × 4.5 mm originated from the anterior communicating artery and mild atherosclerosis of the intracranial artery. Both CTA and DSA failed to present the actual size of the aneurysm because of thrombosis and calcification. The patient underwent VW-MRI for risk assessment of aneurysm rupture.[27] Results showed unstable plaque and enhancements of the aneurysm wall, which is a sign of a high risk of rupture. After subfrontal craniotomy, an aneurysm was observed. First, the aneurysm was cut open to remove the thrombus and calcification, and blood started to fill in the cavity. The A1 segment of the right anterior cerebral artery was temporarily blocked, and the aneurysm neck was fully exposed. Considering the thrombus inside the aneurysm alongside the mass effect it caused, aneurysm clipping, aneurysmectomy, and wrapping were performed in sequence. Seven days after surgery, the patient was transferred to a rehabilitation hospital with a GCS of 14 (E3V5M6). After two weeks, a headache and consciousness obstacle occurred, and a CT scan revealed an intracranial hematoma (Fig. 7). Removal of the hematoma, decompressive craniectomy and bilateral ventricular drainage were performed. There was a progressive decrease in blood pressure on the day following surgery, possibly due to central shock due to the massive cerebral infarction. The patient discharged with GCS = E1VTM1.

Case 4

A 60-year-old female patient with diabetes and hypertension had hypodynamia and dizziness for a year. Physical examination revealed no positive signs. MRI, CT, and CTA revealed a 9 × 8 mm basilar artery apex aneurysm with calcification (Fig. 8). DSA confirmed an 11 × 8 × 4.1 mm aneurysm originating from the basilar artery apex. Arterial stenting and aneurysm coil occlusion were performed sequentially via the femoral artery. The patient discharged in good condition.

Case 5

A 67-year-old male patient with hypertension, who had suffered from headaches for 30 years, had left limb paralysis. Physical examination confirmed weakness in the left limbs and a GCS score of 14 (E3V5M6). CT and CTA revealed a 16 × 15 × 15 mm anterior communicating artery aneurysm and mass intraventricular hemorrhage (Fig. 9). DSA confirmed that the aneurysm originated from the anterior communicating artery. Laminal terminalis fenestration and aneurysm clipping were performed after DSA. In the 6-month follow-up, mild ventricular expansion can still be seen on CT scanning, and the clipped aneurysm was stable on CTA (Fig. 10). The patient's neurological function recovered to self-maintenance level.

Discussion

Literature Review and Case series

Among our patients, one of them was considered to be a craniopharyngioma involving the suprasellar region, according to MRI. One case consisted of a rather small, instead of a giant, aneurysm but still caused hydrocephalus. One patient with aneurysm rupture had central neurogenic shock and massive cerebral infarction. All masses block or oppress the third ventricle and cause hydrocephalus, which can also be found in most of previous cases. Our cases showed features of this disease in one hospital to minimize between-group differences at baseline. In addition, our cases are unique in that the giant aneurysms were detected by CTA instead of DSA for the first time, which is considered the gold standard for aneurysm diagnosis. CTA is a standard preoperative examination in our intracranial tumor surgical procedure for detecting aneurysms before craniotomy. Several studies have determined that CTA can replace DSA for aneurysm diagnosis,[28–30] especially for giant aneurysms.[31, 32] We used CTA to diagnose giant aneurysms mimicking intraventricular tumors and used it as the main index of follow-up after aneurysm coil occlusion procedures, and the results of CTA are precise and stable. Aneurysms presenting as third ventricular masses have been studied in several limited cases between 1979 and 2020 because of the infrequency of this disease. This study aimed to systematically review previous studies and our new series of five cases to determine the outline of aneurysms presenting as third ventricular masses on neuroimaging, treatment, and follow-up outcomes and to add more necessity to preoperative CTA before craniotomy.

We reviewed the literature from PubMed and Embase databases and identified 27 cases of aneurysms (including the cases above) presenting as third ventricular masses.[8–26] The average age of the patients was 62 years (range, 14–82 years). In previse cases, all patients were middle-aged and elderly, with one of our cases (case 1) being the first adolescent reported. Case 1 suggests that giant intracranial aneurysms can cause hydrocephalus in adolescents and children, so aneurysms should be included in the differential diagnosis of hydrocephalus and intracranial hypertension in adolescents. The female-to-male ratio of the patients was 14:13. All aneurysms were angiographically positive except for one case from Liu et al., which is a case of a completely thrombosed aneurysm for which angiographic studies were negative.[16] Case 3 in our series was also a thrombosed aneurysm that required more than angiographic studies, and other examinations such as MRI and blood coagulation function should be included before treatment. In case 3, CTA reconstruction imaging showed greater precision than DSA. Our case is unique in that it used CTA to diagnose and depict the aneurysm when all other cases from the literature review did not apply this modality to diagnose the existence of the aneurysm. It is also the first case to use CTA in follow-up. The basilar artery is the most common artery with giant aneurysms presenting as third ventricular masses (21 of 27 cases), while others develop in the anterior communicating artery, posterior communicating artery, anterior cerebral artery, and middle cerebral artery. The symptoms of these cases are similar, with nearly all cases presenting symptoms and signs of hydrocephalus or intracranial hypertension, except for one case from the literature review that presented as intramural hemorrhage and then disastrous hemorrhage.[13] Other symptoms are diverse, including seizure,[9] ataxia, dementia, and hemianopia. In previous cases, intracranial hemorrhage[13, 22, 23, 26] and aneurysm rupture[11, 13, 26] occurred in some cases, and all aneurysm ruptures resulted in the death of the patients; other causes of death included thrombogenesis,[25] cerebral infarction, intraoperative hemorrhage,[10] and intraoperative cardiac arrest.[8] Cerebral infarction (cases 2, 3, and 5) and intracranial hemorrhage (cases 3 and 5) both occurred in our series. In previous cases from literature review, all patients received CSF diversion, and nine patients only had CSF diversion without treatment of the aneurysm. In our five cases, all patients received treatment of the aneurysm, while treatment exclusively for CSF diversion, such as ventriculoperitoneal (VP) shunt, was not applied to cases 2 and 4. The most commonly used procedure to treat aneurysms was aneurysm coil occlusion (nine of 23 cases), and this treatment has been most commonly applied in the last ten years.

Preoperative Neuroimaging Examination

It is very important in clinical practice to select simple and effective examination methods among various neuroimaging techniques to improve the diagnostic accuracy of brain space-occupying lesions. In cases we gathered, all patients were hospitalized with clinical presentation and received a CT scan or MR scan as the preferred inspection. All the third ventricular masses were found in the first neuroimaging examination, and characteristics such as the size of the lesion and hydrocephalus were identified. Although MRI provides precise location of the mass and the relationship of the lesion to surrounding structures, and CT scan can detect mural calcification, it is difficult to differentiate giant intracranial aneurysms from intraventricular tumors. In addition, this type of patient is usually received by the neuro-oncology department instead of the cerebrovascular surgery department, which has less experience of aneurysms, meaning that craniotomy could take place for the resection of the "tumor," which is very hazardous for the patient. Intraoperative hemorrhage has been reported in previous literature.[10] Furthermore, in one case, the aneurysm, determined under neuroendoscopy, was mistakenly taken as a hematoma.[23] To avoid such adverse events, angiography is required to determine the substance of the lesions. DSA remains the gold standard for evaluating intracranial aneurysms with excellent spatial and temporal resolution. In previous cases, DSA was used as the gold standard for diagnosis. Magnetic resonance angiography (MRA) was used in some cases alongside DSA with no reports of misdiagnosis in cases we collected, and one case reported a positive result on MRA and negative result on DSA.[24] The DSA for case 3 in our series also did not obtain patent results because of thrombosis and calcification, the diagnosis was made comprehensively according to VW-MRI, CT, and DSA, suggesting that DSA is not the only choice for the diagnosis of giant aneurysms. DSA evaluates the circulation of aneurysms, which is not enough for complex cases such as aneurysms presenting as a third ventricular mass. Luminal size/patency evaluation, the relationship between aneurysms and surrounding structures, and the calcification of the aneurysmal sac, which are significant for evaluating aneurysmal rupture risk, choosing treatment methods, and making prognosis, cannot be obtained through DSA.[33, 34] In cases of giant aneurysms and aneurysms with mass effect, angiographies like CTA and MRA present a more comprehensive evaluation than DSA.

Use of CT angiography

CT angiography is increasingly becoming a diagnostic tool for vessel pathology.[31] Aneurysms larger than 3 or 4 mm can be recognized with CTA. Teksam et al. reported that CTA missed only seven out of 106 cases, and of these, only two were larger than 4 mm.[30] In cases with aneurysm rupture and cerebral hemorrhage, which may require emergency surgical evacuation, CTA is a quick and obviously better vascular evaluation tool than DSA. Because calcification often appears in vessel pathology and non-cooperative patients make MR or MRA impossible, CTA also has advantages over MRA in certain aspects. According to a recent study on imaging morphology,[32] because of the multipass or recirculation phenomenon of the contrast medium within the aneurysm, CTA is superior to 3D Time-of-Flight MRA, contrast-enhanced MRA, and even to DSA in the visualization of the patent aneurysmal lumen.[35] All these characteristics of CTA made it suitable for the evaluation of giant intracranial aneurysms, but it was not applied in all cases reported in the literature of giant aneurysms adjoining the third ventricle. Our study's reporting of CTA as a diagnostic and follow-up examination and the resultant precise evaluations filled the void of neuroimaging examination of this rare and complex disease. All five patients underwent CTA, which revealed aneurysms before surgery and at postoperative follow-up. CTA reconstruction imaging of the intracranial arterial system is reliable and economical for revealing intracranial aneurysms. CTA has become an imperative preoperative neuroimaging examination for patients with skull base tumors in our ward. With preoperative CTA, misdiagnosis of a third ventricular aneurysm and other vascular malformations can be discovered at an acceptable cost. However, CTA has limitations, such as beam-hardening artifacts related to coil embolization in postoperative patients, which can be found in all of our follow-up CT/CTA examinations. However, due to its viability, fast imaging, and high spatial resolution, it remains the first choice to follow-up postoperative patients with aneurysms.

Vessel wall magnetic resonance imaging

Another neuroimaging examination we applied was VW-MRI, a neuroimaging technology for indicating inflammatory processes in vessel walls. Enhancement of the aneurysm wall on VW-MRI is assumed to be an imaging marker of aneurysm instability and a higher risk of rupture.[36, 37] Case 3 in our series underwent VW-MRI before surgery to evaluate the risk of aneurysm rupture because of discontinuous calcification surrounding the rim of the aneurysm found on CTA. The patient's diabetes may contribute to the risk of aneurysm rupture and hemorrhage. Patients with diabetes had a significantly higher prevalence of calcification and high-risk plaques on vessel walls, which are risk factors for aneurysm rupture and hemorrhage.[38] Interestingly, some recent research suggests that diabetes could be a protective factor against the rupture of intracranial aneurysms.[39, 40] Enhancement of the aneurysm wall and anterior cerebral artery was significant in our case according to VW-MRI. The aneurysm appeared clear with a thrombus on MRI imaging. Considering the thrombus inside the aneurysm alongside the mass effect it caused, aneurysm clipping and aneurysmectomy were applied as a confined operation. Aneurysm wrapping was performed to prevent hemorrhage. However, hemorrhage still occurred after two weeks. The results demonstrate the value of VW-MRI in evaluating the risk of aneurysm rupture in a certain way.

In conclusion, intracranial aneurysms at critical positions, such as the third ventricle, or aneurysms causing clinical syndromes require multiple neuroimaging examinations for differential diagnosis and treatment planning.

Cerebrospinal fluid diversions due to obstruction of the third ventricle caused by giant aneurysms

All patients reported had different degrees of hydrocephalus or intracranial hypertension. Certainly, there is no optimal management option for this delicate and complex situation. CSF diversions had been performed in most patients as a symptomatic treatment to relieve the brain from CSF pressure. Multiple methods are available, including VP shunting, ventriculoatrial (VA) shunting, eternal ventricular drainage (EVD), ventriculostomy with craniotomy, and endoscopic third ventriculostomy (ETV). VP shunting was the most commonly used procedure in the past, with 12 of the 27 patients undergoing this procedure, though all 12 cases were from 10 years ago. Six of the 27 patients received ETV. Four of the 27 patients received EVD, including one case from our series who received EVD for postoperative intracranial hemorrhage. Three of the 27 patients underwent ventriculostomy with craniotomy, including two cases in our series. Two of the 27 patients underwent VA shunting. A previous study showed that VP shunting[41] is the most common type of shunting procedure because it is convenient and effective, and studies have shown no significant differences in terms of the outcome between the different kinds of shunting methods (VP, VA, and lumboperitoneal shunting). ETV is becoming widely used because of the improvements in neuroimaging, operation instruments, and stereotaxic neuronavigation systems in recent years. A meta-analysis based on randomized controlled trials revealed that in obstructive hydrocephalus, ETV had significantly lower blockage rates and could reduce the risk of postoperative hematoma compared with VP shunting.[42] But in our study, the death rate was much higher in the ETV group (three of 6) than in the VP shunting group (three of 12). These deaths were caused by aneurysm rupture and hemorrhage. According to a literature report, reduction of intracranial pressure after CSF diversions can increase the aneurysmal transmural pressure, shift the formed clot inside the aneurysms, and cause a higher risk of rupture.[43–45] Therefore, according to the theory, ETV should be performed with other treatments to stabilize or remove aneurysms. The case results fit this theory: only one out of three deaths among patients who received ETV was caused by aneurysm rupture (the other two were caused by thrombosis), and that case is the only one without treatment for aneurysms. Ventriculostomy with craniotomy has the same mechanism as ETVbut with a different approach, which means it can cause a higher risk of rupture. The appropriate operation combination should be aneurysm clipping and ventriculostomy under one craniotomy, which is safe and less damaging to patients. All three cases attended to receive this combination of treatments, and case 1 finally underwent aneurysm coil occlusion because the aneurysmal neck was not clear. Two cases (cases 2 and 4) did not receive any CSF diversion because the hydrocephalus was mild, and symptoms of cranial hypertension were not typical. Which procedure is the optimal choice for hydrocephalus caused by a giant intracranial aneurysm mimicking an intraventricular tumor? Should aneurysms be treated before CSF diversions in certain cases, according to the theory? Further investigation and clinical evidence are required to answer these questions.

Treatments for Aneurysms

General treatment of aneurysms includes surgical clipping and endovascular management (mainly aneurysmal coiling).[46] Generally speaking, outcomes in patients treated with coiling are better than surgical clipping in terms of long-term dependency and mortality rate.[47] With various methods to treat hydrocephalus, the options for aneurysms are limited, and the aneurysm neck is usually not clear (e.g., Case 1) or too broad to clip. In our literature review, only two patients received aneurysm clipping, and eight patients received aneurysm coil occlusion. Interestingly, two patients who underwent aneurysm clipping had an excellent prognosis when the results of aneurysm coil occlusion were not satisfactory. After these patients underwent aneurysm coil occlusion, one died from cerebral infarction; one died from thrombogenesis of the basilar artery;[25] one had hydrocephalus[21] and received a second operation; one's aneurysm developed and progressively compressed the right thalamus and midbrain, and received a second operation;[20] and one died from aneurysm rupture.[11] Only two patients (including the present case) received satisfactory results,[19] and one patient's prognosis was not reported.[23] In our cases, the results were more favorable: two patients (case 1 and case 4) who received aneurysm coil occlusion achieved good prognosis, particularly case 1, who underwent follow-up after aneurysm coil occlusion for two years and obtained favorable prognosis; and two of the three patients (case 2 and case 3) who underwent aneurysm clipping had unfavorable prognosis due to post-operation hemorrhage. A previous study of middle aneurysms showed that cerebral infarction was the main cause of death after two kinds of treatment,[48] and clipping had a lower death rate (0.3–1.1%), which may be indicative of our cases. Nevertheless, aneurysms presenting as third ventricular mass are mostly giant aneurysms with hydrocephalus; the prognosis of this disease is much worse, the operation is much harder than for general middle aneurysms. Developing a standardized treatment protocol with limited case reports and huge heterogeneity between cases is difficult. Based on the evidence above, we believe that aneurysm coil occlusion with CSF diversion, if necessary, is a favorable option for treating giant aneurysms presenting as third ventricular masses with hydrocephalus.

Based on the results presented above, the treatment for giant intracranial aneurysms mimicking an intraventricular tumor is still non-ideal. It remains a complex and dangerous clinical challenge for both diagnosis and treatment. Neuro-oncology and cerebrovascular surgery departments should enhance communication and act with caution when encountering patients with unidentified third ventricular masses. Further investigations and case reports should be conducted in the future, especially preoperative examinations, to evaluate the rupture risks of giant intracranial aneurysms.

Conclusions

The use of CTA is beneficial for preoperative aneurysm identification. Thrombosed aneurysms should be considered a differential diagnosis in patients with third ventricular masses. Aneurysm coil occlusion might be a favorable treatment, and CSF division is not always necessary because of the high risk of aneurysm rupture. However, further studies should be conducted to confirm our observations.

Abbreviations

ACTH
Adrenocorticotropic hormone
CSF
Cerebrospinal fluid
CT
Computed tomography
CTA
Computed tomographic angiography
DSA
Digital subtraction angiography
ETV
Endoscopic third ventriculostomy
EVD
Eternal ventricular drainage
MRI
Magnetic resonance imaging
VA
Ventriculoatrial
VP
Ventriculoperitoneal
VW-MRI
Vessel wall magnetic resonance imaging

Declarations

Ethical Approval and Consent to participate

All surgical procedures were approved by the ethics committee of Xiangya Hospital, and the patients' family members provided written consent for the publication of this study.

Human and Animal Ethics

Human ethics involving clinical and imaging data are approved by the ethics committee of Xiangya Hospital. Animal ethics are not involved in this study.

Consent for publication

All authors give consent for publication.

Availability of supporting data

All supporting data are available in supplementary document.

Competing interests

All authors declare that they have no conflict of interest.

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Authors' contributions

YL, HL, BC, QL, and WL participated in surgical procedures and data analysis; YL, QL, and WL wrote the manuscript; QL supervised the entire work.

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Figures

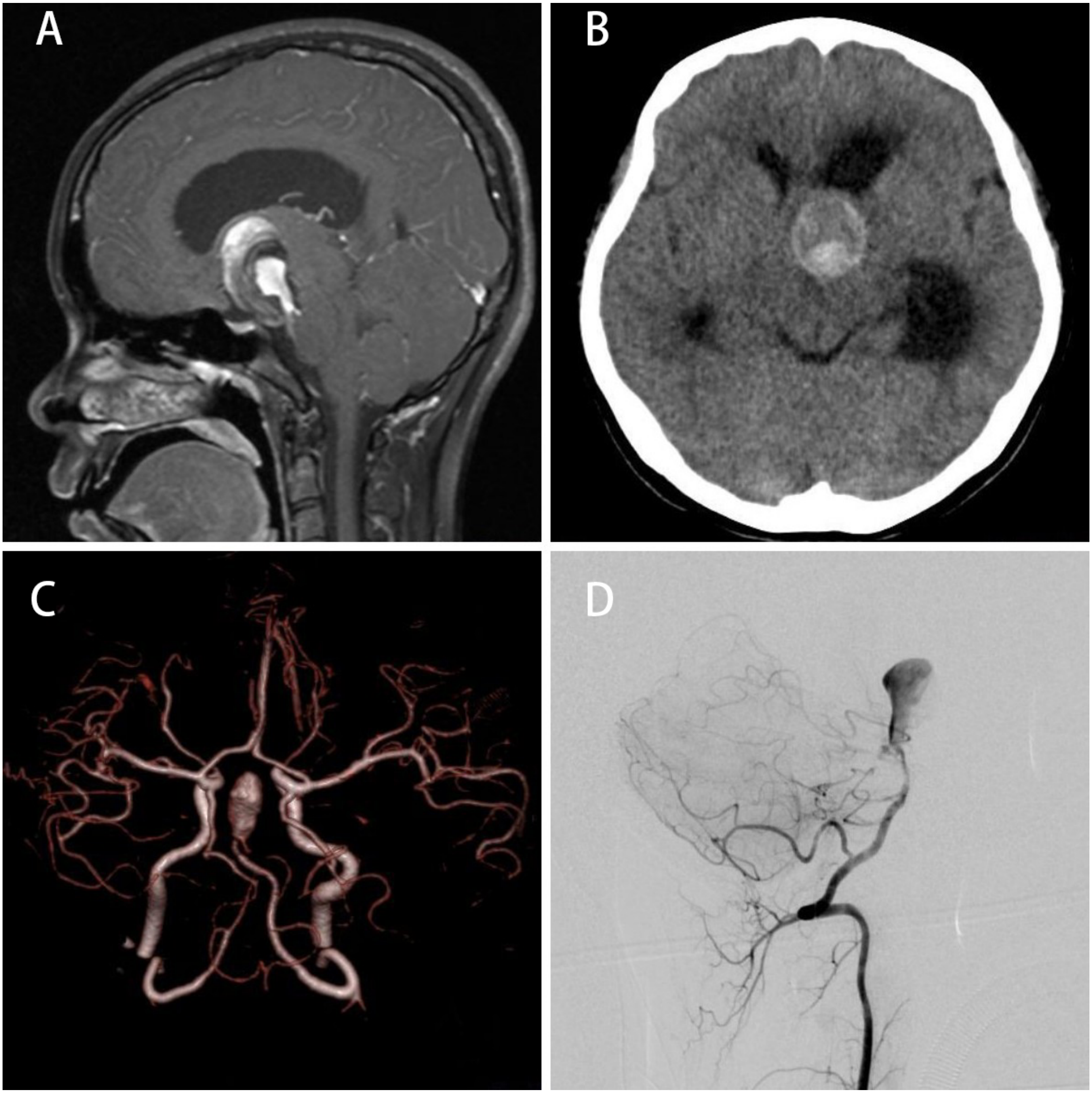

Figure 1

Preoperative neuroimaging and angiography of patient 1. (A) Post-gadolinium magnetic resonance imaging demonstrating a third ventricular mass with partially significantly homogenous enhancement in the suprasellar region and non-communicating hydrocephalus; (B) Annular calcifications at the inferior margin of the lesion revealed by computed tomography (CT) scanning; (C) CT angiography reconstruction imaging of the intracranial arterial system with a giant intracranial aneurysm connected with basilar artery apex; (D) Selective cerebral digital subtraction angiography revealing the aneurysm.

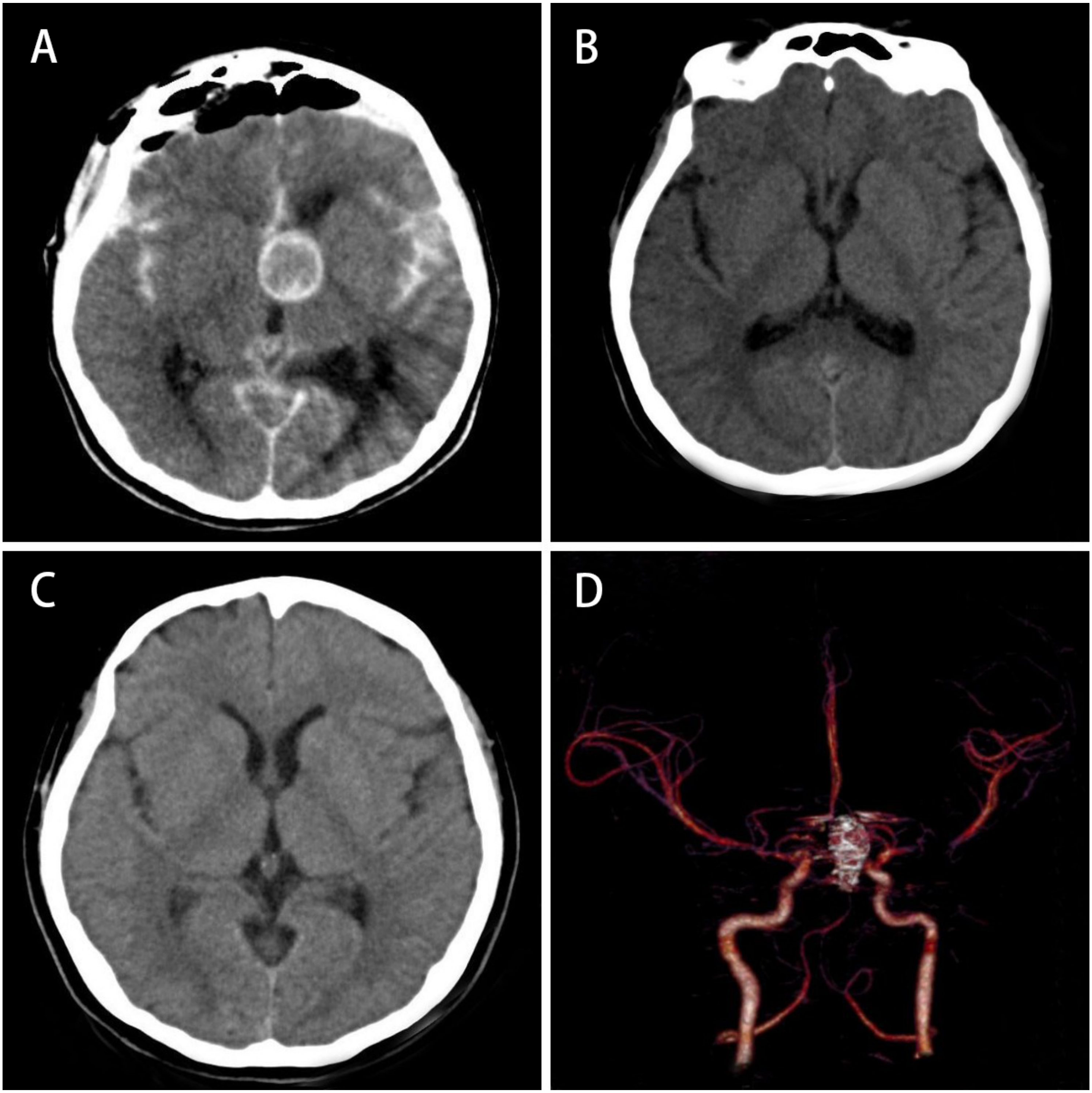

Figure 2

Postoperative neuroimaging and angiography of patient 1. (A) Computed tomography (CT) scanning after operation; (B) CT scanning after four months; (C) CT scanning after 19 months; (D) 19 months follow-up results of patient 1 demonstrated by CT angiography: the coiled aneurysm remained stable.

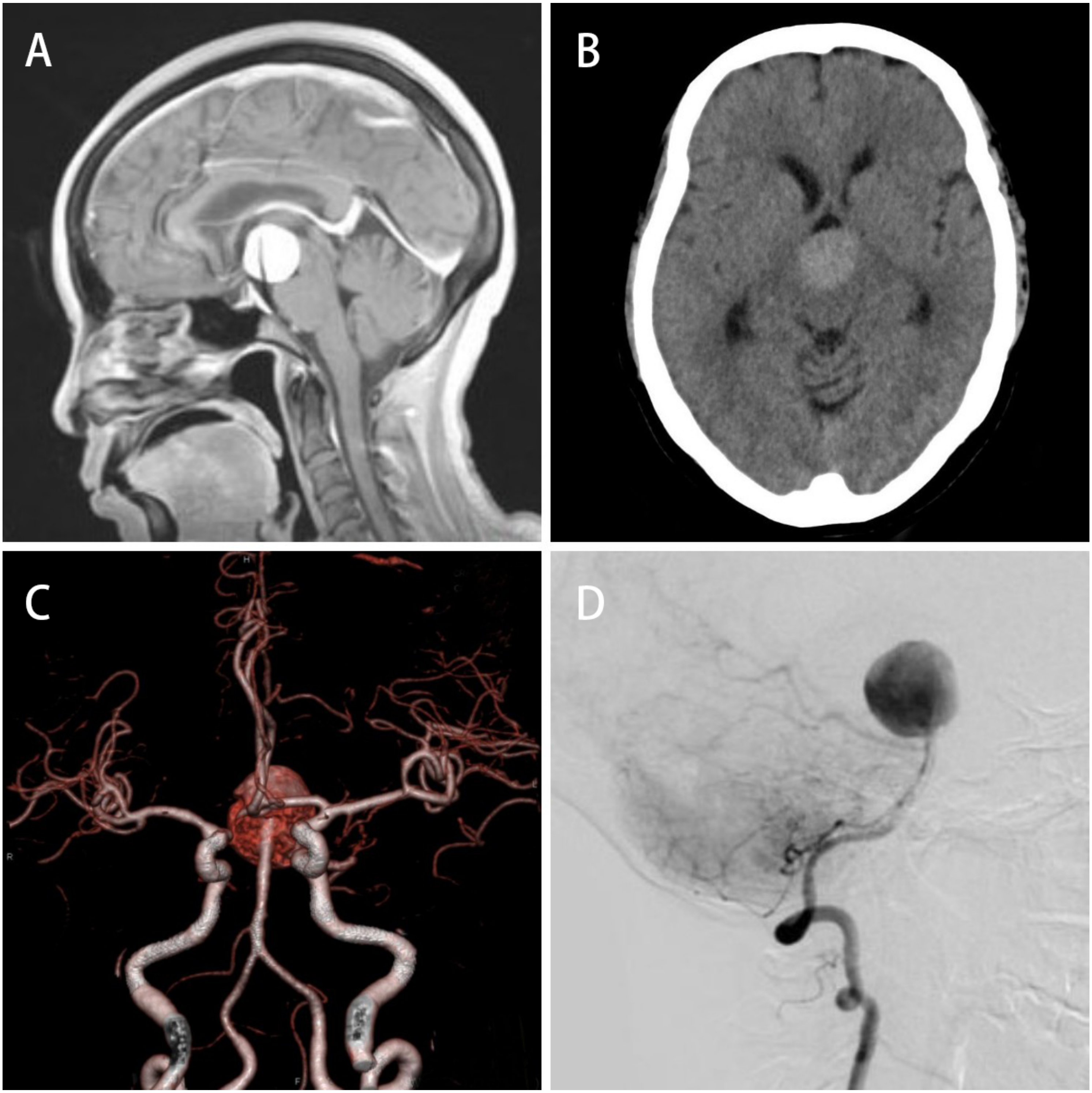

Figure 3

Preoperative neuroimaging and angiography of patient 2. (A) Magnetic resonance imaging of patient 2 demonstrating a mass occupying the third ventricular and cisterna interpeduncularis; (B) Hydrocephalus and third ventricle mass in computed tomography (CT) scanning; (C) CT angiography demonstrating a giant intracranial aneurysm connected with basilar artery; (D) Selective cerebral digital subtraction angiography revealing the aneurysm.

Figure 4

Postoperative computed tomography scanning of patient 2: Small accumulation of blood in the ventricular system (arrow) and cerebral infarction in the right frontal, temporal lobe, and basal ganglia region.

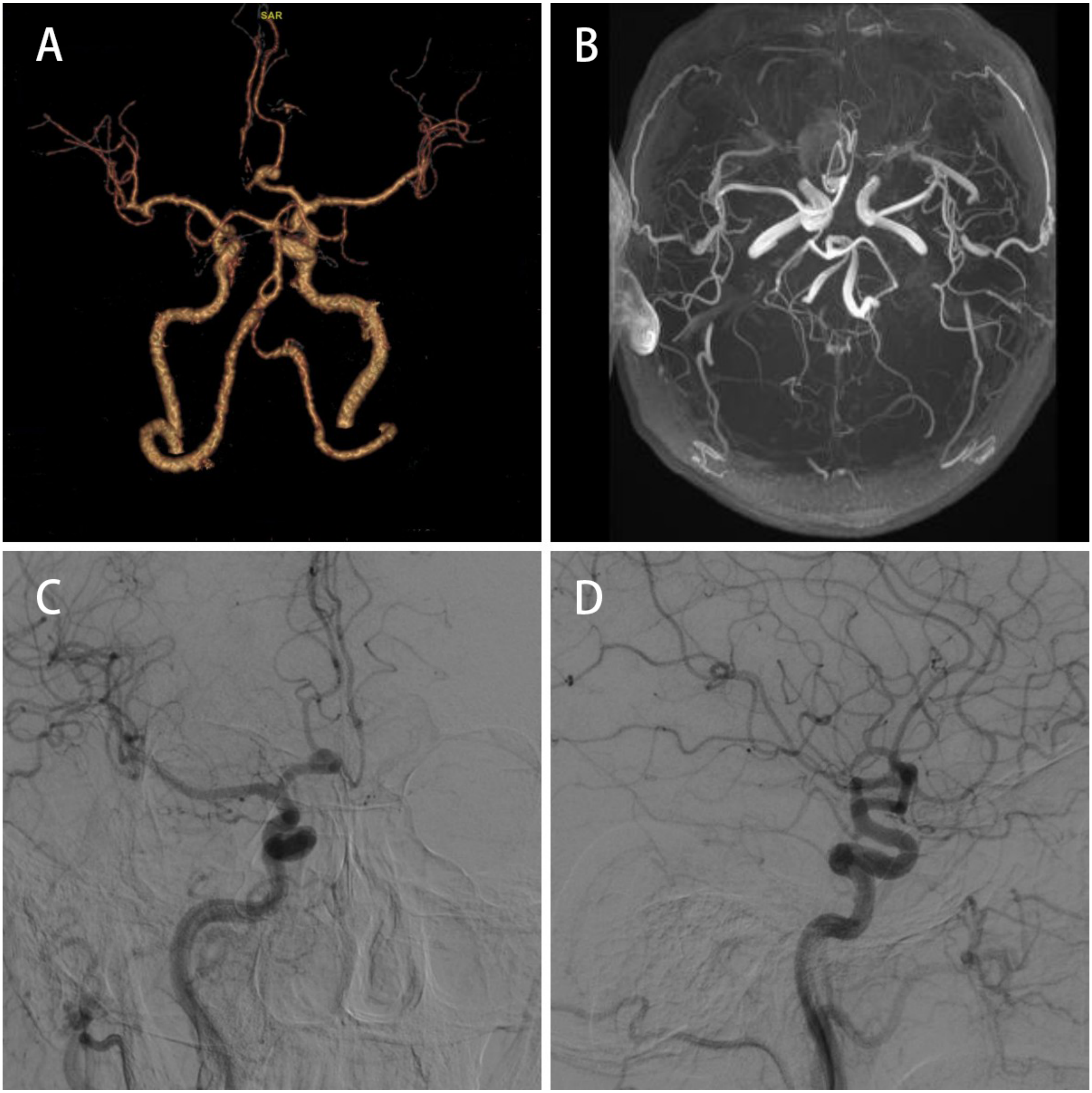

Figure 5

Preoperative neuroimaging of patient 3. (A-C) High-resolution vessel wall magnetic resonance (MR) imaging of patient 3 demonstrating a mass in the anterior cranial fossa with significant enhancement in the margin: (A) Sagittal T1-weighted post-gadolinium MR image with marked vessel wall thickening in the aneurysm margin; (B) Transverse T1-weighted post-gadolinium MR image with vessel wall thickening in the aneurysm margin; (C) Post-contrast anterior circulation curved range image of the coronal plane show eccentric wall thickening (arrow) with enhancement; (D) Computed tomography scanning revealing a cystoid lesion with massive calcifications at the margin in the anterior cranial fossa.

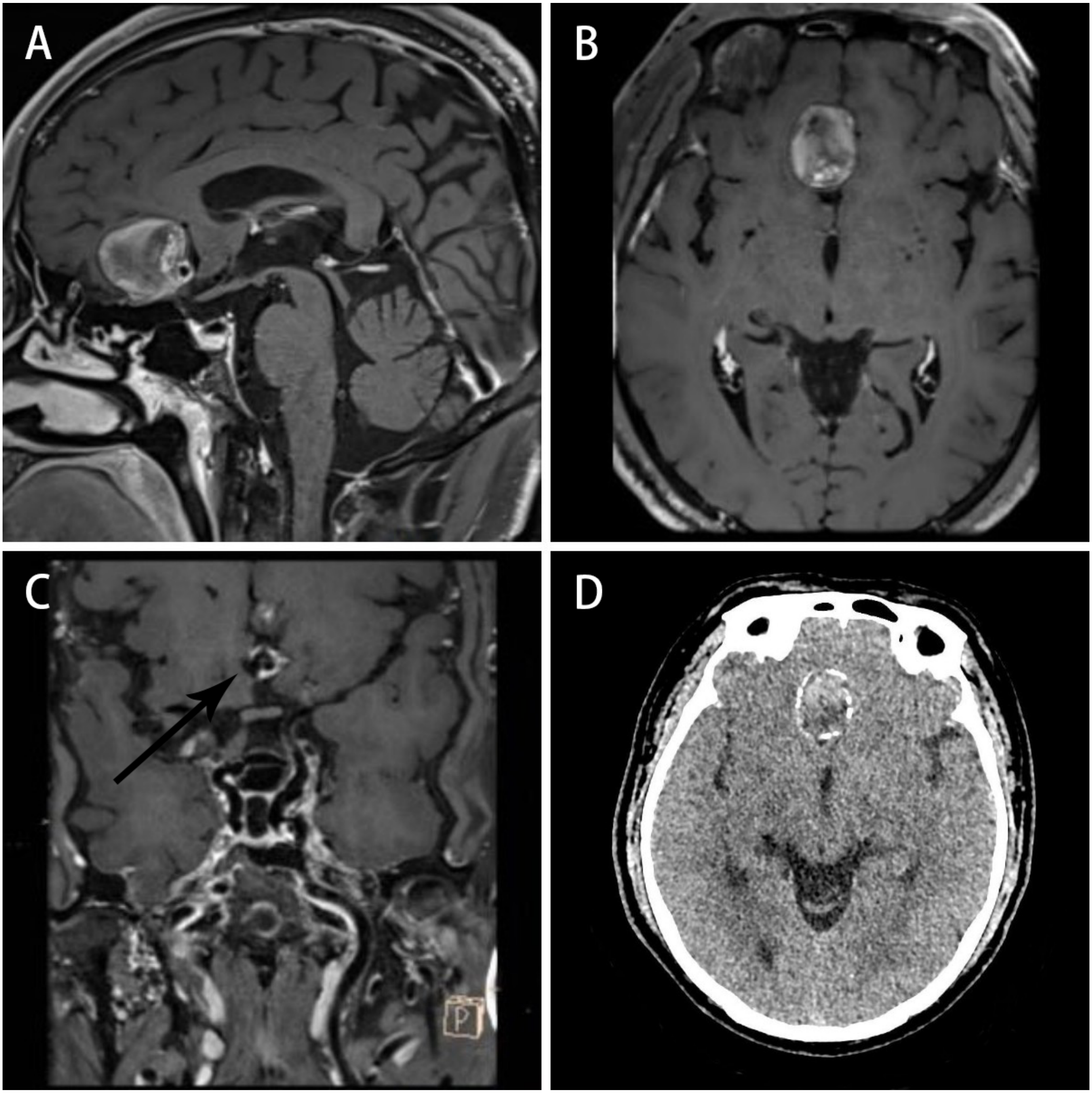

Figure 6

Preoperative angiography of patient 3, none of them demonstrate the aneurysm clearly:

(A) Computed tomography angiography; (B) Magnetic resonance angiography; (C-D) Selective cerebral digital subtraction angiography.

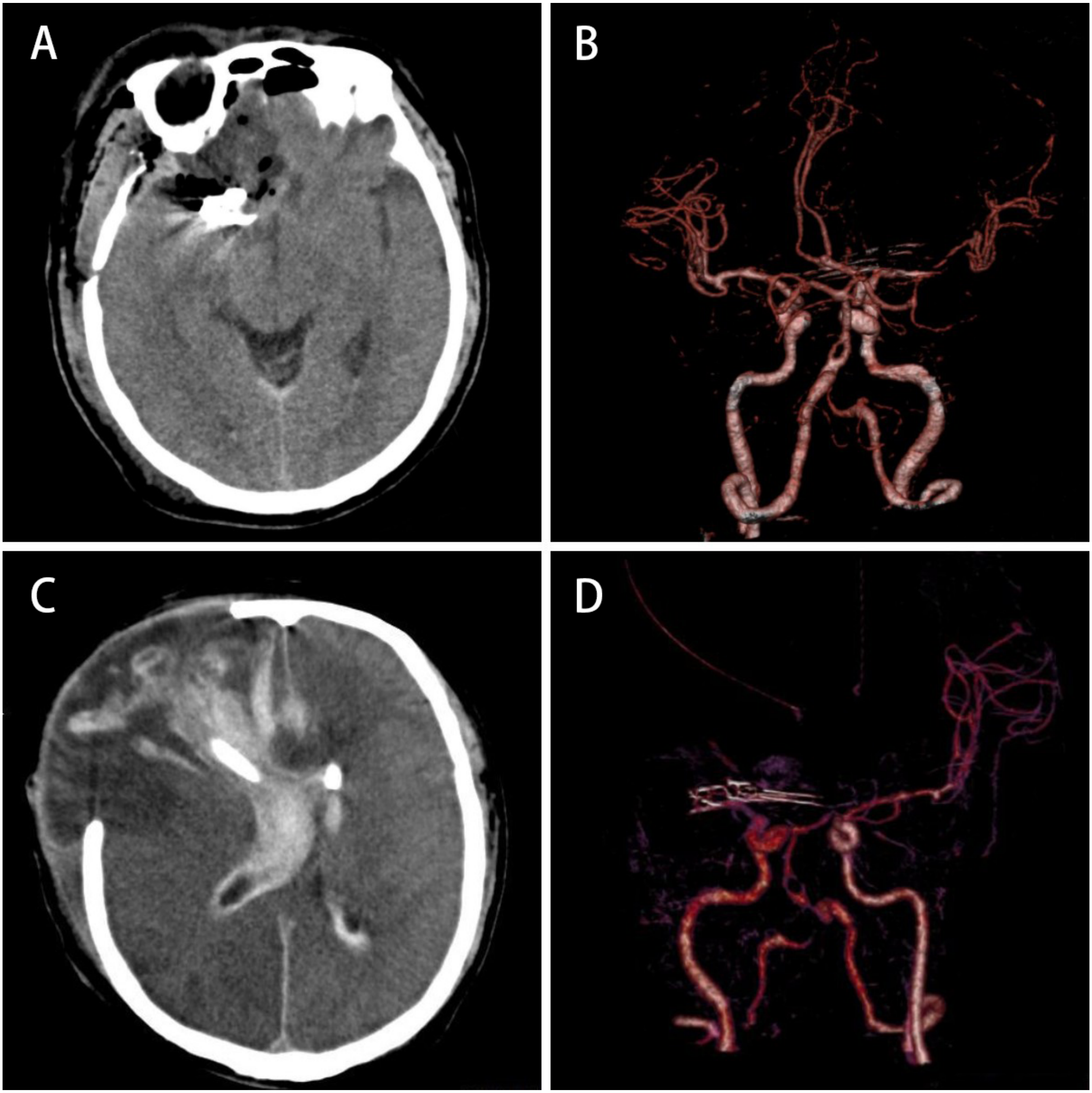

Figure 7

Postoperative neuroimaging and angiography of patient 3. (A) Computed tomography (CT) scanning after the aneurysm clipping, aneurysmectomy and wrapping: cerebral infarction in the right frontal lobe and basal ganglia region; (B) CT angiography after the operation; (C) CT scanning after the removal of the hematoma, decompressive craniectomy, and bilateral ventricular drainage: frontal temporal lobe meningoencephalocele and intraventricular hemorrhage; (D) CT angiography two weeks after the second operation.

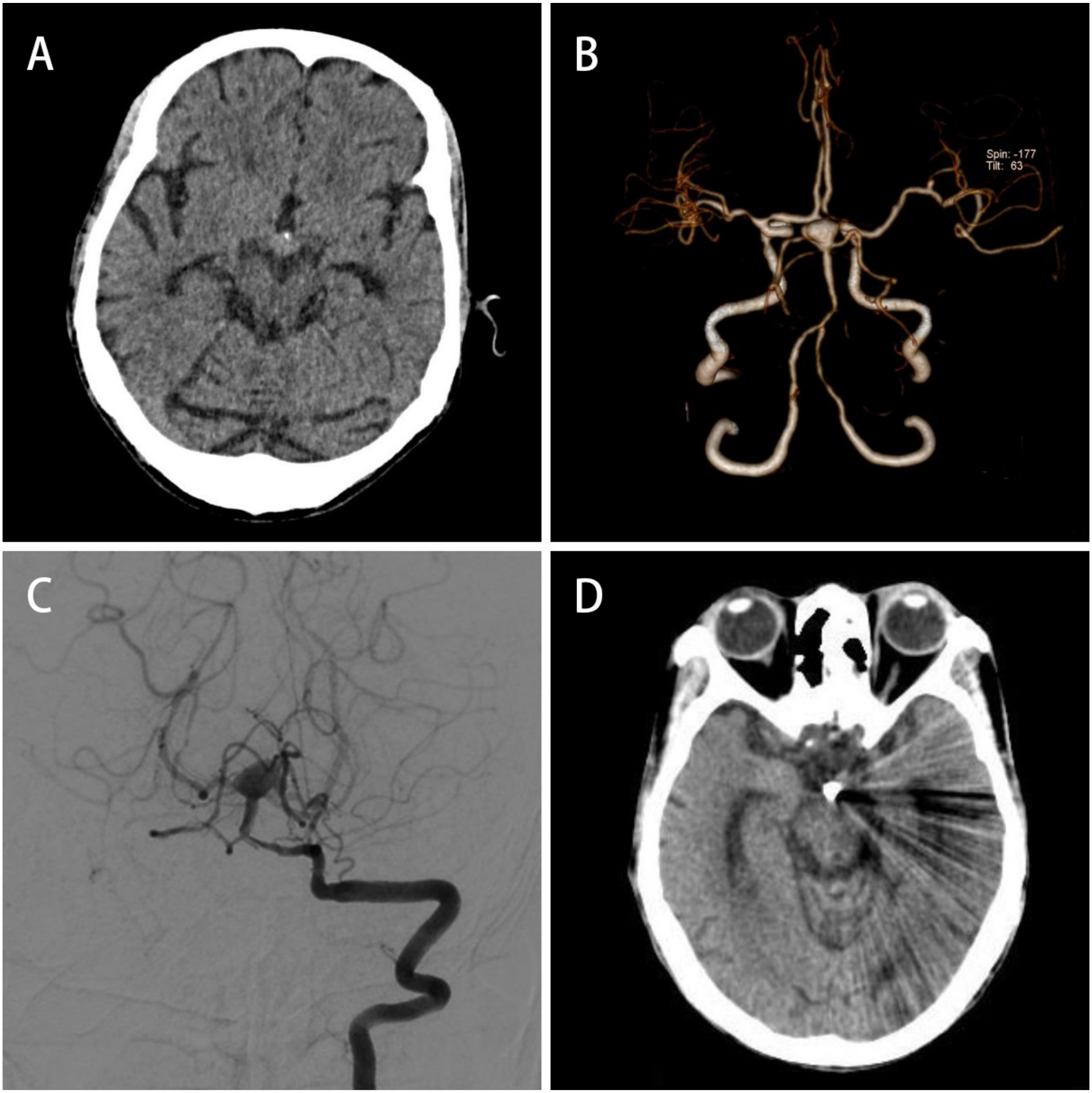

Figure 8

Neuroimaging and angiography of patient 4: (A) Preoperative computed tomography (CT) scanning showing a lesion with calcification at the anterior margin; (B) CT angiography imaging of the intracranial arterial system and an intracranial aneurysm connected with basilar artery apex; (C) Selective cerebral digital subtraction angiography of the left internal carotid artery revealing the aneurysm; (D) CT scanning after the aneurysm clipping.

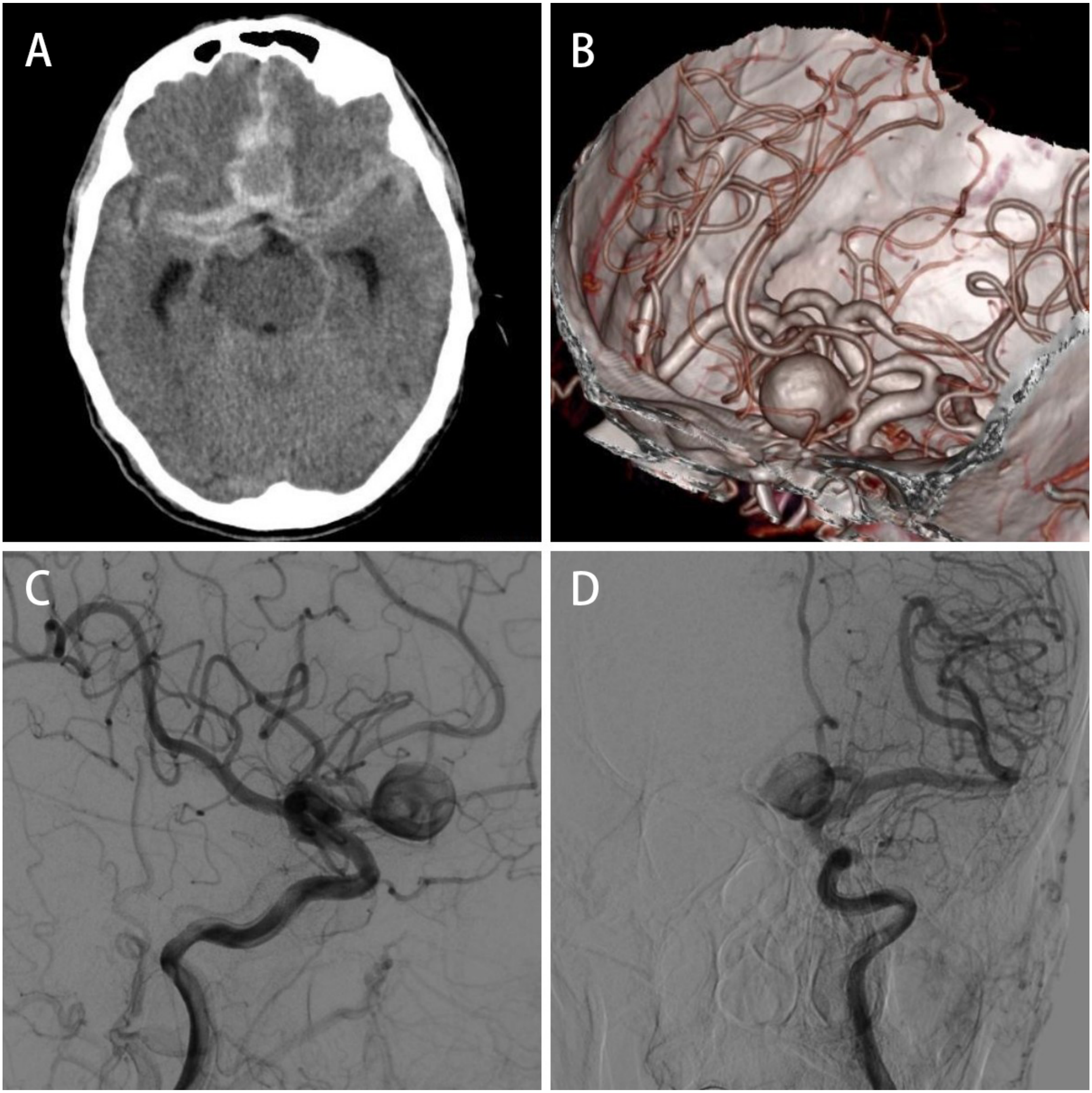

Figure 9

Preoperative neuroimaging of patient 5: (A) Computed tomography (CT) scanning of patient 5 showing an anterior communicating artery aneurysm and hemorrhage around the aneurysm and the lateral fissure cistern. (C) CT scanning of patient 4 showing a lesion with calcification at the anterior margin; (B) CT angiography reconstruction imaging of the intracranial arterial system and skull base revealing a giant aneurysm connected with the anterior communicating artery; (C-D) Selective cerebral digital subtraction angiography of the anterior circulation and the aneurysm.

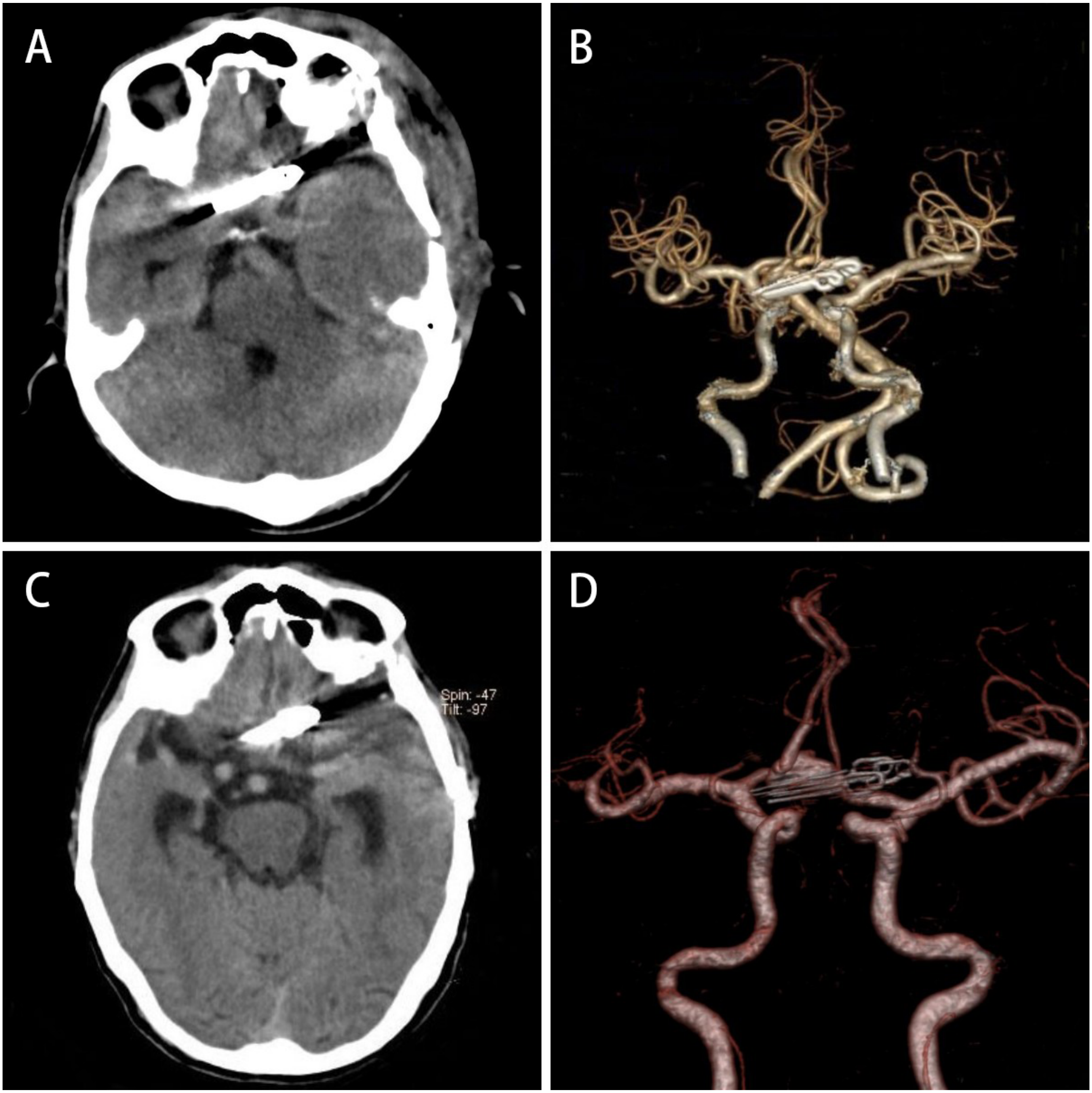

Figure 10

Postoperative computed tomography (CT) scanning and angiography of patient 5: (A) CT scanning after the operation; (B) CT angiography after the operation; (C) CT scanning after six months; (D) 6 months follow-up results of patient 5 demonstrated by CT angiography: the clipped aneurysm remained stable.