TFCA를 이용한 뇌혈관이상의 평가

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How are we going to evaluate cerebral arterial anomalies with TFCA?

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Owing to technological advances in non-invasive cerebrovascular imaging procedures such as magnetic resonance angiography, the role of cerebral angiography (CA) has been decreasing in clinical practice. However, CA remains a useful diagnostic modality for the diagnosis and management of cerebrovascular diseases. To optimize patient care, it is necessary to know how to evaluate cerebrovascular anomalies by CA and its indications.

Key Words: Cerebral angiography, Carotid artery disease, Intracranial arterial disease

Introduction

Historically, cerebral angiography (CA) has played an important role in the diagnosis, treatment decision-making, and treatment of several cerebrovascular diseases. However, owing to technological advances in non-invasive cerebrovascular imaging modalities such as magnetic resonance angiography (MRA), the role of cerebral angiography (CA) has been decreasing in clinical practice. Nevertheless, CA remains the standard diagnostic tool for patients with cerebrovascular disease because in contrast to other non-invasive vascular imaging techniques, CA enables direct evaluation of the cerebral blood flow dynamics at various angles and in different directions and facilitates zooming in and out to obtain vascular images with high spatial resolution. Although MRA can detect atherosclerotic stenosis or occlusion of the major intracranial vessels, CA is a more accurate tool in this regard. Furthermore, CA is useful for the detection of more distal intracranial occlusions and can determine blood flow from arteries into capillaries and veins. CA is the gold standard for the diagnosis of intracranial aneurysms and is instrumental in the selection of an optimal management strategy. Although MRA is useful for screening of cerebrovascular malformations, diagnostic confirmation of cerebrovascular malformations through the CA is needed in most cases. CA is also useful for the definitive diagnosis of arteritis, arterial dissection, or fibromuscular dysplasia (FMD).

However, CA is an invasive procedure, and clinicians should be aware of and prepared for the potential intra- and/or postprocedural complications. Close preprocedural monitoring is essential, and careful attention to the CA technique is important to prevent the aforementioned potential complications. In this section, we review the role of CA in the evaluation of cere-

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brovascular abnormalities.

Conventional cerebral angiography

CA is commonly performed through the common femoral artery based on the following rationale: (a) The wide diameter of the common femoral artery enables placement of a relatively large femoral sheath for the insertion and advancement of a large-bore catheter into the neck arteries and, (b) the femoral artery can easily be compressed against the hard surface of the underlying femoral head to achieve adequate hemostasis. The radial and brachial arteries or even the carotid artery could be used for vascular access. Conventional catheter angiography involves the injection of a contrast agent directly into the blood vessels through an indwelling vascular catheter. Following catheter insertion into the selected arterial access point, it is navigated into the vascular territory of interest. CA commonly involves catheter insertion into the common carotid artery, internal carotid artery (ICA), external carotid artery, or vertebral artery. The catheter may also be placed in the innominate or subclavian artery, or even the aortic arch. After confirming that the catheter is in the appropriate position, a bolus injection of a contrast agent is performed, and radiographs are obtained over a varying time period to obtain images of the contrast agent as it progresses through the vascular tree from arteries into capillaries and veins. Usually, biplane radiographs (anterior/posterior and lateral views) are obtained in a fixed position. The angiographic system consists of a standard biplane C-arm unit comprising a floor-mounted frontal plane and a ceiling mounted lateral plane. (Fig. 1) Different views of the blood vessels of interest can be obtained by moving the table on which the patient is placed or by changing the position of the X-ray tube. This forms the basis of two-dimensional angiography. We performed three-dimensional (3D) rotational angiography during the bolus injection of the contrast agent into the vascular tree by rotation of a movable X-ray tube in an arc around the patient. Radiographic data were transferred to a computer workstation, which created a 3D model of the vasculature that was studied. This 3D model can be manipulated on the workstation in real time to provide an infinite number of projections of the imaged vessels.

Figure 1. The angiographic system consists of a standard biplane C-arm unit comprising a floor-mounted fromtal plane and a ceiling mounted lateral plane.

Applications

Atherosclerotic cerebrovascular disease

CA can effectively detect the culprit vascular lesion, the mechanism underlying a stroke, compensatory vascular changes, or collateral flow in patients with acute ischemic stroke. Furthermore, CA is essential to quantify arterial stenosis during preoperative evaluation in patients who undergo revascularization procedures, such as carotid endarterectomy (CEA) or angioplasty. The radiologist and neurologist decide the vessel that needs to be evaluated and the preprocedural sequence. CA is performed at the proximal part of the vessel of interest. Arterial lesions can be classified as those showing complete vascular occlusion, those presumably associated with thrombosis, those associated with severe flow-reducing stenosis, or those associated with normal or mildly stenosed vessels without impaired flow.

Atherosclerotic carotid artery disease contributes to cerebral ischemia or infarction owing to diminished blood flow distal to the site of stenosis or as a result of embolization from a site of stenosis or ulceration.

Usually, lesions at the carotid bifurcation are known to cause cerebrovascular disease; however, lesions between the origin of the common carotid artery and the terminal segment of the ICA are implicated in this regard. Immediate management warrants accurate assessment of the status of the ICA at the carotid bifurcation. Notably, 70–99% reduction in the diameter of the ICA in patients with a recent hemispheric ischemic attack warrants CEA or carotid artery stenting (CAS).[1] Anatomical characteristics are important to predict postprocedural complications. Complicated anatomy secondary to diffuse atherosclerotic disease could lead to a technically challenging procedure. CA is useful for confirmation of anatomical accessibility prior to CAS in elderly patients. Moreover, a severely stenotic but patent ICA may appear occluded on non-invasive vascular imaging; this phenomenon is referred to as pseudo-occlusion and is the most common cause of an angiographic string sign. Low perfusion pressures distal to the stenotic site lead to collapse of the distal ICA lumen, which is often attributable to decreased blood flow and reduced arterial pressure. This is critical because it usually provides an opportunity for successful revascularization after CEA or CAS.[2] Intracranial atherosclerotic cerebrovascular disease involves the major vessels at the base of the brain or their distal branches. CA can detect these abnormalities and focal alterations in cerebral blood flow, such as retrograde collaterals, focal areas of slow flow, and reactive hyperemia; these findings are useful predictors of the final infarct area and clinical outcomes.[3] (Fig. 2) CA provides valuable inputs to establish an appropriate treatment plan. Angiography is indicated when it is likely to answer these clinically relevant questions. Therefore, CA remains a valuable diagnostic tool to detect, localize, and quantify most atherosclerotic cerebrovascular lesions.

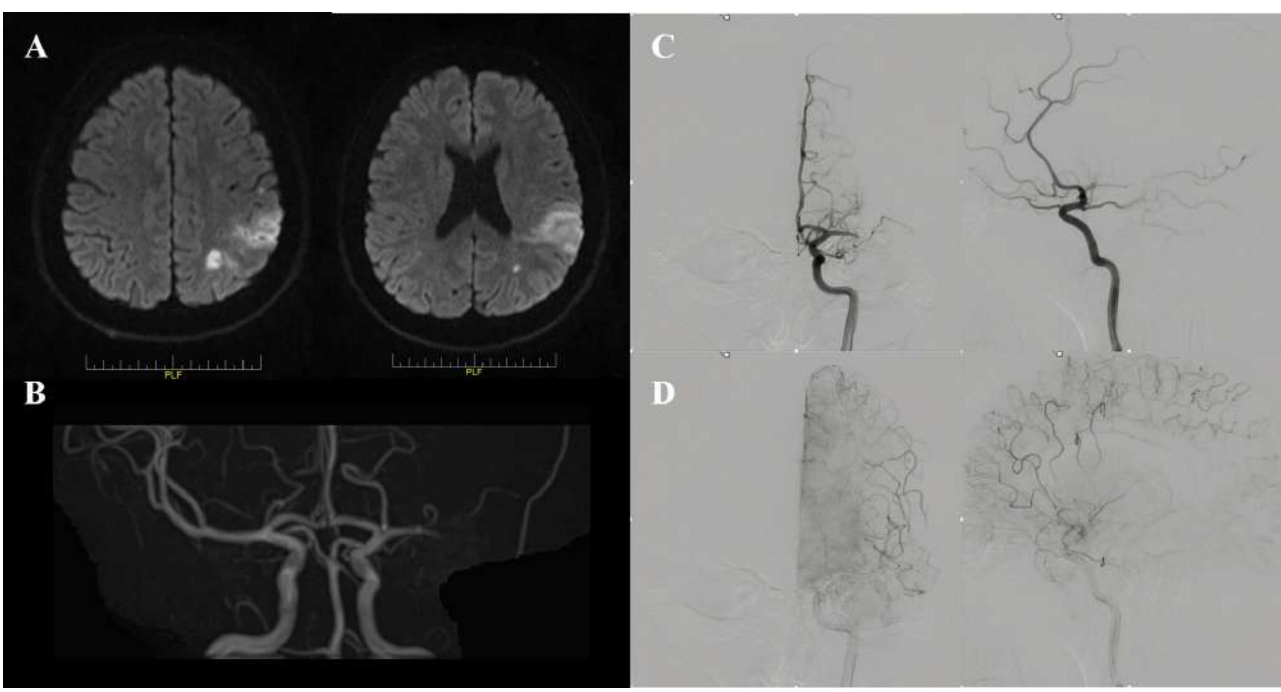

Figure 2. 27 year-old man with left distal M1 occlusion. (A) Diffusion-weighted image showing acute infarctions in the paracentral area. Magnetic resonance angiogrpahy (B) and early arterial phase of cerebral angiography (C) showing an occlusion in the left distal M1. (D) Leptomeningeal collateral flows are observed in the left frontal lobe in late arterial phase of cerebral angiography. That's why cerebral infarction has not yet seen in that area.

Cerebral aneurysms

Subarachnoid hemorrhage (SAH) in a non-comatose patient necessitates immediate CA. The site of the SAH and concomitant intracerebral hematoma in computed tomography can provides information regarding the vessel that is most likely to have ruptured. For example, angiographic evidence of blood in the interhemispheric fissure suggests an aneurysm of the anterior communicating artery. The probability of an aneurysm is low in patients in whom CA reveals diffuse hemorrhage or bleeding localized to the perimesencephalic cistern.[4] CA of the anterior and posterior circulation should be terminated only after all potential sources of bleeding have been accurately verified. Following the detection of an aneurysm, oblique views are required to identify the neck of the aneurysm for effective surgical clipping or coiling. (Fig. 3) An aneurysm at the circle of Willis necessitates close scrutiny to confirm patency of all components of the circle of Willis. For example, patency of the anterior communicating artery indicates that safe surgical occlusion of the A1 segment of the anterior cerebral artery is possible. Patency of the posterior communicating arteries enables decision-making regarding safe surgical occlusion of the P1 segment. Some of this information can be obtained only through CA with manual compression of other carotid arteries and injection of the contralateral carotid or vertebral arteries. In patients with vertebrobasilar circulation compromise secondary to vascular disease, preoperative determination of the contributions of the ICA and the external carotid artery to the basilar artery is important for the management of posterior circulation aneurysms.[5] Usually, repeat CA is not required after clip placement except in patients who undergo technically difficult surgery; CA may be necessary in these patients to confirm adequate clipping of the aneurysmal neck. CA is necessary in patients in whom inadvertent surgical occlusion of a major artery or branch is suspected and in those with multiple aneurysms or associated arteriovenous malformations (AVMs).

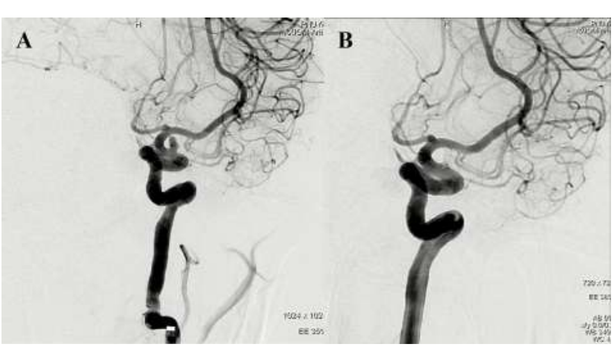

Figure 3. A dorsal wall aneurysm in the supraclinoid internal carotid artery. (A) An oblique view to identify the neck of the aneurysm for effective surgical clipping or coiling (working angle). (B) Post coil-embolization of the dorsal wall aneurysm.

Cerebrovascular malformations

MRI, MRA, or CA can all diagnose AVMs. Three-dimensional time-of-flight MRA can accurately define the nidus but cannot completely define hyperdynamic afferent arteries.[6] CA is useful to confirm and better define an AVM; it accurately delineates the angioarchitecture and location of AVMs. CA is also useful for accurate determination of the size and location of the AVM nidus, to define the venous drainage, and detect any associated aneurysms. This information serves as a guideline to select surgical excision, interventional angiographic obliteration, or radiotherapy as the optimal therapeutic approach. CA must necessarily include evaluation of all potential arterial feeders to the AVM. An AVM on the brain surface may receive blood supply partially or exclusively from the external carotid system; therefore, selective external carotid angiography is necessary in such cases. Occult or cryptic AVMs are defined as lesions that are not visualized on angiography, which is attributable to their small size or thrombosis within the malformation.[7] Dural arteriovenous fistulas (DAVFs) represents 10-15% of all intracranial AVMs.[8] CA remains the gold standard for detection and evaluating a suspected DAVF. A six-vessel angiogram, including both ICAs, both ECAs, and both Vas, is mandatory. The hallmark of DAVFs is the presence of early venous drainage due to abnormal communication within the dura mater between meningeal arterial branches and a venous sinus or subarachnoid vein. CA can provide information regarding the fistula location, the arterial supply, patency of the venous sinuses, and the pattern of venous drainage. (Fig. 4) When a complex DAVF is supplied by multiple arterial feeders from different vascular territories, it may be diffult to confirm the exact fistulous point. Although intracranial DAVFs without cerebrovascular disease (CVA) have a benign natural history, those with CVA can have an aggressive natural history, particularly when symptomatic. Angiographic features suggestive of increased hemorrhagic risk included petrosal or straight sinus location, presence of leptomeningeal venous drainage, and the presence of a venous varix on the draining vein.[9] Usually, most cavernous malformations cannot be confirmed on CA, although early or widened veins, stains, pooling, blushes, or slight neovascularity have been reported.[10] Venous angiomas are associated with a low risk of bleeding.[11] However, CA may be indicated in patients with suspected venous angiomas to confirm the distribution of medullary veins and venous tributaries.

Other vascular lesions

CA can detect areas of focal arterial narrowing associated with arteritis or migraine. The affected cerebral arteries may appear narrowed or dilated, and these abnormalities may be focal, multifocal, or diffuse in distribution. Narrowing or a telangiectatic arterial network in the supraclinoid segments of the ICA and the adjacent proximal anterior, middle, and posterior cerebral arteries represents the characteristic angiographic appearance of moyamoya disease. Patients with lupus erythematosus, periarteritis nodosa, and temporal arteritis may show multiple peripheral aneurysms in addition to luminal irregularities. Radiation-induced arteritis usually involves small arteries and may not be evident on CA. However, large-vessel stenosis with or without a moyamoya pattern and diffuse arteritis may be visualized on CA.[12] Carotid or vertebral artery dissection, FMD, or aneurysms with intraluminal thrombi can cause ischemic stroke in some patients. Although carotid or vertebral artery dissections can be detected on computed tomography or MRI, CA remains the gold standard for the diagnosis of cervical dissections. Angiographic evidence of an intimal flap or double lumen confirms dissection. Other angiographic findings suggestive of dissection include flame-shaped or tapered narrowing, the “string sign”, aneurysm formation, or occlusion.[13] FMD includes a group of non-atherosclerotic, non-inflammatory arterial diseases that commonly involve the renal and carotid arteries. Histopathologically, FMD is categorized into the intimal, medial, and perimedial subtypes. Based on angiographic features, FMD is classi-

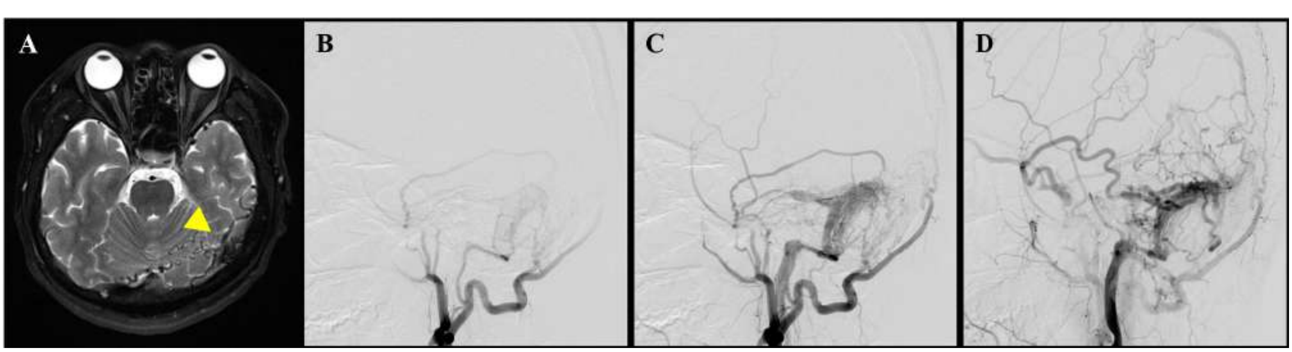

Figure 4. A case of transverse dural arteriovenous fistula. (A) Axial sections from a T2-weighted MRI study showing large vascular flow voids (arrowhead) near the left transverse sinus. (B–D) Cerebral angiography showing arteriovenous shunt from the left middle meningeal artery, ascending pharyngeal artery and occipital artery, supplied from the left external carotid artery to the transverse sinus.

fied into the multifocal type with multiple sites of stenosis and the 'string-of-beads' appearance associated with medial FMD and the tubular and focal types, which do not show specific histopathological lesions. Cervicocranial FMD can be complicated by dissection, which invariably presents clinically with headache, Horner's syndrome, or stroke, or may be associated with intracerebral aneurysms with a risk of SAH or intracerebral hemorrhage. CA is the gold standard for the diagnosis of FMD; however, CA is useful only for patients in whom it is clinically feasible to proceed with endovascular revascularization.[14]

Conclusions

It is reasonable to conclude that following technological innovations in MRA in the future, CA will have a limited role as a diagnostic tool in patients with cerebrovascular disease. However, CA remains a useful diagnostic and therapeutic modality for the management of various cerebrovascular diseases. Notably, interventional neuroradiology has largely replaced open surgery or is being performed before the surgery in a hybrid form, and CA is a basic component of interventional neuroradiology. Clinicians should have thorough knowledge of CA as a diagnostic tool to evaluate anomalies of the cerebral arteries and should be familiar with the indications for CA, to optimize patient care.

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