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Case Report

Sinus Arrest and Bradycardia Induced by Carotid Baroreceptor Reflex Activation during Rotational Angiography: A Case Report

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Objective: We describe a rare patient with a cavernous sinus dural arteriovenous fistula (CS DAVF) in whom diagnostic rotational angiography (RA) caused sinus arrest and bradycardia.

Case Presentation: A 79-year-old woman with no previous history of cardiovascular diseases presented with left oculomotor nerve paresis. Conventional angiography confirmed a bilateral CS DAVF. During a three-dimensional RA (3DRA) examination of the left internal carotid artery, sinus arrest occurred. Subsequently, the use of 3DRA to image the left external carotid artery and the use of cone beam computed tomography (CBCT) to image the left internal and external carotid artery also caused transient sinus bradycardia. Two weeks later, we inserted a temporary transvenous pacemaker and completed the transvenous embolization of the left CS DAVF. The left oculomotor paresis improved without any perioperative complications.

Conclusion: RA is a standard radiological modality for the diagnosis of cerebrovascular disease. Although the physical force generated by the injection of the contrast medium at the carotid bifurcation can theoretically cause hemodynamic instability, no previous reports have described sinus arrest or bradycardia in association with diagnostic carotid angiography. The present case demonstrates that 3DRA and CBCT can provoke rare, but serious, incidences of cardiac arrhythmia.

Keywords ▶ carotid baroreceptor reflex, cone beam computed tomography, dural arteriovenous fistula, sinus arrhythmia, three-dimensional rotational angiography

Introduction

Hemodynamic instability, including hypotension and bradycardia, is a well-recognized complication secondary to surgical manipulation at or in the vicinity of the carotid bifurcation.[1–4] A recent report showed that cardiac arrest can also be elicited during the deployment of a flow-diverter.[5] To the best of our knowledge, however, no previous reports have described severe hemodynamic instability related to diagnostic rotational angiography (RA).

Here, we report a patient with a cavernous sinus dural arteriovenous fistula (CS DAVF) who experienced a sinus arrhythmia during three-dimensional RA (3DRA) and cone beam computed tomography (CBCT) for the visualization of the internal and external carotid arteries.

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Case Presentation

A 79-year-old woman had noted diplopia and left ocular pain for 2 months prior to visiting our institute. She had no past cardiac history. Her physical examination revealed ptosis, a mildly dilated pupil, an impaired downward gaze, and an impaired rightward gaze in the left eye, suggesting left oculomotor nerve paresis. Magnetic resonance imaging and three-dimensional CT (3D-CT) showed an abnormal blood signal in the bilateral cavernous sinuses. The image obtained using 3D-CT revealed a small calcified plaque at the left carotid bifurcation (**Fig. 1**). Although a stenosis was not observed at the bilateral carotid bifurcations, the proximal part of the internal carotid artery and external carotid artery was tortuous on both sides. Her electrocardiogram upon admission was normal. We performed cerebral angiography via the right femoral artery using a biplane angiographic system (Infinix Celeve; Canon, Tokyo, Japan) with the patient under local anesthesia. Nonionic contrast material (iopamidol, Oypalomyn [300 mg I/mL]; Fuji Pharmaceutical Co., Toyama, Japan) was used for all the vascular imaging. First, we navigated a 4-Fr catheter (GlideCath Bentson-Hanafee-Wilson Angiographic Catheter; Terumo, Tokyo, Japan) using a 0.035-inch guidewire (Radifocus Guidewire M Angle Type; Terumo) into the proximal part of the left internal carotid artery. The internal carotid angiography performed by the injection of a total of 6 mL of contrast medium at 4 mL/second showed that the dural branches of the left internal carotid artery were connected to the left cavernous sinus. The shunt flow drained into the left superior ophthalmic vein and the left pterygoid plexus (**Fig. 2A**). During the injection of the contrast medium, the vital-signs monitor did not show any changes in the electrocardiogram.

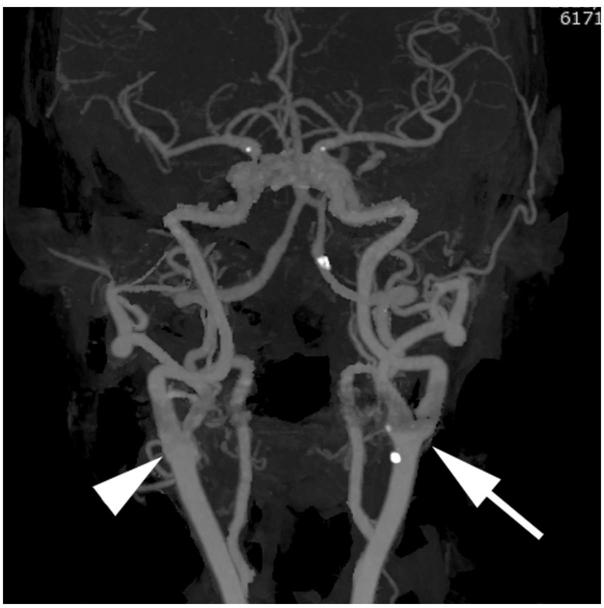

Fig. 1 Preoperative cervical 3D-CT angiography showing that the external carotid artery and internal carotid artery were tortuous on both sides. Although a small calcified plaque was observed at the left carotid bifurcation, no stenosis was apparent. The arrow indicates the left carotid bifurcation. The arrowhead indicates the right carotid bifurcation. 3D-CT: three-dimensional computed tomography

Then, 3DRA was acquired with the mechanical injection of 20 mL of contrast material at 3 mL/second. The tube rotation was a 200° arc with a rotation time of 5 seconds and the following parameters: gantry rotation speed of 50°/s over 200°arc; field of view, 12 × 12 inches; matrix size, 1024 × 1024; acquisition time, 4 seconds; total number of frames, 108; and delay time, 3 seconds (**Fig. 2B**). When the contrast medium was injected, sinus arrest occurred. Immediately cardiac resuscitation was started, and a normal sinus rhythm was restored (**Fig. 3A**). On the vital-signs monitor, the sinus arrest lasted 5.4 seconds. We provided cardiac resuscitation for approximately 10 seconds. Although the patient's mental status was lethargic for a short time, it soon fully recovered. Because the injection

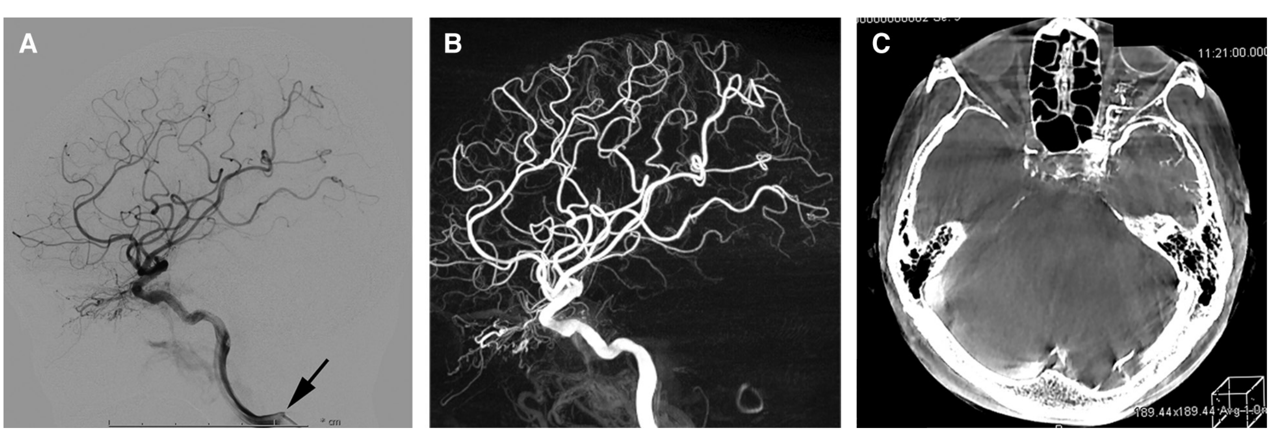

Fig. 2 Lateral views obtained using conventional angiography (**A**) and 3DRA (**B**) of the left internal carotid artery show a cavernous sinus dural arteriovenous fistula supplied by the dural branches of the left C4 portion with antegrade drainage into the left pterygoid plexus and retrograde drainage into the left superior ophthalmic vein. The CBCT (**C**) shows many feeders from the left internal carotid artery into the left cavernous sinus. The arrow indicates the tip of the catheter. 3DRA: three-dimensional rotational angiography; CBCT: cone beam computed tomography

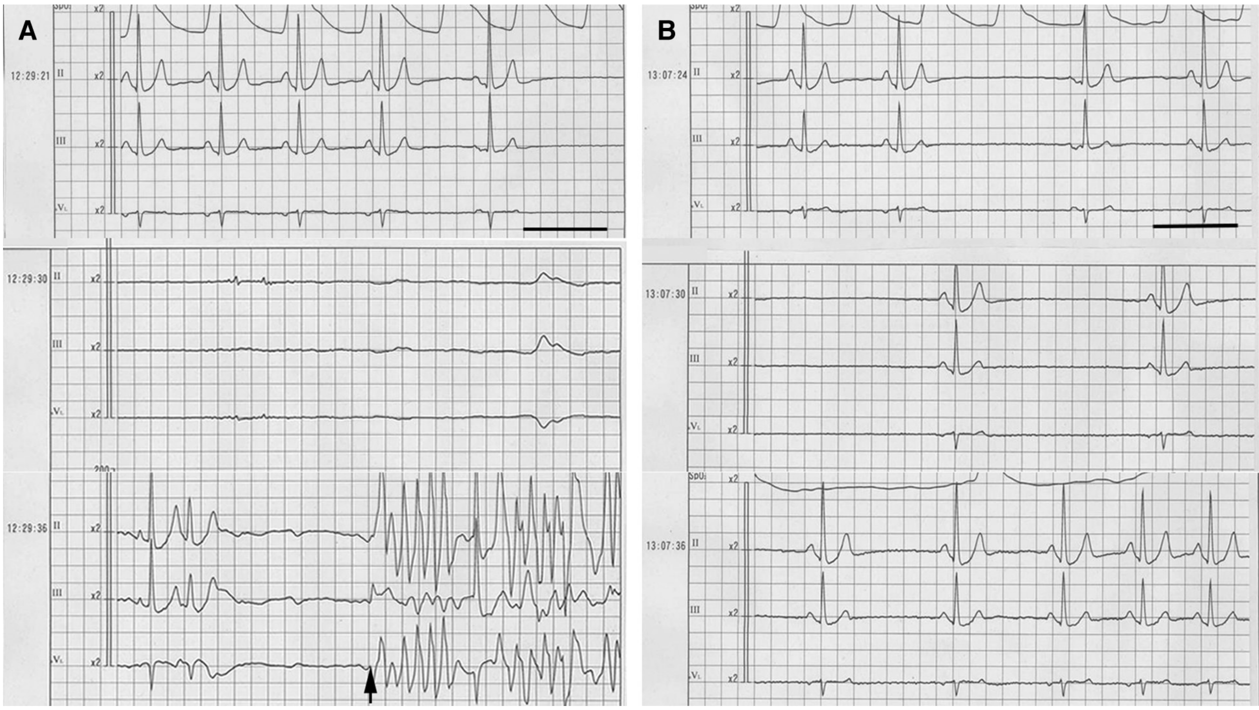

Fig. 3 (**A**) An electrocardiogram recorded during 3DRA of the left internal carotid artery shows the sinus arrest. The arrow indicates the time at the start of chest compressions. The scale shows one second. (**B**) An electrocardiogram recorded during CBCT of the left internal carotid artery shows sinus bradycardia. The scale shows one second. 3DRA: three-dimensional rotational angiography; CBCT: cone beam computed tomography

of the contrast medium in the vicinity of the carotid bifurcation was thought to have triggered a carotid baroreceptor reflex, the cardiologists at our institute placed two pads on the chest of the patient so that we could deal with any sinus arrest that could be induced by the subsequent angiography. The CBCT was performed with the following rotational parameters: gantry rotation angle, 216°arc; field of view, 12 × 12 inches; matrix size, 1024 × 1024; acquisition time, 20 seconds; total number of frames, 571; and delay time, 9 seconds. A total of 36 mL of diluted contrast medium at a concentration of 30% was injected at a rate of 3 mL/second (**Fig. 2C**). During the injection of the diluted contrast medium, the heart rate transiently decreased and then returned to normal (**Fig. 3B**).

Next, the catheter was navigated to the proximal part of the left external carotid artery. The tip of the catheter was placed at the origin of the lingual artery. The external carotid angiography was performed by the injection of a total of 3 mL of contrast medium at 2 mL/second (**Figs. 4A** and **4B**). The cardiac monitor showed no abnormal signs. The images showed that the left CS DAVF received its blood supply from the left ascending pharyngeal artery and drained into the left cavernous sinus, then finally into the left superior ophthalmic vein and the bilateral inferior petrosal sinus. To identify the shunt point and to visualize the approach route for transvenous embolization, 3DRA was acquired with the mechanical injection of 14 mL of contrast material at 2 mL/second (**Fig. 4C**). The CBCT was acquired with a mechanical injection of 18 mL of the contrast medium diluted to 30% at 2 mL/second (**Fig. 4D**). The cardiac monitor showed transient bradycardia during the 3DRA and the cone beam CT examinations.

Subsequently, we performed right internal and external carotid angiography (**Fig. 5**). The images showed dural branches of the right internal carotid artery, right ascending pharyngeal artery, the artery of the foramen rotundum, and the posterior convexity branch of the right middle meningeal artery to be connected to the bilateral cavernous sinuses, draining into the bilateral inferior petrosal sinuses. Hemodynamic instability, including bradycardia and hypotension, was not observed during the conventional angiography, the 3DRA, or the CBCT for the right carotid artery.

In this case, we did not perform a cardiac examination, including echocardiography or inspection for arrhythmia, after the angiography. Retrospectively, we should have performed further cardiac assessments to rule out cardiac abnormality.

Because the left CS DAVF was symptomatic, transvenous embolization of the left cavernous sinus, including

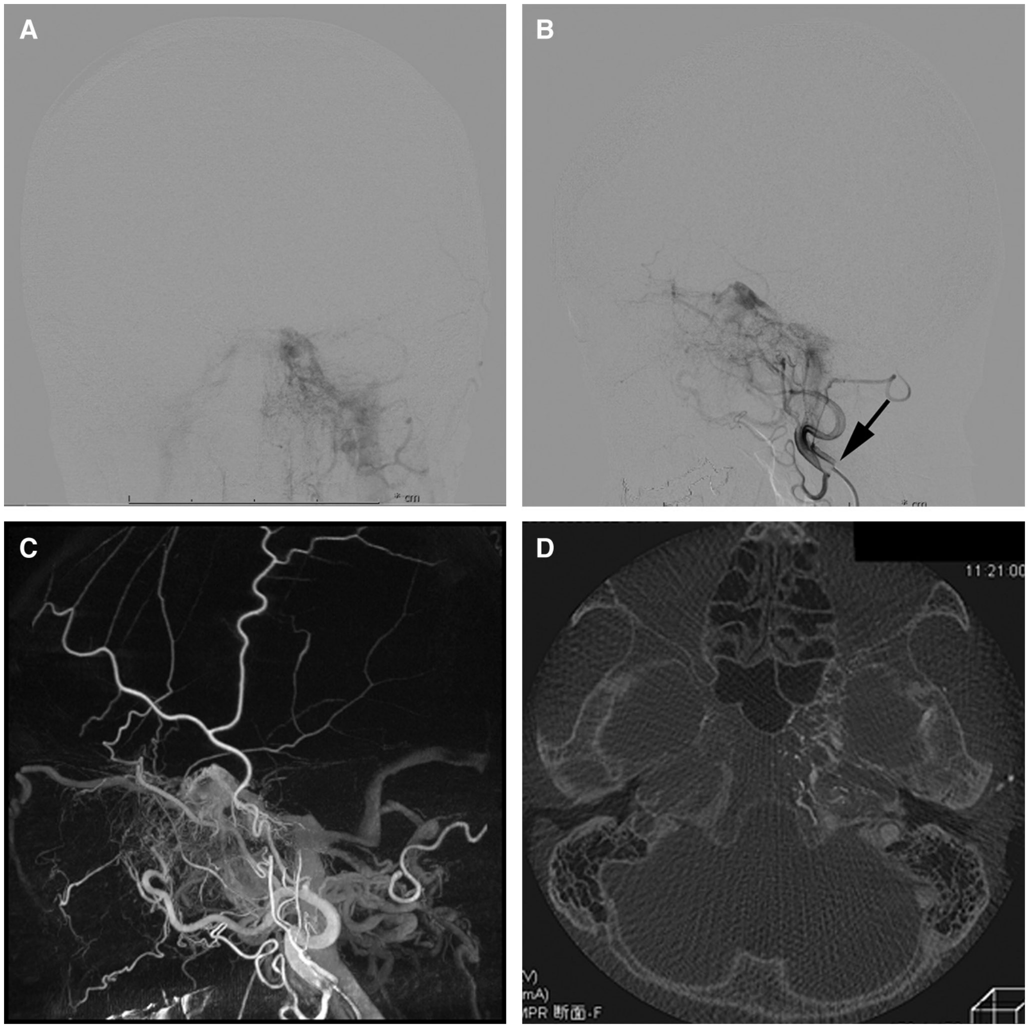

Fig. 4 Left external carotid angiography (anteroposterior view (**A**), lateral view (**B**)), 3DRA (lateral view (**C**)), and CBCT (**D**). The pharyngeal branch and the neuromeningeal branch of the left ascending pharyngeal artery are shunted to the junction of the left cavernous sinus and the intercavernous sinus. The shunt flow drains to the left superior ophthalmic vein and the bilateral inferior petrosal veins. The CBCT shows intraosseous feeders connected to the left cavernous sinus. The arrow indicates the tip of the catheter. 3DRA: three-dimensional rotational angiography; CBCT: cone beam computed tomography.

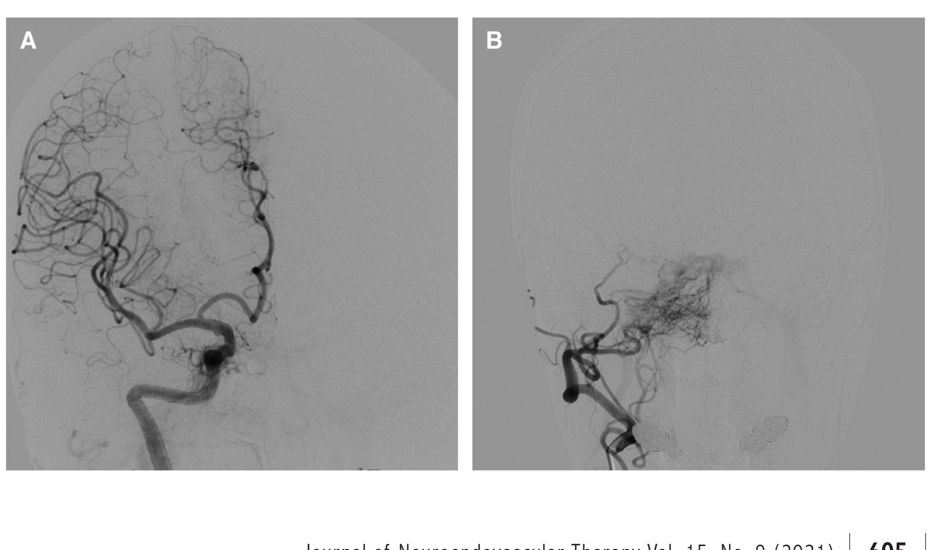

Fig. 5 Right external (**A**) and internal (**B**) carotid angiography (anteroposterior view). The dural branches of the right internal carotid artery, the pharyngeal branch and the neuromeningeal branch of the right ascending pharyngeal artery, the artery of the foramen rotundum, and the posterior convexity branch of the right middle meningeal artery connect to the left cavernous sinus and the intercavernous sinus, then drain into the bilateral inferior petrosal sinuses.

tight packing of the fistulous point, was attempted through the left inferior petrosal sinus. After the induction of the general anesthesia, a temporary transvenous pacemaker was placed via the left femoral vein. To demonstrate the target angioarchitecture, two 4-Fr diagnostic catheters with continuous heparin flushing were placed in the left external carotid artery via the left femoral artery and in the right external carotid artery via the right radial artery, respectively. A 6-Fr guiding sheath (ASAHI FUBUKI Dilator; ASAHI INTECC, Aichi, Japan) was then advanced transvenously via the right femoral vein and was placed at the left jugular vein. A 6-Fr guiding catheter (Cerulean DD6; Medikit, Tokyo, Japan) was coaxially navigated to the jugular bulb to improve the stability of the microcatheters. A microcatheter (Neurodeo; Medico's Hirata, Osaka, Japan) was advanced to the left superior ophthalmic vein using a microguidewire (ASAHI CHIKAI, 0.014 inches; ASAHI INTECC). Another microcatheter (Excelsior SL-10 STR; Stryker, Kalamazoo, MI, USA) was placed in the vicinity of the shunt point with a microguidewire (Tenrou; Kaneka Medix, Osaka, Japan). Through the two microcatheters, the left cavernous sinus, including the shunt point, was tightly packed with 23 coils (Target; Stryker, and ED coils; Kaneka Medix Corporation, Osaka, Japan) (**Fig. 6A**). During the endovascular treatment, we did not perform RA. Cardiac arrhythmia did not occur during this treatment. Although a minor shunt flow remained on the final angiographical image (**Figs. 6B, 6C,** and **6D**), the patient's left oculomotor paresis improved and the patient was discharged from hospital 7 days after the treatment.

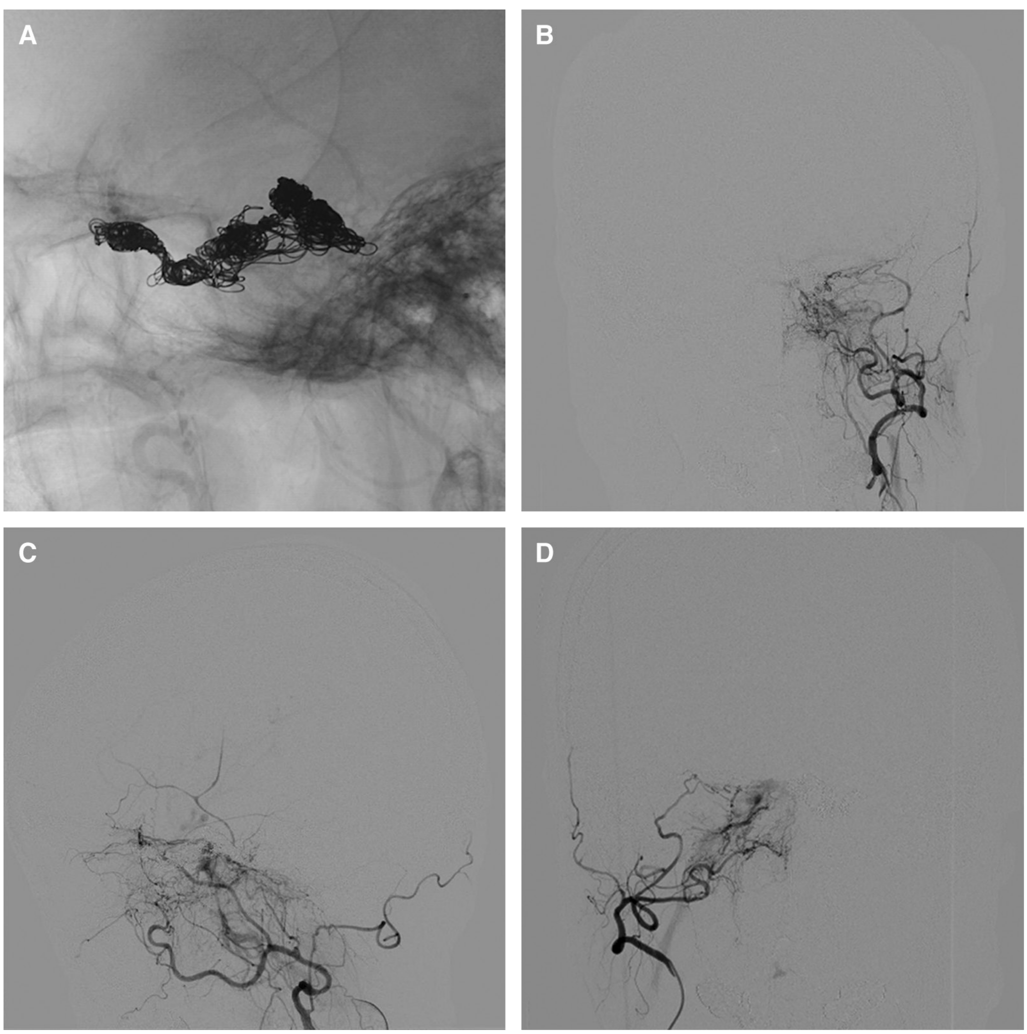

Fig. 6 Postoperative images. (**A**) A craniogram (lateral view) shows the distribution of the coil masses in the left cavernous sinus. A left external carotid angiography (anteroposterior view (**B**) and lateral view (**C**)) and a right external carotid angiogram (anteroposterior view (**D**)) show a significant decrease in the shunt flow to the left cavernous sinus from the bilateral external carotid arteries.

The patient's clinical course was uneventful, and no recurrences of the left oculomotor paresis had occurred at 3 months after the treatment.

Discussion

Complications of diagnostic catheter angiography, including artery-site related complications, iatrogenic dissection, and ischemic stroke, have been well described.[6,7] However, the triggering of a carotid baroreceptor reflex in association with diagnostic RA has not been previously reported.

Baroreceptors are strain-sensitive fibers located in both carotid sinuses near the carotid bifurcation.[8] These receptors respond to stretching of the arterial wall so that if the arterial pressure suddenly rises, the walls of these vessels passively expand and stimulate the firing of these receptors. These signals are transmitted via the glossopharyngeal nerve to the nucleus tractus solitarii in the dorsal medulla. Through a negative feedback cycle, sympathetic tone is reduced in the efferent part of the baroreceptor reflex and the parasympathetic tone is increased.[8,9]

In the present case, sinus arrest or sinus tachycardia occurred during RA while conventional angiography did not cause any arrhythmias. During the RA, the injection time was longer and the total volume of the injected fluid was larger, compared with the parameters used for the conventional angiography. Accordingly, we concluded that RA is more likely to have a strong effect on the carotid baroreceptor. However, whether the length of the injection time or the total volume of the injected contrast medium has a greater impact on the carotid baroreceptor remains unknown.

In the present case, we started cardiac resuscitation immediately after the sinus arrest was recognized, and the sinus rhythm was restored. The sinus arrest was probably a temporary phenomenon, since cardiac arrhythmia caused by the compression of the carotid sinus receptor usually returns to normal after the causative factors, such as a percutaneous transluminal balloon and the delivery wire of the flow-diverter, have been eliminated.[5]

In the present case, the 3DRA performed to visualize the contralateral internal carotid artery did not cause a carotid sinus reflex. This finding suggests a definite laterality in baroreflex sensitivity. This laterality agrees with the findings of a previous report showing a similar laterality in postprocedural hemodynamic instability induced by carotid artery stenting.[3]

In the present case, 3DRA caused a more severe carotid sinus reflex, compared with CBCT. The viscosity of non-diluted contrast medium is higher than that of diluted contrast medium. This difference might explain why the non-diluted contrast medium had a stronger physical impact on the carotid baroreceptor.

The severity of the sinus arrhythmia caused by 3DRA for the left external carotid artery was slightly smaller than that for 3DRA for the left internal carotid artery. The severity of the carotid baroreflex may simply depend on the distance between the carotid bifurcation and the tip of the catheter. However, two other plausible reasons also exist. One, the smaller amount of contrast medium used for 3DRA for the external carotid artery might have resulted in a weaker effect on the baroreceptor. Two, the injection of the contrast medium into the external carotid artery might have had a smaller impact on the carotid bifurcation because of some anatomical feature. During the RA of the internal and external carotid arteries, the injected contrast medium moves away from the carotid bifurcation. Thus, the physical force caused by the contrast medium might not have been strong enough to stimulate the carotid baroreceptor in the present case.

As the proximal part of the internal carotid artery and the external carotid artery was tortuous, the bended diagnostic catheter might have strongly rubbed against the arterial wall at the carotid bifurcation. Therefore, it is also possible that a direct mechanical effect caused by the catheter at the carotid baroreceptor induced the sinus arrhythmia during the RA.

The trigeminocardiac reflex is also a well-known phenomenon responsible for the development of severe bradycardia or even asystole and arterial hypotension during ophthalmic, craniomaxillofacial, and skull base surgery, as well as operations involving manipulations of the trigeminal ganglion and falx cerebri.[10] In neurosurgical or endovascular treatment, the trigeminocardiac reflex can be triggered by mechanical stimulation at several sites, including the ophthalmic division of the trigeminal nerve, the meningeal branch of the mandibular nerve in the foramen spinosum, and the trigeminal nerve root in the lateral wall of the cavernous sinus.[11–15] One previous case report described how the injection of contrast medium from the middle meningeal artery caused the trigeminocardiac reflex.[15] Several reports have described cases of CS AVF in which Onyx injected into the middle meningeal artery or the cavernous sinus caused a trigeminocardiac reflex. In the present case, when the contrast medium was injected into the internal carotid artery, its physical force might have been transmitted to the cavernous sinus via the meningeal branches of the internal carotid artery or to the ophthalmic artery. When the contrast medium was injected into the external carotid artery, the physical force elicited by the contrast medium could have been transmitted into the cavernous sinus via the feeding arteries or into the middle meningeal artery. Further exploration as to whether the mechanical force induced by the contrast medium injected from the vicinity of the carotid bifurcation is indeed sufficient to trigger the trigeminocardiac reflex is needed. Nevertheless, this phenomenon could be considered as an alternative mechanism of the sinus arrhythmia described in the presently reported case.

The present case suggests a potential risk of RA for visualization of the internal and external carotid arteries. To the best of our knowledge, no other reports have described a severe baroreceptor reflex in association with diagnostic angiography. Whether such carotid baroreceptor reflexes could cause serious complications also remains unknown. Nevertheless, a previous review mentioned that although cardiac arrhythmias induced by carotid bifurcation stimulation cannot provoke death alone, cardiac arrest arising from a cardioinhibitory reflex could be a contributing factor to death in the presence of drug abuse and/or cardiac pathology.[16] Physicians should be well aware of the risk of rotational carotid angiography performed in the vicinity of the carotid bifurcation.

Conclusion

Rotational carotid angiography can cause severe cardiac arrhythmia related to the carotid baroreceptor reflex. This complication could be fatal for patients with a history of cardiovascular disease. Physicians should be aware of the cardiac risk related to 3DRA and CBCT.

Disclosure Statement

We declare no conflict of interest.

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