Journal of Neuroendovascular Therapy 2025; 19: 2024-0122 DOI: 10.5797/jnet.cr.2024-0122

Case Report

Sublingual Nitroglycerin Administration before Computed Tomography Angiography for Detection of the Artery of Adamkiewicz in Patients with Spinal Dural Arteriovenous Fistula

Yusuke Kobayashi,[1] Sakyo Hirai,[1] Satoru Takahashi,[1] Kyohei Fujita,[1] Hirotaka Sagawa,[1] Jun Oyama,[2] Hiroto Hada,[3] Hikaru Wakabayashi,[1] Shoko Fujii,[1] and Kazutaka Sumita[1]

Objective: Presurgical identification of the artery of Adamkiewicz (AKA) is crucial in thoracic and lumbar spinal lesions. Although CTA is widely employed to identify AKA, the detection rate varies across reports and is often difficult, especially in patients with spinal dural arteriovenous fistulas (SDAVFs). We report 2 cases where sublingual administration of nitroglycerin (NTG), a vasodilator, before CTA enabled good visualization of the AKA in patients with SDAVF.

Case Presentation: (Case 1) A patient in his 60s presented with progressive gait disturbance, and an MRI revealed a spinal vascular lesion. CTA with sublingual NTG administration revealed an SDAVF supplied by the right seventh intercostal artery and an AKA branching from the left ninth intercostal artery. A chronic descending aortic dissection was identified on CTA, but spinal angiography was not performed. The patient was successfully managed with direct surgical disconnection of the SDAVF, and his symptoms improved. (Case 2) A patient in his 60s presented with progressive bilateral lower-limb numbness, and a thoracic SDAVF was diagnosed using MRI. CTA without NTG administration failed to identify the AKA, but after the administration of NTG, a clear depiction of the AKA branching from the left 10th intercostal artery was obtained. Endovascular shunt occlusion was successfully performed via the right 10th intercostal artery, resulting in significant symptom improvement.

Conclusion: Sublingual NTG administration before CTA may improve AKA expression in patients with SDAVF.

Keywords ▶ the artery of Adamkiewicz, nitroglycerin, computed tomography angiography

Introduction

The artery of Adamkiewicz (AKA), also referred to as the great anterior radiculomedullary artery, usually supplies the spinal cord at the lower thoracic and lumbar levels.[1)]

[1]*Department of Endovascular Surgery, Institute of Science Tokyo, Tokyo, Japan*
[2]*Department of Diagnostic Radiology, Institute of Science Tokyo, Tokyo, Japan*
[3]*Department of Radiology Center, Institute of Science Tokyo, Tokyo, Japan*

Received: January 8, 2025; Accepted: April 3, 2025
Corresponding author: Kazutaka Sumita. Department of Endovascular Surgery, Institute of Science Tokyo, 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8519, Japan
Email: sumita.nsrg@tmd.ac.jp

The intraprocedural sacrifice of the AKA has a potential risk of spinal cord infarction. Therefore, accurate identification is necessary for surgery or endovascular treatment (EVT) of descending aortic or thoracolumbar spinal cord lesions, including tumors and spinal dural arteriovenous fistulas (SDAVFs). The use of spinal angiography is the gold standard for AKA identification. Although computed CTA and MRA are minimally invasive alternatives, the detection of AKA remains difficult, especially in cases of SDAVFs.[2–8)] According to previous reports, the detection rate of the AKA using CTA in patients with abdominal aortic aneurysms ranged from 9% to 80%.[9,10)] Conversely, another study reported a 72.3% detection rate of the AKA in patients with SDAVF.[3)] However, it is important to note that in the latter study, the AKA was defined as any vessel identified entering the intradural space from a segmental artery. Previous studies have discussed various techniques for a clear depiction of AKA.[3,9,11,12)]

Sublingual administration of nitroglycerin (NTG) before coronary CTA is reported to facilitate the delineation of small vessels.[13] Moreover, the utilization of NTG before CTA or MRA reportedly facilitates AKA delineation.[5,10] However, no reports confirm whether NTG administration before CTA improves the visualization of AKA in patients with SDAVF.

In this study, we presented cases of thoracic SDAVF where CTA imaging with NTG administration improved the visualization of AKA and reviewed our experiences with the depiction of AKA with or without NTG. This case report has been approved by the institutional ethics review board of the Institute of Science Tokyo (M2020-102).

Case Presentation

CTA imaging acquisition

Patients who underwent CTA at our facility were administered 0.3 mg of NTG sublingually approximately 5 min prior to the examination. No patients exhibited hypotension before drug administration. Eighty-kV CTA was performed using a 192-section dual-source CT scanner (Somatom Force; Siemens, Erlangen, Germany). The dual-power scan mode was applied with the following parameters: 192 × 0.6 mm detector configuration, 0.5 s per rotation, 0.6 pitch, quality reference 350 mAs (Care Dose 4D; Siemens), and reference 120 kV (CARE kV; Siemens). The scanning was extended from the level of the first thoracic vertebra to that of the fifth sacral vertebra. The imaging method for contrast-enhanced CT is as follows: 135 mL of high-osmolarity iodinated contrast medium (Iomeprol 350; Bracco Japan, Tokyo, Japan) was injected at a rate of 4.5 mL/s, followed by a 50 mL saline chaser via a 20-gauge intravenous catheter placed in an antecubital vein using a double-head power injector. The bolus-tracking method was employed to determine the timing of image acquisition. A circular region of interest was placed in the descending aorta at the level of the first lumbar vertebra. After 10 s, attenuation in the aorta increased by 150 Hounsfield units, and scanning was automatically initiated in the craniocaudal direction. Scanning was performed during a single breath hold. Images were reconstructed with a 0.6-mm slice thickness, a 512 × 512 matrix, a 200-mm display field of view, and kernels Bf36 and Br59 using an iterative reconstruction algorithm (Advanced Modeled Iterative Reconstruction [ADMIRE]; Siemens) in the standard setting. The AKA was identified using a 3D image analysis workstation (Ziostation 2, version 2.3.4.0; Ziosoft, Tokyo, Japan).

The details of the CTA imaging acquisition performed at the previous institution for Case 2 are as follows: Eighty-kV CTA was performed on a 192-section dual-source CT scanner (Aquilion One GS; Canon Medical Systems, Tochigi, Japan). Dual-power scan mode was applied with the following parameters: 80 × 0.5 mm detector configuration, 0.5 s per rotation, 0.813 pitch, and reference 120 kV (CARE kV; Siemens). The imaging method for contrast-enhanced CT is as follows: 100 mL of high-osmolarity iodinated contrast medium (Lopamiron 370; Bayer, Leverkusen, Germany) was injected at a rate of 4.0 mL/s, followed by a 40 mL saline chaser. The bolus-tracking method was the same as the protocol of our institution. Images were reconstructed with a 0.5-mm slice thickness, a 512 × 512 matrix, a 200-mm display field of view (FOV), and kernel Fc13 using an iterative reconstruction algorithm (Adaptive Iterative Dose Reduction 3D; Canon Medical Systems) at the standard setting.

Case 1

A patient in his 60s presented to our hospital with a 2-year history of bilateral lower-limb numbness, gait disturbance for the past 3 months, and recent onset of bladder and rectal dysfunction. MRI demonstrated hyperintense signal lesions at the level of Th7–Th12, and multiple vascular flow voids were noted on T2-weighted images (**Fig. 1A**). The patient had a history of aortic dissection surgery, and preoperative CTA revealed chronic descending aortic dissection. CTA with 0.3 mg NTG sublingual administration revealed SDAVF supplied by the right seventh intercostal artery and AKA branching from the left ninth intercostal artery (**Fig. 1B**–**1E**). The feeder of the shunt was presumed to be the left seventh intercostal artery; however, the exact shunt point could not be clearly identified (**Fig. 1E**). The AKA was not visualized in the volume rendering (VR) or maximum intensity projection (MIP) images of the CTA. The patient underwent resection of the lower half of the spinous process of Th6, laminectomy of Th7 and Th8, and microsurgical disconnection of the SDAVF. Although urinary dysfunction persisted, the symptoms gradually improved. The patient was transferred to a rehabilitation hospital 5 weeks after surgery.

Case 2

A patient in his 60s presented to another hospital with progressive bilateral lower-limb numbness. MRI revealed a hyperintense signal lesion in the thoracic spinal cord below Th6 on T2-weighted images, with some vascular flow voids observed on constructive interference in steady-state

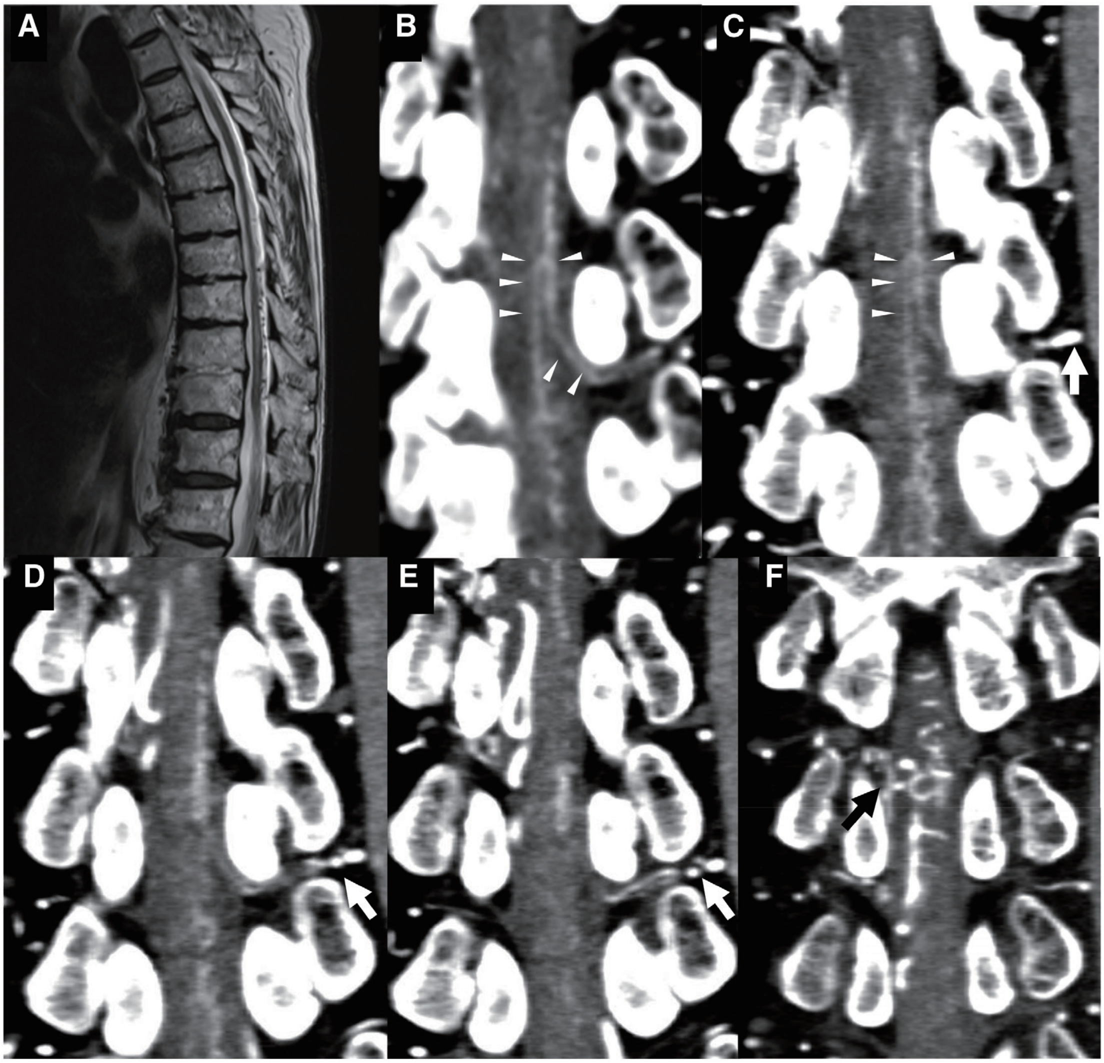

Fig. 1 (**A**) A sagittal section of MRI displaying the high T2 signal at the level from Th7 to Th12, along with flow voids. (**B** and **C**) The hairpin curve of the AKA is depicted on the oblique coronal and coronal MPR images of CTA (white arrowhead). (**D** and **E**) The continuity from the left ninth intercostal artery to the anterior surface of the spinal cord is distinctly observed on the coronal image of CTA (white arrow). (**F**) In the coronal view of the CTA, a shunt supplied by the right seventh intercostal artery as the feeder is observed; however, the exact shunt point cannot be definitively identified (black arrow). AKA, artery of Adamkiewicz; MPR, multiplanar reconstruction

(CISS) images (**Fig. 2A** and **2B**). Although CTA without NTG administration did not depict the AKA, elongated and dilated spinal veins were identified (**Fig. 2C**). The patient was then referred to our hospital for further treatment. CTA with 0.3 mg NTG sublingual administration clearly depicted AKA branching from the left 10th intercostal artery (**Fig. 2D**–**2F**), which was consistent with the findings of spinal angiography (**Fig. 2I**). A feeder from the right 10th intercostal artery was presumed to be involved in the shunt; however, as in Case 1, the exact shunt point could not be clearly identified (**Fig. 2G** and **2H**). Similar to Case 1, the AKA was not clearly visualized on the VR or MIP images of the CTA. Subsequently, the patient underwent endovascular shunt occlusion via the right 10th intercostal artery. The SDAVF was successfully occluded with *N*-butyl-2-cyanoacrylate (**Fig. 2J** and **2K**). Numbness in the lower limbs significantly improved postoperatively, and no complications related to embolization were observed. The patient was transferred to a rehabilitation hospital on the eighth day after surgery.

Discussion

NTG is commonly administered to improve the visualization of the coronary artery and increase its detection rate on CTA.[13] However, the vasodilatory effect of NTG extends

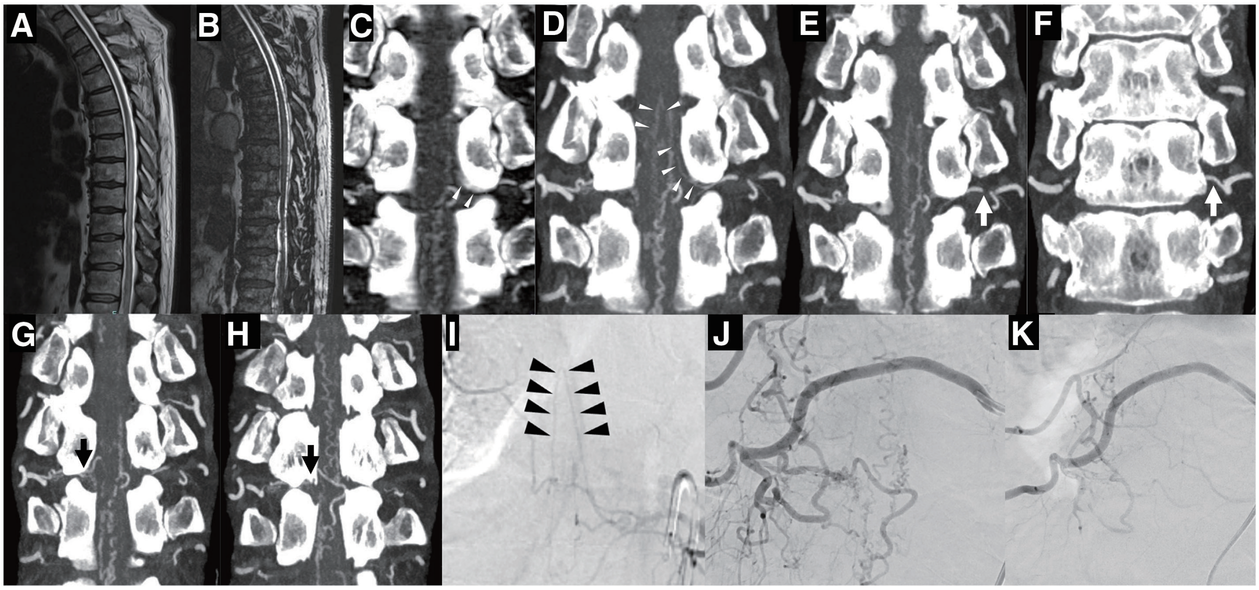

Fig. 2 (**A**) A sagittal section of the MRI image demonstrates hyperintense signal lesions in the thoracic spinal cord below Th6 on a T2-weighted image. (**B**) A sagittal section of the CISS image displays the tortuous veins on the surface of the spinal cord. (**C**) CTA without sublingual NTG did not depict the AKA (white arrowhead). (**D**) CTA with sublingual NTG depicts the hairpin curve of the AKA excellently (white arrowhead). (**E** and **F**) The continuity from the left 10th intercostal artery to the ventral side of the spinal cord is observed on the coronal image of CTA (white arrow). (**G** and **H**) The coronal view of the CTA reveals a shunt supplied by the right 10th intercostal artery; however, the precise shunt point cannot be definitively determined (black arrow). (**I**) A preoperative spinal angiography reveals that the AKA originates from the left 10th intercostal artery, which is consistent with the CTA findings (black arrowhead). (**J**) A spinal angiography at the right 10th intercostal artery displays the SDAVF. (**K**) After embolization using NBCA, the shunt is successfully occluded. AKA, artery of Adamkiewicz; CISS, constructive interference in steady state; NBCA, *N*-butyl-2-cyanoacrylate; NTG, nitroglycerin; SDAVF, spinal dural arteriovenous fistula

beyond the coronary vessels, as it is known to affect blood vessels throughout the circulatory system.[14] Reports have indicated that the administration of NTG enhances the visualization of AKA in patients with non-SDAVFs, such as aortic aneurysms.[10] Conversely, according to a previous report that did not involve the administration of NTG, the AKA in patients with SDAVF was more difficult to visualize on CTA than in patients without SDAVF.[3] Eckart Sorte et al. suggested that venous hypertension occurs as a result of shunt reflux from the radicular vein to the perimedullary vein, which impacts the arteriovenous pressure gradient within the spinal cord, making visualization of the AKA difficult.[8] Furthermore, the presence of dilated and tortuous shunt vessels makes the visualization of small-caliber AKA challenging. Therefore, we hypothesized that the administration of NTG might lead to clearer visualization of the AKA on CTA in patients with SDAVF.

Our study suggests that NTG administration may help visualize the AKA, even in patients with SDAVF. In particular, in Case 2, the AKA, which could not be recognized on CTA without NTG administration, became recognizable after NTG administration.

Identifying the location of the AKA in patients with thoracic and lumbar spinal lesions including spinal tumors, vertebral body tumors, and descending aortic aneurysms or dissections requiring surgical intervention is important. If the AKA is identified before surgical intervention in patients with the aforementioned conditions, the risk of spinal cord ischemia due to occlusion of the segmental artery originating from the AKA may be reduced. In patients with SDAVF, EVT and direct surgery are viable treatment options. Although EVT has garnered significant attention in recent years, the outcomes of direct surgery also remain favorable. Additionally, neurological complications, such as spinal cord infarction, have been reported to be more frequent in EVT than in direct surgical procedures.[15] Preoperative anatomical identification of the AKA and feeding arteries may be useful for selecting relatively safe therapeutic options. Although spinal angiography is the gold standard for SDAVF, preoperative CTA with NTG administration may still be valuable, even in cases where spinal angiography is planned. Visualization of the location of AKA before spinal angiography could optimize the sequence of selective catheterization, potentially reducing procedure time, contrast medium usage, and radiation exposure.

Notably, sublingual NTG administration has potential side effects, including hypotension, headache, and dizziness. Although no adverse events were observed in our cases, previous reports suggest that side effects, when they occur, are typically mild and resolve spontaneously without requiring medical intervention.[16] However, given the vasodilatory effects of NTG, careful monitoring during CTA is necessary, especially in older patients and those with cardiovascular conditions.

Future prospective investigations are needed to increase the number of cases and demonstrate the usefulness of CTA with NTG for delineating the AKA. Such studies would further elucidate the role of this technique in the preoperative evaluation of thoracolumbar spinal lesions, including vascular disorders, tumors, and aortic diseases, potentially leading to efficient and safe treatment strategies.

Furthermore, although the effects of NTG on radiculopial artery and posterior spinal artery were not examined in this study, the visualization of these vessels is also essential for determining treatment strategies. Therefore, investigating how NTG affects the visualization rate of small-caliber vessels remains an important issue for future research.

In Case 2, CTA images acquired under different scanning parameters are presented, which constitutes a limitation in terms of direct comparison. At our institution, the decision was made not to perform a second contrast-enhanced CTA without NTG administration on the same patient due to ethical considerations regarding the invasive nature of repeated contrast agent use. For a more rigorous evaluation, it would be necessary to compare NTG-administered and non-administered groups under identical scanning conditions.

Conclusion

Sublingual NTG administration before CTA may improve the AKA depiction in patients with SDAVF.

Acknowledgments

We would like to thank Editage (www.editage.jp) for English language editing.

Disclosure Statement

Kazutaka Sumita received lecture fees from Japan Stryker. The remaining authors declare that they have no conflicts of interest.

References

1) Alvernia JE, Simon E, Khandelwal K, et al. Anatomical study of the thoracolumbar radiculomedullary arteries, including the Adamkiewicz artery and supporting radiculomedullary arteries. *J Neurosurg Spine* 2023; 38: 233–241.
2) Chen J, Gailloud P. Safety of spinal angiography: complication rate analysis in 302 diagnostic angiograms. *Neurology* 2011; 77: 1235–1240.
3) Hoshiai S, Shiigai M, Konishi T, et al. Detection of the artery of Adamkiewicz using multidetector row computed tomography in patients with spinal arteriovenous shunt disease. *Pol J Radiol* 2020; 85: 163–168.
4) Takagi H, Ota H, Natsuaki Y, et al. Identifying the Adamkiewicz artery using 3-T time-resolved magnetic resonance angiography: its role in addition to multidetector computed tomography angiography. *Jpn J Radiol* 2015; 33: 749–756.
5) Bley TA, Duffek CC, François CJ, et al. Presurgical localization of the artery of Adamkiewicz with time-resolved 3.0-T MR angiography. *Radiology* 2010; 255: 873–881.
6) Yoshioka K, Niinuma H, Ehara S, et al. MR angiography and CT angiography of the artery of Adamkiewicz: state of the art. *Radiographics* 2006; 26(Suppl 1):S63–S73.
7) Nordin AB, Fallon SC, Jea A, et al. The use of spinal angiography in the management of posterior mediastinal tumors: case series and review of the literature. *J Pediatr Surg* 2013; 48: 1871–1877.
8) Eckart Sorte D, Pardo CA, Gailloud P. Angiographic suppression of the artery of Adamkiewicz by venous hypertension resolving after embolization in a case of spinal epidural arteriovenous fistula. *J Neurointerv Surg* 2015; 7: e31.
9) Utsunomiya D, Yamashita Y, Okumura S, et al. Demonstration of the Adamkiewicz artery in patients with descending or thoracoabdominal aortic aneurysm: optimization of contrast-medium application for 64-detector-row CT angiography. *Eur Radiol* 2008; 18: 2684–2690.
10) Higuchi A, Kubota Y, Yokota H, et al. Computed tomography angiography assessment of Adamkiewicz artery with sublingual nitroglycerin administration. *Neuroradiology* 2024; 66: 2215–2221.
11) Guziński M, Bryl M, Ziemińska K, et al. Detection of the Adamkiewicz artery in computed tomography of the thorax and abdomen. *Adv Clin Exp Med* 2017; 26: 31–37.
12) Kubota Y, Yokota H, Mukai H, et al. Low-tube-voltage CT assessment of Adamkiewicz artery: precise comparison between 100-kVp- and 120-kVp protocols. *Eur J Radiol* 2019; 111: 56–61.
13) Okada M, Nakashima Y, Nomura T, et al. Coronary vasodilation by the use of sublingual nitroglycerin using 64-slice dual-source coronary computed tomography angiography. *J Cardiol* 2015; 65: 230–236.

14) Gupta S, Dixit R, Prakash A, et al. Can sublingual nitrate improve visualization of lower limb arteries on computed tomography angiography? *J Comput Assist Tomogr* 2023; 47: 576–582.
15) Zanin L, Di Bonaventura R, Agosti E, et al. Surgery versus endovascular treatment for spinal dural arteriovenous fistulas: a multicenter experience and systematic literature review. *Neurosurg Rev* 2024; 47: 206.
16) Takx RA, Suchá D, Park J, et al. Sublingual nitroglycerin administration in coronary computed tomography angiography: a systematic review. *Eur Radiol* 2015; 25: 3536–3542.