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Case Report

Identification of Adamkiewicz artery by 4D flow MRI and intra-arterial ultra-high-resolution CT angiography in preoperative assessment of patients with chronic aortic dissection: A case report☆

Satoshi Higuchi, MD, PhD[a,*], *Yuta Sato, MD*[a], *Hideki Ota, MD, PhD*[a], *Ryuichi Mori, RT*[b], *Yuki Ichinoseki, RT*[b], *Hitoshi Nemoto, RT*[b], *Shingo Kayano, RT*[b], *Kiichiro Kumagai, MD, PhD*[c], *Yoshikatsu Saiki, MD, PhD*[c], *Kei Takase, MD, PhD*[a]

[a] *Department of Diagnostic Radiology, Tohoku University Hospital, Sendai, Miyagi, Japan*
[b] *Department of Radiological Technology, Tohoku University Hospital, Sendai, Miyagi, Japan*
[c] *Department of Cardiovascular Surgery, Tohoku University Hospital, Sendai, Miyagi, Japan*

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ABSTRACT

Preoperative identification of the Adamkiewicz artery (AKA) with adequate reconstruction or preservation during surgery is useful for protecting the spinal cord from ischemia during thoracoabdominal aortic repair. However, the identification of the AKA remains challenging in some cases, especially with chronic aortic dissection. In a 45-year-old man with chronic aortic dissection requiring thoracoabdominal aortic repair, conventional contrast-enhanced CT or MR angiography failed to detect AKA due to the large entry tear and an enlarged false lumen. Intra-arterial ultra-high-resolution CT angiography combined with hemodynamic assessment using 4D flow MRI successfully identified the AKA, allowing for aortic repair with targeted intercostal artery reconstruction without postoperative signs of spinal cord ischemia.

Introduction

Spinal cord infarction (SCI) represents a severe and potentially devastating complication of thoracoabdominal aortic repair. The Adamkiewicz artery (AKA), a vital segmental artery supplying the spinal cord, typically originates from an intercostal or lumber artery, and its precise localization is paramount during surgical procedures to mitigate the risk of spinal cord ischemia [1]. Preoperative identification and preservation of

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* Corresponding author.
E-mail address: satoshi.higuchi.b4@tohoku.ac.jp (S. Higuchi).

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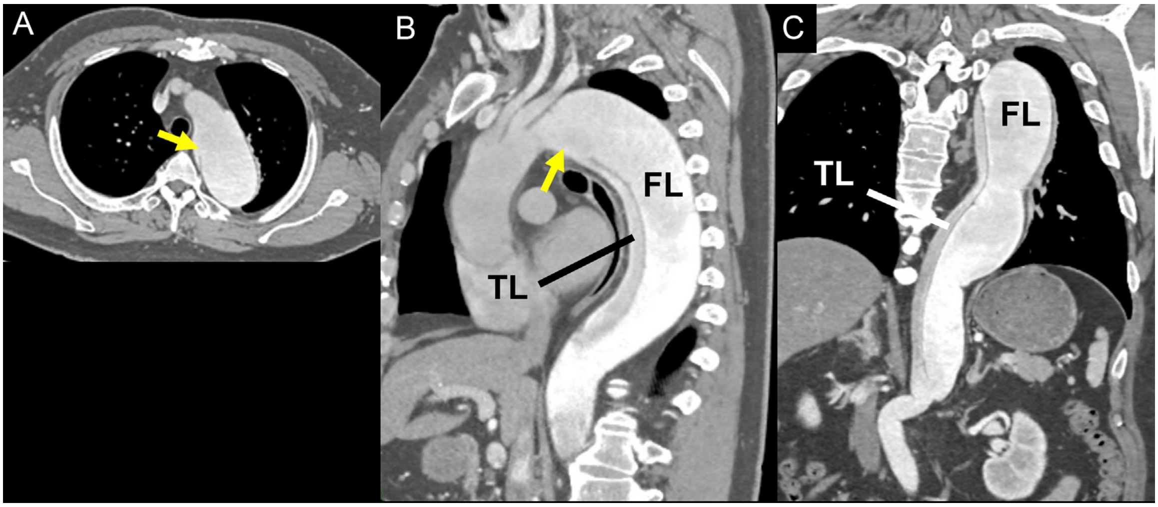

Fig. 1 – Axial (A) and MPR (B, C) CT images of the chronic aortic dissection. An axial image (A) and oblique sagittal MPR image (B) show the large 40 mm entry at the proximal descending aorta (yellow arrows). A coronal MPR image (C) shows a dilated false lumen (FL), low contrast effect in the true lumen (TL), dilated descending aorta of 62 mm, and re-entry at the level of the celiac artery.

the AKA during surgery have been reported as useful for effective spinal cord protection [2]. However, the identification of the AKA with CT angiography (CTA) is challenging due to its small diameter (0.5–1.5 mm), surrounding bony structures, and its anatomical proximity to the anterior spinal vein and great anterior radiculomedullary vein. Recent advancements in CT imaging and intra-arterial contrast injection techniques have facilitated preoperative identification of the AKA in up to 90% of patients with descending/thoracoabdominal aortic aneurysms [3–5]. However, optimal scan timing remains difficult to determine in cases with chronic aortic dissection (AD) due to complex hemodynamics. 4D flow MRI enables visualization of complex flow patterns in the aortic dissection and provides quantitative flow data at any location within the imaged volume. This report presents a case of chronic AD in which intra-arterial CT angiography (CTA), optimized with 4D flow MRI hemodynamic assessment, successfully identified the AKA.

Table 1 – 4D flow MRI acquisition parameters.

Field strength	3 Tesla
TR/TE	44.24/2.97 ms
Flip angle	8 °
FOV	312*400 mm
Acquisition matrix	192*107
Reconstruction matrix	300*384
Slice thickness	5 mm
Slices	26
Velocity encoding	100 cm/sec
Calculated phase	13
Acceleration	CS 7.7
Acquisition time	8 min 2 sec
Band width	473 Hz
Temporal resolutions	44.24 ms
Contrast medium	gadobutrol
Injection volume	9.9 mL

TR, repetition time; TE, echo time; FOV, field of view; CS, compressed sensing.

Case report

A 45-year-old man with chronic Stanford type B AD for over six years was referred for thoracoabdominal aortic replacement. Serial CTA demonstrated gradual expansion of the false lumen (FL) at a rate of 3 mm per year, with the most recent study showing a descending aortic diameter of 62 mm and a 40 mm entry tear at the proximal descending aorta (Fig. 1). Thoracoabdominal aortic replacement was planned, but intravenous CTA and dynamic MR angiography failed to identify the AKA due to poor contrast opacification in the true lumen (TL), the origin of most intercostal arteries in this case. 4D flow MRI was performed to evaluate hemodynamics following MR angiography, with scan parameters outlined in Table 1. 4D flow MRI quantified the average net flow of 7.1 mL/s in the TL and 65.8 mL/s in the FL, indicating higher blood flow in the FL (Fig. 2A, and B). Streamline images revealed a large vortex and retrograde flow in the FL, suggesting that AKA identification is challenging due to the prolonged retention of transvenous contrast in the FL (Fig. 2C, Movie 1). Consequently, intra-arterial CTA targeting the TL was planned. A 5Fr. pig-tail catheter was inserted via the right femoral artery, positioning its tip in the TL of the abdominal aorta. Digital subtraction angiography was performed using 30 mL of contrast medium injected at 10 mL/s, a rate exceeding the TL flow as estimated by 4D flow MRI, revealing retrograde and congested flow in the TL (Movie 2). Subsequently, intra-arterial CTA was performed using an ultra-high resolution detector CT (Aquilion Precision, Canon Medical Systems, Otawara Japan) with parameters detailed in Table 2. The images revealed the an-

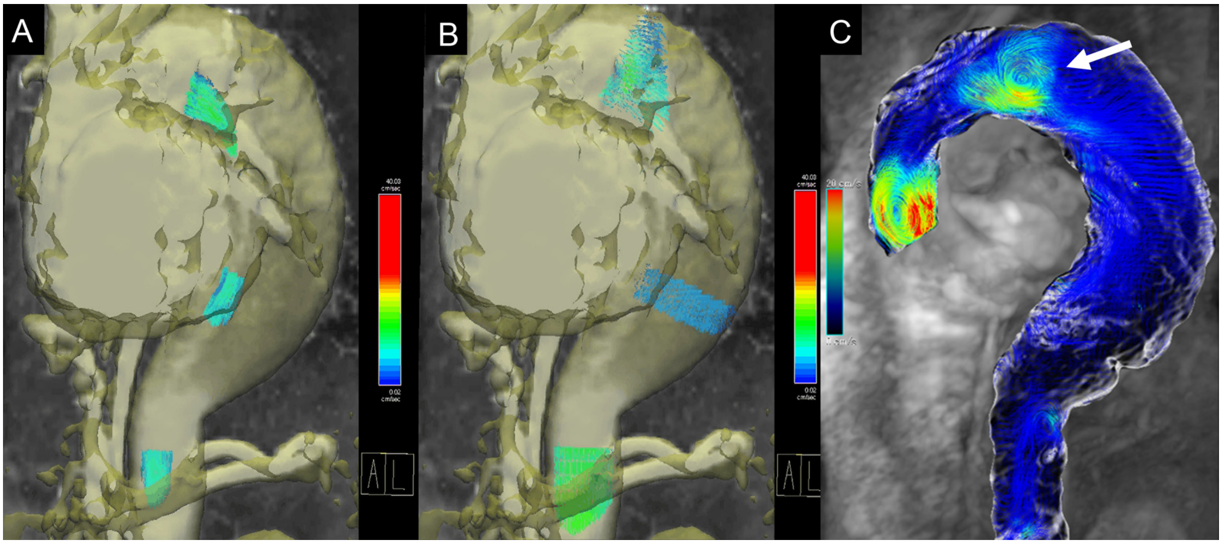

Fig. 2 – Oblique sagittal pathline images in the TL (A) and FL (B), and a streamline image (C) obtained from 4D flow MRI. The images (A, B) revealed that the average net flow in the TL and FL were 7.1 and 65.8 mL/sec, respectively. The streamline image (C) demonstrated a large vortex flow and retrograde flow in the proximal part of the FL of the descending aorta (white arrow).

Table 2 – Transarterial CTA acquisition parameters.

Tube voltage	120 kV
Tube Current	AEC: SD 13 @5 mm
Reconstruction method	MBIR
Kernel	FIRST
Iterative level	Body sharp STND
Thickness	0.25 mm
Display FOV	240 mm
Matrix	1024
Scan pitch	0.569
Scan time	11 sec
$CTDI_{vol}$	31.8 mGy
DLP	1577.3 mGy·cm
Injector	Dual Shot GX7
Contrast medium	iomeprol 300
Injection rate	10 mL/s
Injection volume	80 mL
Saline flash	0 mL

ACE, automatic exposure control; SD, standard deviation; MBIR, model based iterative reconstruction; FIRST, forward projected model-based iterative reconstruction solution; STND, standard; FOV, field of view; CTDI, computed tomography dose index; DLP, dose length product.

terior spinal artery connecting to the right 10th intercostal artery via the posterior spinal artery, forming a characteristic hairpin curve with adequate contrast opacification (Fig. 3). During surgery, differential selective hypothermic intercostal artery perfusion was applied. This technique involved the perfusion of 15°C blood into each intercostal artery, while cerebrospinal fluid temperature was monitored, using a drainage catheter with an integrated temperature sensor. During perfusion of the right 10th intercostal artery, CSF temperature dropped from 29°C to 25°C, indicating it as the primary spinal cord feeder. The patient exhibited no signs of SCI following aortic repair, which included reconstruction of the right 10th intercostal artery, and was discharged without complications.

Discussion

This case highlights the efficacy of intra-arterial CTA combined with the hemodynamic assessment using 4D flow MRI for preoperative identification of the Adamkiewicz artery. Open surgical repair for thoracoabdominal aortic aneurysm remains challenging, with considerable mortality and high complication rates [6,7]. Permanent paraplegia caused by SCI represents one of the most severe complications. Previous studies have demonstrated that preoperative AKA identification, along with its reconstruction or preservation, serves as an effective strategy for ensuring spinal cord protection during descending and thoracoabdominal aortic repairs [2,8]. However, minimally invasive CTA can struggle with poor visualization of the AKA due to a low contrast-to-noise ratio, despite advancements in imaging techniques that have improved the detection rate [9–11]. The challenge is particularly pronounced in patients with chronic AD, where turbulent and aberrant flow dilute the contrast medium within the dilated FL [11]. Intra-arterial CTA has been proposed in multiple reports as a method to achieve adequate contrast opacification for reliable AKA identification [2–4]. In this case, intravenous injection failed to produce sufficient intraluminal opacification of its TL, which supplies the intercostal arteries. Thus, intra-arterial injection into the TL should be considered as an appropriate alternative.

The second issue concerns the appropriate injection rate and scan timing. The hemodynamics of the contrast agent are influenced by both blood flow and injection rate. Previous

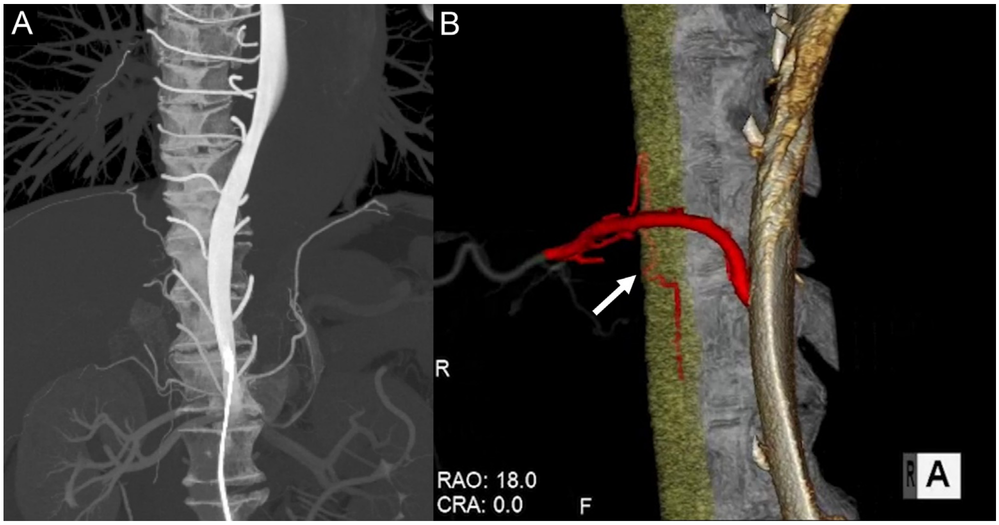

Fig. 3 – A maximum intensity projection of the intraarterial CT angiography image (A) shows adequate contrast effect in the TL and intercostal arteries. The volume rendering image (B) shows an anterior spinal artery branch from the right 10th intercostal artery via the posterior spinal artery forming a characteristic hairpin curve (white arrow).

reports have shown primarily antegrade laminar flow in the TL and multidirectional, nonlaminar flow with frequent retrograde components in the FL [12]. In this case, extremely slow antegrade flow was observed in the TL, and injecting the contrast agent at a rate exceeding the flow estimated by 4D flow MRI resulted in prolonged contrast accumulation in the TL. These findings underscore the role of 4D flow MRI in optimizing contrast injection and scan protocols.

The final key was the use of an ultra-high-resolution detector CT, capable of providing 0.25 mm slice images, which allowed the visualization of fine anatomical details [13]. In this case, an atypical AKA was identified, originating from the posterior spinal artery and connecting to the anterior spinal artery via an anastomosis on the conus medullaris, forming a so-called arterial “basket.”

In recent years, the indications for treating Stanford type B aortic dissection with thoracic endovascular aortic repair (TEVAR) have expanded. One study reported that covering the intercostal artery supplying the AKA with a stent graft is indirectly associated with an increased risk of SCI in patients with a shaggy aorta, iliac artery access, and prolonged procedural time, highlighting the importance of preoperative AKA identification [14]. This report demonstrates that in cases where noninvasive CT angiography (CTA) fails to accurately identify the AKA, multimodal imaging approaches will be valuable.

Conclusion

In cases where preoperative identification of the Adamkiewicz artery is challenging, intra-arterial CTA combined with hemodynamic assessment using 4D flow MRI provides a reliable strategy for its detection, aiding in the prevention of spinal cord infarction.

Disclosure

The authors declare no conflicts of interest associated with this manuscript.

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Ethics

This case report was written in line with the Declaration of Helsinki (2013) guidelines and the author obtained written informed consent forms from the patient.

Patient consent

The authors obtained written, informed consent for publication of the case from the patient.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.radcr.2024.12.001.

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