Multi-Detector Row Computed Tomography Angiography in Diagnosing Spinal Dural Arteriovenous Fistula

Initial Experience

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Background and Purpose—Multi-detector computed tomographic (MDCT) angiography is a recently developed imaging technique that can study small vessels such as medullary arteries and veins. The purpose of this study was to evaluate MDCT angiography in diagnosing SDAVF.

Methods—Eight patients with initial magnetic resonance imaging (MRI) and clinical findings suggestive of spinal dural arteriovenous fistula (SDAVF) and 8 control subjects underwent MDCT angiography. Both MDCT angiography and catheter angiography were performed within 5 days in patients with SDAVFs. The results of MDCT angiography in patients with SDAVFs were compared with those of catheter angiography.

Results—MDCT angiography detected engorged perimedullary draining veins and correctly localized the fistula of the SDAVFs, and correlated well with catheter angiography. Fistula was at the thoracic level in 7 patients, and sacral level in 1 patient. MDCT angiography did not visualize the engorged perimedullary venous plexus in the control group.

Conclusion—MDCT angiography correlated well with catheter angiography in diagnosing SDAVFs. It might play a role in shortening the length of the catheter angiography in diagnosing this disease. (Stroke. 2005;36:000-000.)

Key Words: angiography ■ arteriovenous fistula ■ central nervous system ■ computed tomography ■ spinal cord ■ vascular malformations

Spinal dural arteriovenous fistula (SDAVF) is a rare arteriovenous shunt located in the dura along the spinal canal. The arterial supply mostly arises from a dural branch of the radicular artery with venous drainage to engorged perimedullary veins.1,2 Catheter angiography has been used as a primary imaging method for the localization of the shunt of SDAVFs.3 Multi-detector computed tomographic (MDCT) angiography is a recently developed imaging technique that can provide extended thin-slice scanning range with high spatial resolution and high-contrast images.4 Takase et al reported that computed tomography angiography (CTA) with MDCT (4-detector row) could clearly visualize the normal medullary arteries and medullary veins.5 To our knowledge, the value of MDCT angiography in detecting spinal vascular lesion has never been evaluated. The purpose of this study was to evaluate MDCT angiography in diagnosing SDAVF.

Materials and Methods

Between November 2002 and July 2004, 8 patients with initial MR and clinical findings suggestive of SDAVF were referred for MDCT angiography. Catheter angiography was performed later within a 5-day period. Informed consent was obtained from all patients. Eight patients with a diagnosis of thoracoabdominal vascular disease who underwent MDCT angiography were chosen as age- and sex-matched control subjects. Our institutional review board did not require its approval for this study.

MDCT angiography was performed with a 16-detector row helical scanner (Sensation 16; Siemens Medical Systems). Scanning covered the volume extending from the first thoracic spine down to the sacrum. Scans were obtained with the following parameters: 0.5 seconds per rotation, 0.75-mm collimation, and 36-mm/s table increment. The voltage of the x-ray tube was 120 kV, and the current was 120 effective mA. The scan delay was set by means of automatic bolus tracking technique after the start of a bolus injection of 120-mL nonionic contrast medium at a flow rate of 4 mL/s, similar to that previously reported.6

A 2-mm-thick transversely oriented thin-slab image was reconstructed. In this fashion, the bilateral intercostal or lumbar or iliac arteries were systematically visualized, which helped confirm their normal anatomic relations and/or identify the SDAVF. With use of the multisplanar reformation, the imaged portions of the spine were systematically evaluated until the area of fistula was well understood in 3 planes. Two trained radiologists independently analyzed the all CT images. Interobserver agreement for the detection of engorged perimedullary veins in SDAVFs and control subjects and localization of the fistula of the SDAVFs was evaluated by using x statistics. All
catheter angiographic examinations were performed with a previously described standard protocol. All angiographers were informed of the CTA results and were encouraged to select the specified arteries early in the procedure.

Results
All 8 patients had a SDAVF, and this CTA technique precisely identified the site of the fistula by recognizing the enlarged radiculo-medullary vein that drains the fistula. MDCT angiography is good at detecting the fistula, feeding artery, and engorged perimedullary veins of the SDAVFs, and correlated well with catheter angiography (Figures 1 and 2). Fistula was at the thoracic level in 7 patients and at the sacral level in 1 patient. The coexistent nonenlarged intercostal or internal iliac artery at the level of the fistula was observed as a major feeding artery to each fistula. An additional feeding artery was present in 1 patient with catheter angiography and was not prospectively identified with MDCT angiography. MDCT angiography did not visualize the engorged perimedullary veins in the control subjects. The $\kappa$ values for interobserver agreement of the MDCT angiography for detection of engorged perimedullary veins and localization of the fistula of the SDAVFs were 1.000 and 0.849, respectively.

Discussion
MDCT angiography provides very short scan time, more scan length coverage (≈55 cm), and higher spatial resolution (0.5×0.5×0.75 mm) compared with contrast-enhanced magnetic resonance angiography (MRA) (36 cm, 1.0×1.0×1.2 mm) in diagnosing SDAVFs. Farb et al reported that repeated double/triple MRA was required to search the SDAVF in another region in more than half of the patients. In contrast, with the MDCT method, the added imaging volume was easily performed in the craniocaudal direction with an additional several seconds of examination. Another advantage of CTA is it allows observation of enhanced vessels among the bony structures. MDCT angiography is feasible and is an alternative modality in diagnosing SDAVF compared with contrast-enhanced MRA.

The search for a SDAVF at catheter angiography is often tedious and requires selective injections into multiple bilateral thoracic intercostal, lumbar, and sacral arteries. If no fistula is found, then cervical and intracranial regions are sequentially explored. An exhaustive search for a SDAVF may include as many as 40 selective injections. The ability to predict the fistula level noninvasively by MDCT angiography can potentially expedite subsequent invasive catheter angiographic examination by directing the angiographer to certain spinal levels initially. The commonly lengthy catheter angiographic examinations were performed with a previously described standard protocol. All angiographers were informed of the CTA results and were encouraged to select the specified arteries early in the procedure.

Figure 1. Transverse (a) and oblique coronal (b) reformation images show the fistula (large arrows), intradural medullary vein (small arrow), and engorged perimedullary venous plexus (arrowheads). Catheter angiography (c) of right T10 intercostal artery shows similar depiction of (a) and (b).

Figure 2. Oblique sagittal (a) and coronal (b) reformation images show the fistula (large arrows) on the right S-1 root sheath supplied by the lateral sacral artery (white arrow), and engorged perimedullary venous plexus (small arrows). Catheter angiography (c) of right internal iliac artery shows similar depiction of (a) and (b).
angiography sessions could be shortened by more than half of the time.

The disadvantage of MDCT angiography is the use of ionizing radiation. We opted to evaluate the field of view from thoracic spine to sacrum to include >90% of SDAVs,\(^1,2\) not including the intracranial and cervical spine regions, for minimizing radiation dose delivered to the patients. We assessed effective dose calculations by application of the CT dosimetry spreadsheet of the British Imaging Performance Assessment of CT (ImPACT) group.\(^8\) The average effective dose for MDCT angiography of the SDAVs was 9.1 mSv.

As is the case with MRA, the time resolution of CTA is not sufficient to distinguish anterior spinal arteries from draining veins in SDAVF compared with catheter angiography. Catheter angiography is still mandatory before embolization to determine whether an anterior spinal artery arises from the same pedicle that supplies the fistula. If the same radicular artery supplies the SDAVF and anterior spinal artery, it may indicate a contraindication for endovascular treatment.\(^3\) Finally, case numbers limit the high reliability of MDCT angiography and interobserver agreement \(\kappa\) values in diagnosing the SDAVF, and a large series of patients are needed to test in the future.

In conclusion, findings in this initial assessment have shown that MDCT angiography is good at detecting the fistula, feeding artery, and draining veins of the SDAVF, and correlated well with catheter angiography. This technique might greatly reduce the amount of time required for catheter angiography.

**Acknowledgments**

We thank Dr Wei-Liang Chen, Dr Yuk-Keung Lo, Dr Chi-Man Yip, and Dr Chung-Ren Jan for their contribution and invaluable advice on preparing and reviewing the manuscript. This study was supported by grant NSC 93-2314-B-075B-010 (P.H.L.) from the National Science Council, Taiwan, ROC.

**References**

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Stroke. published online June 2, 2005;
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/early/2005/06/02/01.STR.0000170048.94718.07.citation

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