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SHORT REPORT

A practical protocol for shortening reconstruction time of volumetric data and imaging bilateral middle cerebral arteries for thrombectomy in acute ischemic stroke using an 80-row computed tomography scanner

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Abstract

Time-consuming reconstruction of volumetric data by area-detector-computed tomography (ADCT) scanning and narrow coverage of small-row ADCT may hinder volumetric scanning in acute stroke stage. To design a practical protocol of volumetric scanning for thrombectomy using an 80-row ADCT. An imaging protocol that focuses on the middle cerebral arteries by tilting the gantry of an 80-row ADCT with 0.5-mm-thick detectors can shorten the reconstruction time by 1.0-mm thickness scanning without subtraction. The reconstruction time of small volumetric data was 69 second. This practical protocol is applicable before thrombectomy in different stroke centres with narrow-coverage ADCT scanners.

Keywords Area-detector computed tomography · Middle cerebral artery · Reconstruction · Stroke · Volumetric scanning · Volumetric data

Abbreviations

CM	Contrast medium
80r-ADCT	80-row area-detector-computed tomography
4D-CTA	Four-dimensional computed tomography angiography
VD	Volumetric data
VS	Volumetric scanning

Introduction

Previous studies have reported that magnetic resonance (MR) perfusion imaging [1, 2] and computed tomography (CT) perfusion imaging can indicate irreversible brain injury in the ischemic core and the potentially salvageable ischemic penumbra [3, 4]. Other studies have reported that triphasic CT angiography (CTA) is a tool for imaging triage of stroke patients [5, 6]. Current area-detector CT (ADCT) scanners, such as the 320-row ADCT scanner, can perform volumetric scanning (VS) and provide four-dimensional (4D) CTA images, showing more vascular and haemodynamic information. However, time-consuming reconstruction hinders its practical use in an acute stroke setting [7]. In addition, in case of small-row ADCT scanners, narrow coverage of the ADCT VS cannot show sufficient information of the middle cerebral arteries (MCAs). In the acute stroke setting, intracranial vascular and cerebral haemodynamic information must be obtained as early as possible [8]. Many stroke centres probably have narrow-coverage CT scanners, such as the 64-, 80-, or 128-row ADCT scanners. However, 4D-CTA is not usually performed before thrombectomy. Therefore, we aimed to design a practical protocol for shortening the reconstruction time of volumetric data (VD) and for imaging bilateral MCAs for thrombectomy using a general 80-row ADCT (80r-ADCT) scanner with only 4-cm coverage [9].

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Materials and methods

Image acquisition was performed by the 80r-ADCT scanner (Aquilion PRIME Focus Edition, V7.0SP0305J, 2015-year model, Canon Medical Systems, Otawara, Tochigi, Japan). Since January 2018, the acquisition procedure involves initiation from the line connecting the pituitary fossa with the point 2 cm upward from the internal occipital protuberance by tilting the gantry to focus on the MCA axis (Fig. 1a, b). VS by 1-s single rotation and 1-s intermittent dataset scans were acquired at 80 kVp and 100 mA. After injecting 40 mL of a non-ionic contrast medium (iopamidol 370 mg/mL) at a rate of 4 mL/s, 25 intermittent volume scans were acquired. The first scan was acquired at 2 s after injection, the second scan at 8 s, and subsequent scans, till the 25th scan, every other second during possible entry of the contrast medium into the intracranial arteries. To reduce VD, VS was performed with 1-mm thickness and z-axis coverage of 4 cm, and each volume scan consisted of 40 images (CTDIvol: 6.9 mGy), because 80r-ADCT of 0.5-mm thickness typically generates 80 images with 0.5-mm thickness scanning, indicating production of double VD. An 80-row CT performance is not high, and double VD requires extended reconstruction time. Less VD requires shorter reconstruction time. Totally, 1000 images (40 images multiplied by 25 scans) were acquired (total CTDIvol, 172.5 mGy; total DLP, 690 mGy cm/25 scans and 4 cm). After transferring the VD of 1000 images without subtraction to a workstation (Ziostation2, Ziosoft, Inc., Tokyo, Japan), axial 4D-CTA images of bilateral MCAs were generated. Reconstruction time and image quality were evaluated.

Statement of ethics

The study did not require written informed consent for CT scanning because acquisition was performed in accordance with the method approved by the Ministry of Health, Labour and Welfare. All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the retrospective analysis.

Results

VS was performed by tilting the gantry of the 80r-ADCT scanner and the reconstruction time of the VD of 1000 images was 69 s. A small amount of VD was automatically transferred to the workstation without subtraction, and 4D axial images of bilateral MCAs were generated in approximate 1 min. The 4D axial images included **a**lmost all the bilateral MCAs (Fig. 2). From January 2018 to February 2018, seven patients underwent VS using the protocol, revealing internal carotid artery occlusion in 2 patients and MCA occlusion in 5 patients. The 4D axial images were useful for determining the occlusion site, occlusion length, and collateral development status (Figs. 1c and 2).

Discussion

VS using the 320-row ADCT with 16-cm coverage is typically performed without tilting the gantry, and 4D-CTA images and perfusion maps are generated. When VD per scan consisting of 320 images with 0.5-mm thickness is performed and 25 volumetric scans are acquired by the 320-row ADCT (Aquilion One, 2010-year model, Cannon Medical Systems, Tochigi, Japan), the reconstruction time is officially 12 min and 59 s (Canon Medical Systems, Tochigi, Japan), and the

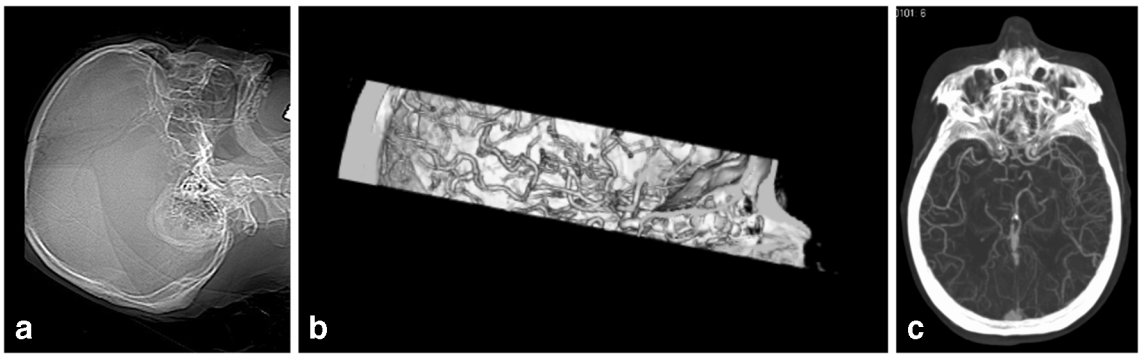

Fig. 1 **a** A computed tomography (CT) scout image. Acquisition was started from the line (inferior white line) connecting the pituitary fossa (black dot) with the point (white circle) 2 cm upward from the internal occipital protuberance (black arrow) by tilting the gantry (broad white arrow). CT scanning was performed with 4-cm coverage (dashed arrows). **b** A three-dimensional CT lateral-image showing the pituitary fossa (white dot) and the supraclinoid ICA (white arrow). Peripheral branches of the MCA are included within the 4-cm coverage. **c** An axial 4D-image showing bilateral supraclinoid ICAs (black arrows) and proximal occlusion (arrowhead) of the right MCA

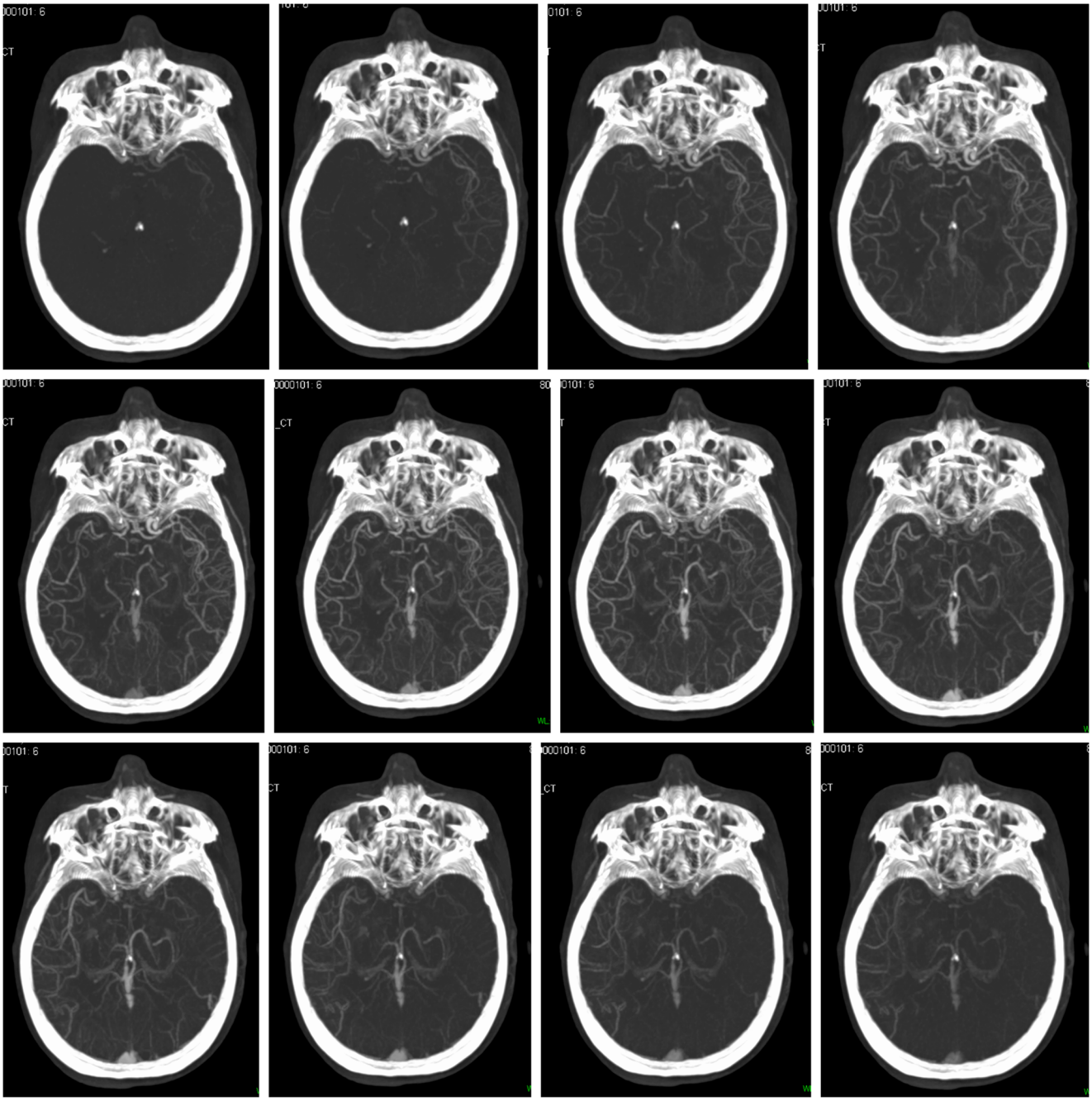

Fig. 2 Four-dimensional CT angiograms including almost all bilateral MCAs and showing proximal occlusion of the right MCA with good collateral development

subtraction time is officially 6 min and 4 s (Canon Medical Systems). Before the subtraction data is transferred to a workstation, totally 19 min and 3 s are required, which is higher than is desirable. When VD per scan consisting of 80 images with 0.5-mm thickness is performed and 25 volumetric scans are acquired by the 80r-ADCT (Aquilion PRIME Focus Edition, V7.0SP0305J, 2015-year model), the reconstruction time of 2000 images is officially 98 s (Canon Medical Systems) and the subtraction time is officially 32 s. Totally 2 min and 10 s are required before the subtraction data is transferred to a workstation. This is one of the reasons why 4D-CTA is not usually performed before thrombectomy in acute stroke settings. In addition, CT scanners with only 3.2-cm, 4.0-cm, or 6.0-cm coverage can cover only a part of the MCAs without tilting the gantry. Our protocol can allow small VD by image acquisition of 1.0-mm thickness without subtraction and can lead to short reconstruction times. Furthermore, our protocol can obtain almost the entire

vascular image of the MCA by tilting the gantry. Time-sequential images enabled visualization of the occlusion site, occlusion length, and peripheral branches. When CT perfusion is used, volumetric data covering almost the entire MCA area probably provides accurate information of the ischemic core and hypoperfused area compared to acquisition data obtained using conventional multidetector CT scanners without tilting the gantry.

Conclusion

Our practical protocol using narrow-coverage CT scanners can shorten reconstruction time and provide information of almost all the bilateral MCAs. Our protocol can allow VS before thrombectomy. The results warrant further clinical application before thrombectomy.

Author contributions Takahisa Mori, MD, had full access to all data in the study and takes responsibility for the integrity of the data and accuracy of the data analysis.

Study concept and design: T. Mori
Acquisition of data: T. Mori and K. Yoshioka
Interpretation of data and statistical analysis: T. Mori
Drafting of the manuscript: T. Mori
Critical revision of the manuscript for important intellectual content: T. Mori
Final approval of the submitted version: T. Mori and K. Yoshioka

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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