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Cerebral CT angiography using a reduced dose of contrast material at high iodine concentration in combination with a saline flush

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AIM: To determine whether cerebral computed tomography (CT) angiography with a 16-detector row system can be performed using a reduced dose of contrast material.

MATERIALS AND METHODS: Twenty-eight patients were assigned to one of four protocols: A = 50 ml of 350 mg I/ml with a saline flush (SF, 40 ml); B = 75 ml of 350 mg I/ml with an SF; C = 75 ml of 350 mg I/ml without an SF; and D = 100 ml of 300 mg I/ml without an SF. The attenuation of the internal carotid, middle cerebral, and anterior cerebral arteries were measured. The demonstration of vessels was also assessed.

RESULTS: There were no significant attenuation differences of the arteries among the four groups, neither were any significant differences noted on the visual assessment.

CONCLUSIONS: By using a reduced dose (50 ml) at higher iodine concentration (350 mg I/ml) with an SF, CT angiograms comparable with those acquired with a standard dose and concentration can be obtained.

Introduction

With the introduction of spiral and multidetector computed tomography (MDCT), CT angiography (CTA) is widely accepted for assessment of the cervical and intracranial vessels. As the imaging time is significantly shorter with this technique, the dose of contrast material can be reduced, which is favourable in terms of cost saving, as well as avoidance of nephrotoxicity.[1,2] However, the volume and concentration of contrast material for CTA of the brain are still controversial. The purpose of the present study was to determine whether cerebral CTA using MDCT with smaller volumes of contrast material of higher iodine concentration is of sufficient quality to replace those with higher volumes and lower iodine concentrations.

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Materials and methods

This prospective study was approved by the institutional review board and informed consent was obtained from patients. The study group comprised 28 consecutive patients referred for cerebral CTA. They included seven male and 21 female patients ranging in age from 32–82 years (mean 60.5 years). They were sequentially assigned to one of four protocols: group A = 50 ml of 350 mg I/ml (Iomeron; Bracco, Milan, Italy) with a saline flush (40 ml); group B = 75 ml of 350 mg I/ml with a saline flush (40 ml); group C = 75 ml of 350 mg I/ml without a saline flush; and group D = 100 ml of 300 mg I/ml (Iomeron; Bracco, Milan, Italy) without a saline flush. The mean ages and diagnoses based on previous imaging studies and clinical history of the patients of the four groups are listed in Table 1. The contrast volumes and concentrations were chosen because of previous reports of cerebral CTA employing volumes of contrast material of 60–100 ml of 300 mg I/ml.[3,4] The injection rate was set at 3 ml/s for all patient groups.

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Table 1 Age ranges, mean ages, and diagnoses of the patients

Group	Age range (years)	Mean age (years)	Diagnoses
A	43–72	65.9	Cerebral aneurysm (4), steno-occlusive disease (2), arterial dissection (1)
B	32–80	55.6	Cerebral aneurysm (5), arterial dissection (2)
C	44–70	54.9	Cerebral aneurysm (5), arterial dissection (2)
D	49–82	65.9	Cerebral aneurysm (5), arterial dissection (1), sinus thrombosis (1)

Number of patients with each diagnosis is given in parenthesis.

CTA was performed using helical scanning on a 16-row system (Aquillion 16, Toshiba Medical Systems, Tochigi, Japan) with the following parameters: pitch 15; collimation 0.5 mm; and reconstruction interval of 0.3 mm. Scanning was started 20 s after initiation of injection of the contrast material using a power injector (Stellant D, Medrad, Indianola, PA, USA). CTA images were reconstructed using a volume-rendering (VR) technique and a maximum intensity projection (MIP) technique by one of the authors. At least 12 images with different view angles and reconstruction areas were recorded in each patient.

On source images, the attenuation of regions of interest (ROI) placed bilaterally on the internal carotid artery (ICA), proximal middle cerebral artery (MCA), and proximal anterior cerebral artery (ACA) were measured. Three measurements in each ROI on both sides were averaged in the assessment. Additionally, on the final VR and MIP images, two readers, who were blinded to the contrast agent employed in each patient, visually evaluated the demonstration of arteries and veins using a four-point grading scale as follows: grade 0 = could evaluate only arteries of the circle of Willis; grade 1 = could evaluate arteries of the circle of Willis and proximal ACA and MCA (i.e., up to A2 or M2); grade 2 = could evaluate arteries of the circle of Willis and distal ACA and MCA (i.e., beyond A2 or M2) but limited demonstration of parasagittal cortical veins (i.e., only veins adjacent to the dural sinuses); and grade 3 = could evaluate arteries of the circle of Willis and distal ACA and MCA (i.e., beyond A2 or M2) and good demonstration of tributaries of parasagittal cortical veins. If there was any discrepancy between the two readers, consensus was obtained through discussion. Statistical analysis of the measurements of attenuation of the ROIs was performed using one-way analysis of variance, Welch's *t*-test, and the Tukey–Kramer test, whereas the results of visual assessment were assessed using the Tukey–Kramer test.

Results

The attenuation measurement results are listed in Table 2. There was no statistically significant difference in attenuation of the ICA, MCA, or ACA among the four groups, the only exception being significantly higher attenuation of the ACA in group A than in group D ($p = 0.02$). Visual assessment resulted in a mean score of 2.8, 2.9, 2.9, and 2.8 in groups A, B, C, and D, respectively, and again there was no significant difference among the four groups. Representative cases from the four groups are illustrated in Figs. 1–4.

Discussion

With the recent advent of helical technology with MDCT, it is possible to perform cerebral CTA with high spatial resolution in a very short scanning time. CTA is widely employed in the diagnosis of cerebral aneurysms, steno-occlusive lesions, and other lesions.[5–7] Regarding the contrast material injection in cerebral CTA, it is likely that a combination of conventional dose and concentration (100 ml of 300 mg I/ml) is still used at many institutions. There has been little investigation of the optimal method of contrast injection for cerebral CTA compared with enhanced CT examination and CTA of the abdomen and cardiovascular system.[8–13]

The present study was focused on assessment of the possibility of dose reduction by using a higher

Table 2 Results of the attenuation measurements

Group	Internal carotid artery	Middle cerebral artery	Anterior cerebral artery
A 350 mg I/ml (50 ml) + saline (40 ml)	416 ± 52	396 ± 56	358 ± 47
B 350 mg I/ml (75 ml) + saline (40 ml)	372 ± 63	354 ± 71	317 ± 61
C 350 mg I/ml (75 ml)	363 ± 58	367 ± 60	305 ± 39
D 300 mg I/ml (100 ml)	329 ± 59	342 ± 59	279 ± 28

Values are expressed in Hounsfield units and as mean±standard deviation.

Figure 1 Group A: CTA undertaken using 50 ml of 350 mg I/ml with a saline flush (40 ml). A 72-year-old woman with unruptured right MCA aneurysm. VR CTA image after bone deletion shows the MCA aneurysm (arrow).

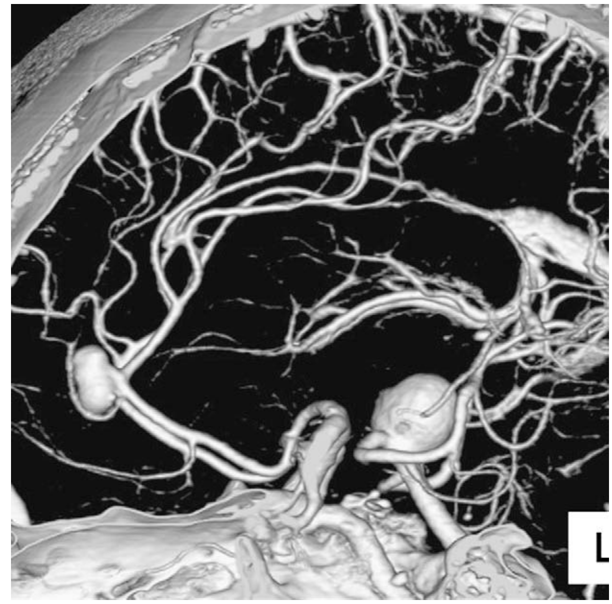

Figure 3 Group C: CTA undertaken using 75 ml of 350 mg I/ml without a saline flush. A 62-year-old woman with distal left ACA and basilar tip aneurysms. VR CTA shows the ACA and basilar tip aneurysms.

concentration of contrast material as well as a saline flush. Dose reduction is favourable, not only to avoid nephrotoxicity, but also to save costs. When compared with a conventional product (100 ml of 300 mg I/ml), cost savings of approximately 15 and 40% are possible by using 75 ml of 350 mg I/ml and of 50 ml of 350 mg I/ml, respectively. Therefore, it is advantageous to use a lower dose of contrast material with a higher concentration in terms of medical economy.

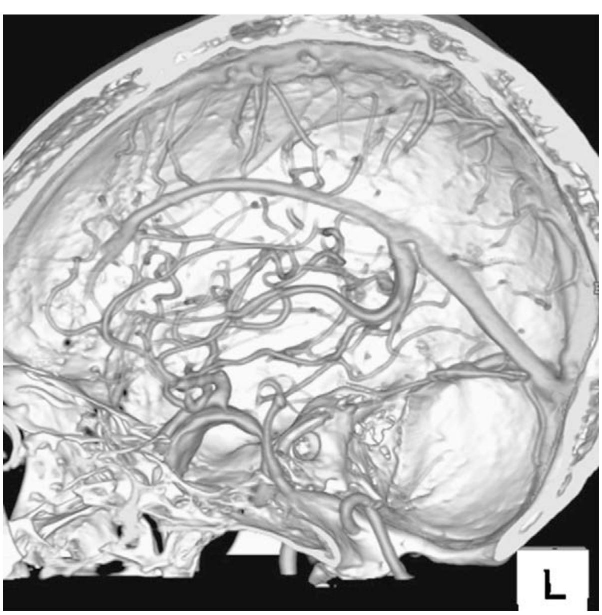

Figure 2 Group B: CTA undertaken using 75 ml of 350 mg I/ml with a saline flush. A 68-year-old woman with a giant right ICA aneurysm. VR CTA shows the partially thrombosed ICA aneurysm.

Figure 4 Group D: CTA undertaken using 100 ml of 300 mg I/ml without a saline flush. An 84-year-old woman with an unruptured right ICA aneurysm. MIP CTA images show the aneurysm; distal ACA branches and cortical veins can also be seen.

In the present study, although no significant difference was present, higher attenuation of the ICA, MCA and ACA was achieved when a product with a lower dose and higher concentration was used (groups A, B, and C). Surprisingly, attenuation was highest in all of the three vessels in group A (50 ml of 350 mg I/ml with saline flush). In particular, attenuation of the three arteries was higher in group A than in group B (75 ml of 350 mg I/ml with saline flush). It is evident that each group consisted of a small number of patients and that the groups may not have been adequately matched for age as well as comorbidities. In addition to attenuation measurements, there was no significant difference in the visual assessment of images. Therefore, the results indicate that, compared with conventional dose and concentration (100 ml of 300 mg I/ml), a lower dose of contrast material of 350 mg I/ml can yield equivalent cerebral CTA images. The present study also suggests that the dose can be practically reduced by using a saline flush.

There are several limitations to this study. First, the dosage and scan timing were fixed without taking into consideration the age or body weight of the patients; however, this enabled the CTA examination procedure to be simple and no related examination failures resulted. There may be a question as to whether an attenuation value of $\geq$400 HU is imperative in cerebral CTA. Unfortunately, to the author's knowledge, there has been no report evaluating the optimal or minimum attenuation value. Furthermore, patient discomfort was not assessed, which is mostly related to heat sensation. Patient discomfort is difficult to examine, as it is a very subjective matter; however, it is worth evaluating when contrast material with a lower dose and higher concentration is administered. As for patient selection, the patients included in this study all had disease entities that may have influenced the delivery of contrast medium to the circle of Willis. A true analysis of the feasibility of reducing contrast doses would have to take this into account. The injection speed and volume of saline flush were also not evaluated in the present study. Finally, it should be stressed that as CTA by MDCT *per se* is a developing technology, factors related to scanning will change further in the near future.

In conclusion, by using a reduced dose (50 or 75 ml) and a higher iodine concentration (350 mg I/ml), it is possible to obtain cerebral CT angiograms comparable with those obtained with a conventional dose and concentration (100 ml of 300 mg I/ml). The dose can be reduced to 50 ml by using a saline flush.

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