Effects of Iodinated Contrast Agent on Diffusion Weighted Magnetic Resonance Imaging

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Effects of iodinated contrast agent on diffusion weighted magnetic resonance imaging

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Abstract

Purpose: To evaluate the effects of iodine contrast agent on diffusion signal intensity and apparent diffusion coefficient (ADC) in diffusion-weighted imaging (DWI) studies in MRI examination just after computed tomography (CT) contrast imaging.

Methods: On a 1.5 T MRI scanner, ADC was calculated from the signal intensity of DWI (b = 0 and 1000) using phantoms filled with contrast agent (0, 4.5, 6.0, 9.0, 30, and 60 mg I/mL). We evaluated the signal intensities of DWI and ADC in 10 patients (3 women, 7 men, 35–68 years old) examined by MRI study less than 40 minutes after injection of 100 mL of iopamidol (300 mg I/mL) for CT study.

Results: The DWI signal increased until a CT value of 190 HU, but showed no changes above this value. The ADC decreased with increases in CT value. Less than 40 minutes after injection of iopamidol (300 mg I/mL) for CT scan, the signal intensity of DWI was significantly increased and ADC was significantly decreased.

Conclusion: It is necessary to recognise the rate of decrease of ADC, because it is dependent on the density of iodine contrast agents.

1. Introduction

Various examination modalities are often used in the same patient for diagnosis, and both computed tomography (CT) and magnetic resonance imaging (MRI) examinations may be performed consecutively on the same day.

Several studies have indicated that contrast agents used for CT and MRI may adversely influence the results of the other imaging modality (1–6). In these reports, it was suggested that iodinated contrast agents shorten T1 and T2 on MRI examination, and cause high signal intensity on T1-weighted imaging and low signal intensity on T2-weighted imaging (1–2).

Body diffusion-weighted imaging (DWI) is often performed in MRI examination to detect malignant tumours and allow discrimination between benign and malignant masses. Detection of a malignant tumour is based on the increase in signal intensity on DWI, and discrimination between benign and malignant tumours is based on the apparent diffusion coefficient (ADC). However, several factors may alter the ADC (7–11). Iodinated contrast agents are predicted to affect the ADC due to their high viscosity and large molecular size.

In this study, a phantom experiment was performed to evaluate the changes in diffusion signal intensity and ADC by iodinated contrast agents in MRI-DWI study performed just after CT contrast imaging.

2. Materials and methods

Institutional review board approval was obtained for the study design and review of patient records and images. First, the distribution of contrast agent used in CT examination to the internal organs was examined. The average CT values of brain meningiomas of 20 patients (19 women, 1 man, 48–87 years old) and the kidney cortex of 20 patients (7 women, 13 men, 35–57 years old) 2 minutes after injection of iopamidol (300 mg I/mL) with a viscosity of 4.5 mPa·s at 37°C (12–15), and the bladders of 12 patients (8 women, 4 men, 32–67 years old) 15 minutes after injection of iopamidol (300 mg I/mL) were measured by setting the regions of interest (ROI). The devices used were a Light Speed Pro16 (General Electric Co.) and ProSeed-SA helical CT scanner (General Electric Co.). ROIs were set manually by three operators and the mean values were used in this study.

The CT values of diluted contrast agent phantoms were also measured. Iopamidol (300 mg I/mL) was diluted with physiological saline solution to concentrations of 0, 4.5, 6.0, 9.0, 30 and 60 mg I/mL and kept in the original bottle to avoid contamination with other substances in the phantom. CT images and CT values of the phantoms are shown in Figure 1. T1- and T2-relaxation times for the phantoms were calculated. T1-relaxation times were measured with change to inversion times of 20–2000 ms with the inversion recovery method. T2-relaxation times were measured with change to TE 27–280 ms/TR = 4000 ms with spin-echo sequence. The device used was a Magnetom Symphony 1.5T (Siemens AG).

Furthermore, the diluted contrast agent phantoms were subjected to DWI. The scanning parameters were TR 4000/TE107 ms/SENSE factor 2 with echo planar imaging using an 8-Ch head coil. The ADC was calculated from the signal intensity at b = 0 and 1000.

In addition, the signal intensities of T1-weighted images (TR 550/TE15 ms), T2-weighted images (TR 3000/TE120 ms/ETL11) and DWI (TR 10000/TE ms), were measured for 10 patients (3 women, 7 men, 35–68 years old) examined by MRI less

than 40 minutes after injection of 100 mL of iopamidol (300 mg I/mL) in the CT study. The regions measured were the renal parenchyma and peripheral fat tissue. Three operators manually designated a circular region of interest (ROI) and calculated the mean signal value. The relative tissue ratio was calculated with each value.

$$\text{Relative tissue ratio} = \text{Signal value of kidney} / \text{Signal value of fat} \quad (1)$$

The fat signal of the circumference was used for normalising kidney signal intensity because the MRI signal changed depending on the signal gain.

Furthermore, the ADC was calculated from the signal intensity at b = 0 and 1000. The Wilcoxon signed-rank test was used for statistical comparisons of all data.

3. Results

The average CT values and standard deviation of the brain meningiomas and kidney cortex 2 minutes after injection and of the bladder 15 minutes after injection in 20 patients are shown in Table 1. CT values ranged from 180 to 200 HU. The calculated T1 and T2 values of the iodine phantom are shown in Figure 2.

The T2 value decreased with increasing CT value of solutions, but there were no

marked changes in T1 value.

DWI results of the phantoms are shown in Figure 3 and an ADC mapping image is shown in Figure 4. In addition, the signal intensities of DWI and ADC of phantoms are shown in Figures 5 and 6, respectively. The DWI signal values increased until a CT value of 190 HU, but there were no further changes above this value. The ADC decreased with increases in CT value.

The relative tissue ratios calculated for the kidney cortex and fat tissue on MRI less than 40 minutes after injection of iopamidol (300 mg I/mL) on CT scans are shown in Figure 7. After administration of the iodine contrast agent, the signal intensity on T2WI was slightly decreased, but the difference was not significant. No significant differences were seen on T1WI. On DWI, the signal intensity was significantly increased after administration of iodine contrast agent. As shown in Figure 8, the ADC of the kidney cortex showed a significant decrease after injection of iodine contrast agent.

4. Discussion

With the recent development of parallel MRI, DWI has often been used in clinical

medicine to both search for tumours and for discrimination diagnosis. In addition, CT and MRI examinations are often performed consecutively on the same day. After CT contrast imaging, diffusion of water molecules may be restricted by the iodinated contrast agents with large molecular size and high viscosity (16) even when diluted. Thus, the signal intensity of DWI and the ADC are predicted to be influenced by the iodinated contrast agents. Therefore, we performed a phantom experiment to evaluate the changes in diffusion signal intensity and ADC in MRI-DWI study performed just after CT contrast imaging.

When MRI examination is performed after CT examination, it usually takes over 40 minutes after iodine contrast agent administration due to preparations required for MRI and transfer of the patient. Over this period, the iodine is thought to remain in the brain, the renal parenchyma and bladder. The CT values were less than 180 HU except in the bladder after 40 minutes because the CT values after 5 minutes were 180–200 HU.

There have been some previous reports regarding the influence of T1WI and T2WI in MRI after injection of iodine (1–2); we performed similar experiments and came to similar conclusions. The T2 value decreased with increasing concentration of iodine;

however, if the CT value was less than 200 HU, there was little difference and this represented no obstacle to diagnosis (See Figures 1 and 2). However, the signal intensity of DWI may be increased with even small CT values (Figure 5). We feel that the signal intensity of DWI in increasing with concentration of iodine reaches a plateau due to conflict between the increase in signal by diminished ADC and decrease in signal by diminished T2-value. However, the diffusion signal increases at lower concentrations of iodine because the ratio of signal decrease caused by T2 shortening is small.

This was confirmed with clinical images. The signal intensities of DWI in the renal parenchyma with and without administration of iodine 40 minutes previously are shown in Figure 7. The signal intensity increased significantly after administration of the iodine contrast agent. However, this may not pose a problem for diagnosis because these masses showed uniform increases in contrast intensity. However, these changes should be recognised. DWI is often used in clinical medicine to both search for tumours and for diagnosis. In particular, small differences in ADC are often used to distinguish between benign and malignant tumour (17–25).

As shown in Figure 8, the ADC of the renal parenchyma was significantly decreased

after administration of iodine contrast agent. Therefore, it is necessary to pay sufficient attention to avoid making a false diagnosis in discrimination of tumours based on ADC, because the ADC decreases with increasing CT value, as shown in Figures 6 and 8.

Clinical images are shown in Figure 9 and 10. Figure 9 shows the ADC map of DWI only on MRI examination without administration of iodine, while Figure 10 shows an image taken 6 months later in the same patient. This image shows the ADC map of MRI examination 30 minutes after administration of contrast agent on CT examination. In Figure 10, it can be seen that the ADC of the liver and kidney had decreased.

5. Conclusions

In case of DWI just after injection of iodine contrast agent for CT examination, the DWI signal increased slightly and the ADC decreased under the influence of iodine. The effects of iodine on diffusion-weighted MRI were evaluated, when MRI study was performed immediately after administration of iodine contrast agent for CT examination. The signal intensity of DWI showed a slight increase, while ADC decreased due to the iodine contrast agent.

It is necessary to recognise the rate of decrease of ADC, because it is dependent on the density of iodine contrast agents used.

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Figure legends

Fig. 1 CT images and CT values of the diluted iodine contrast phantom. The contrast phantom was diluted with physiological saline solution to a concentration of 0, 4.5, 6.0, 9.0, 30 or 60 mg I/mL.

Fig. 2 The calculated T1 and T2 values of the iodine phantom. With increases in CT value of solutions, the T2 value decreased but the T1 value did not change markedly.

Fig. 3 DWI (TR 4000/TE107 ms/SENSE factor 2 with EPI) of diluted iodine contrast phantom.

Fig. 4 ADC mapping image (calculated from signal intensity at b = 0 and 1000) of diluted iodine contrast phantom.

Fig. 5 Signal intensity of DWI of diluted iodine contrast phantom. The signal intensity of DWI increased until a CT value of 190 HU, but there were no further changes at higher values.

Fig. 6 Signal intensity of ADC of diluted iodine contrast phantom. The ADC decreased with increases in CT value.

Fig. 7 Relative tissue ratio calculated for the kidney cortex and fat tissue on MRI less

than 40 minutes after injection of iopamidol (300 mg I/mL) for CT scan. After iodine contrast agent administration, the signal intensity of T2WI was decreased slightly, while that of DWI showed a significant increase.

Fig. 8 ADC of the kidney cortex after injection of iodine contrast agent. The ADC was significantly decreased after iodine contrast agent injection.

Fig. 9 ADC map of DWI only on MRI examination without administration of iodine.

Fig.10 An image after 6 months in the same patient as shown in Figure 9. This image shows the ADC map of MRI examination 30 minutes after administration of contrast agent on CT examination. The ADC of liver and kidney had decreased.

Table 1 Average CT values and standard deviation of brain meningiomas and kidney cortex and of the bladder 2 and 15 minutes after injection of contrast agent, respectively, in 20 patients. CT values ranged from 180 to 500 HU.

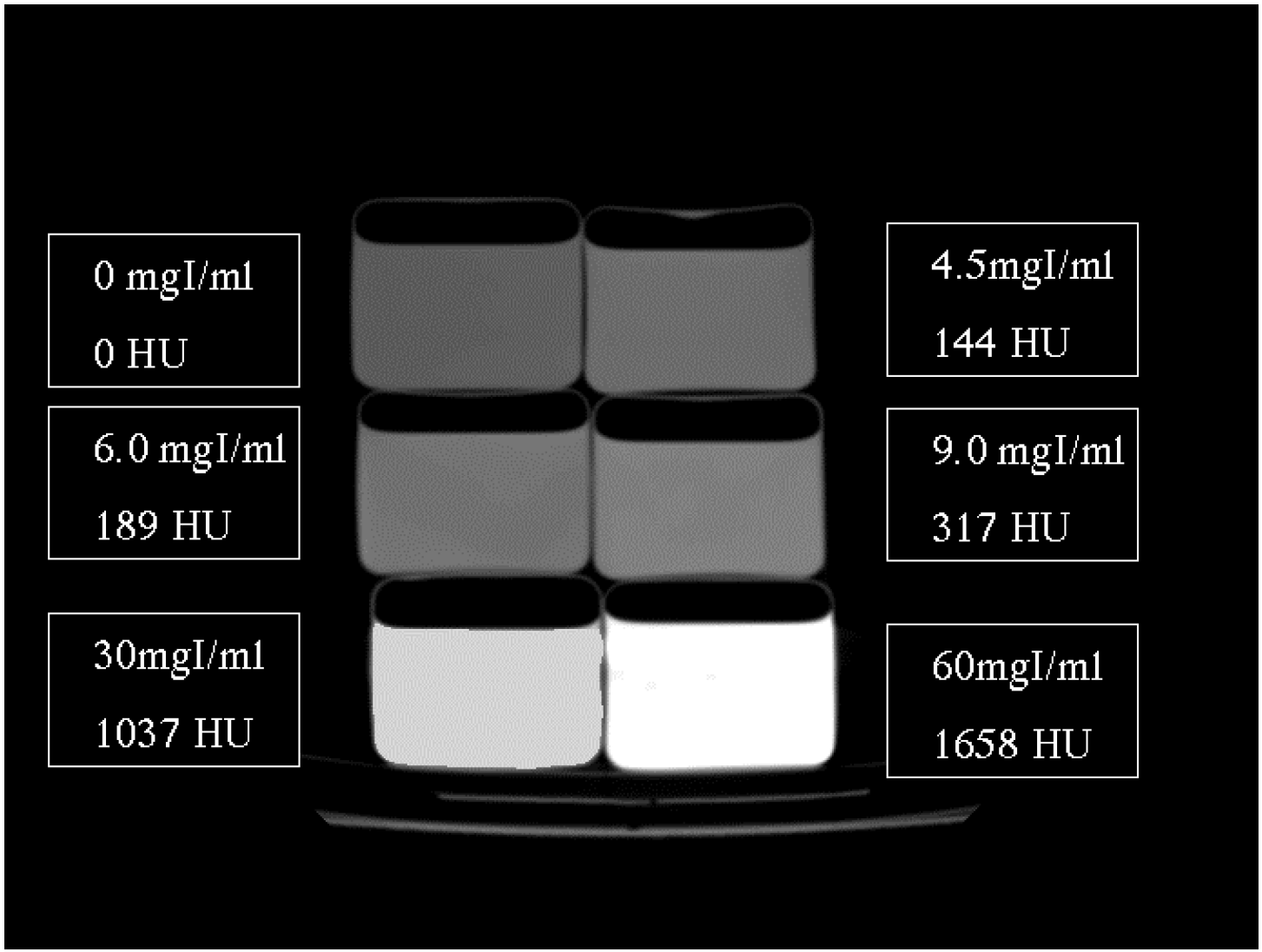
0 mgI/ml
0 HU
4.5mgI/ml
144 HU
6.0 mgI/ml
189 HU
9.0 mgI/ml
317 HU
30mgI/ml
1037 HU
60mgI/ml
1658 HU

Fig.1

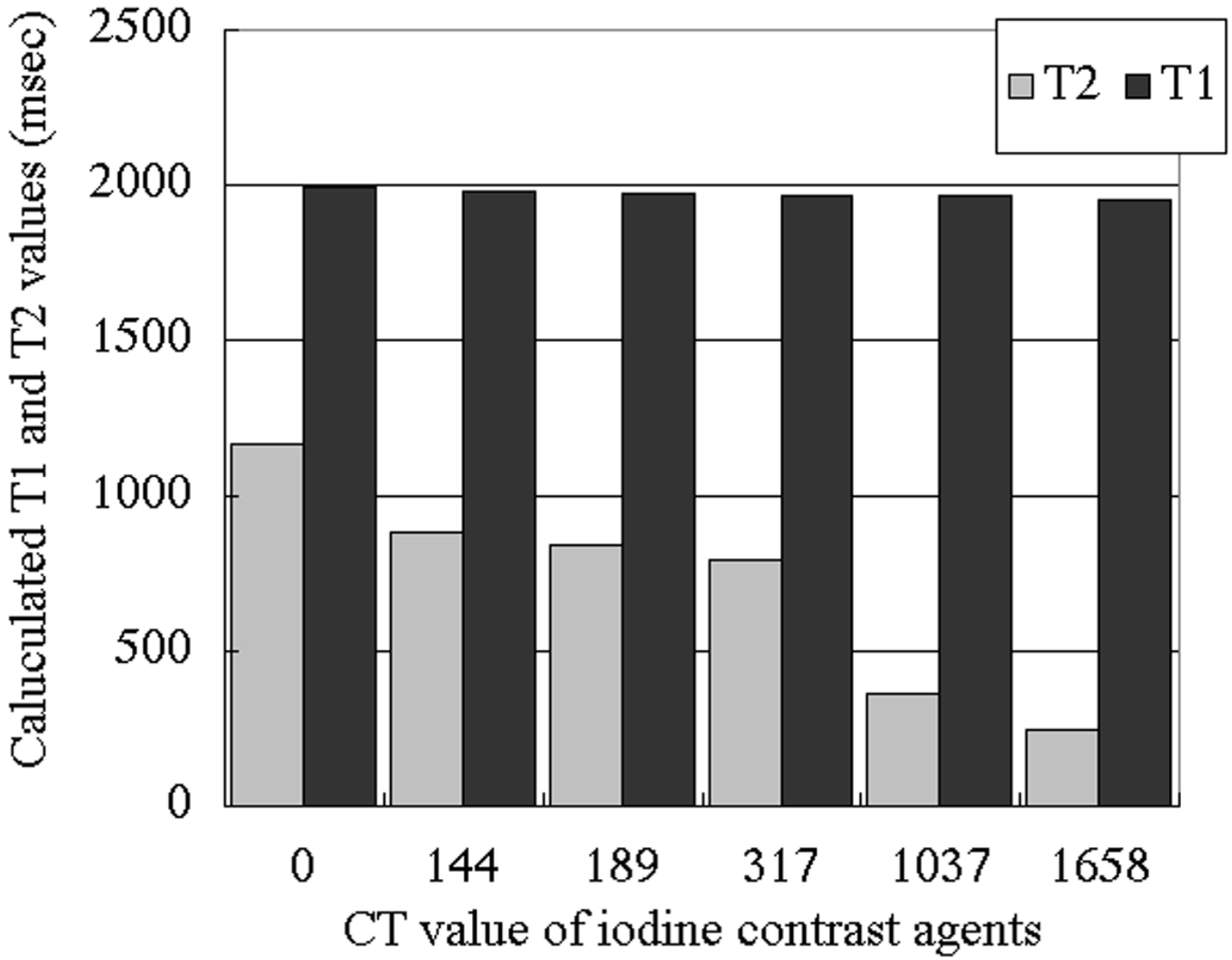
Caluculated T1 and T2 values (msec)
2500
2000
1500
1000
500
0
T2
T1
0
144
189
317
1037
1658
CT value of iodine contrast agents

Fig.2

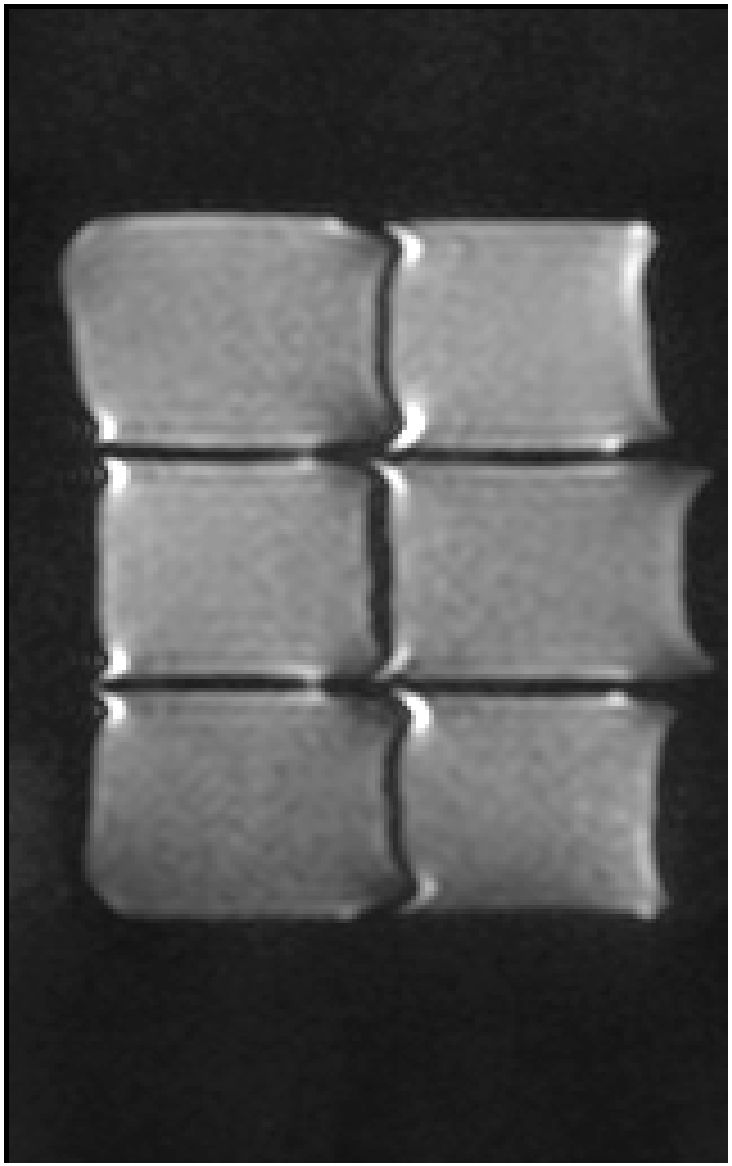

Fig.3

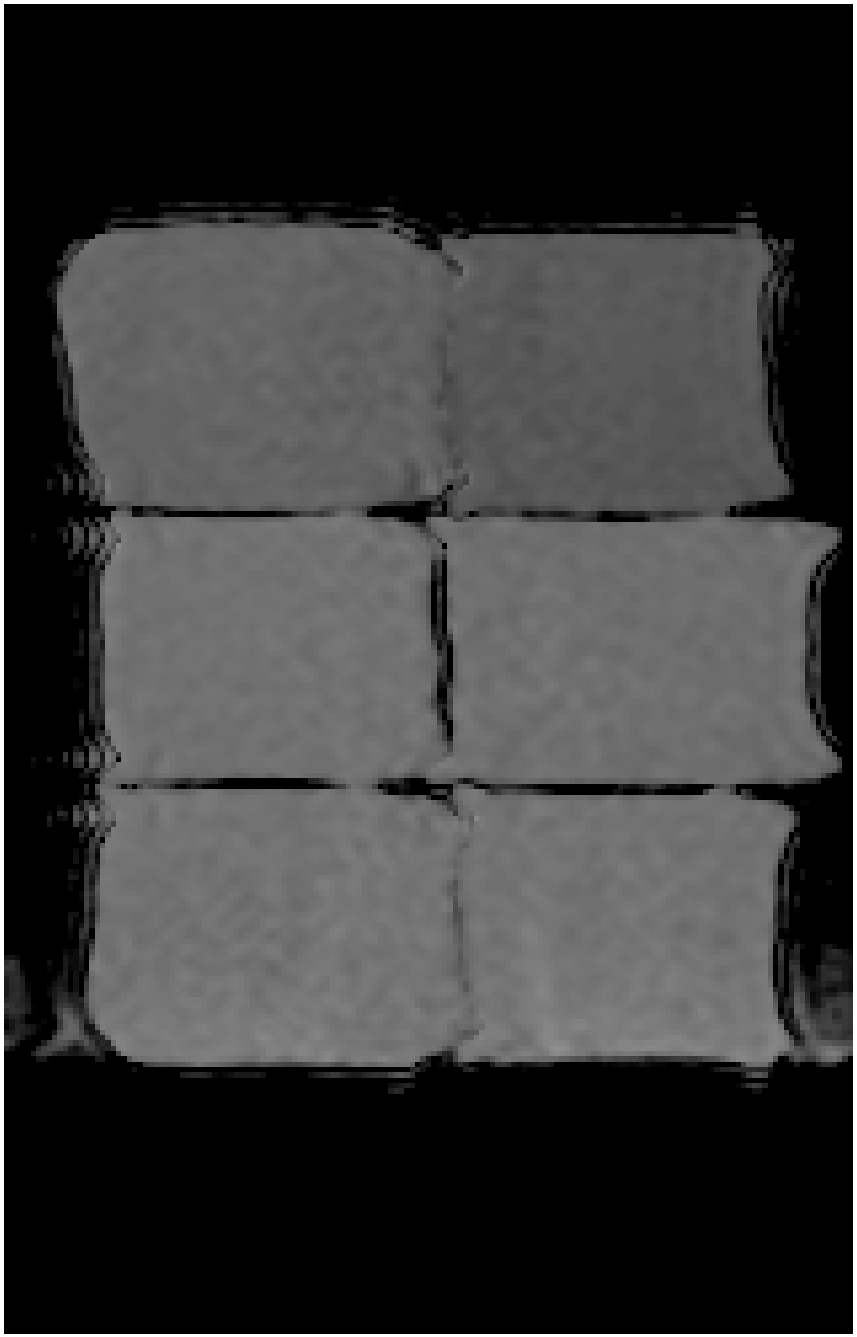

Fig.4

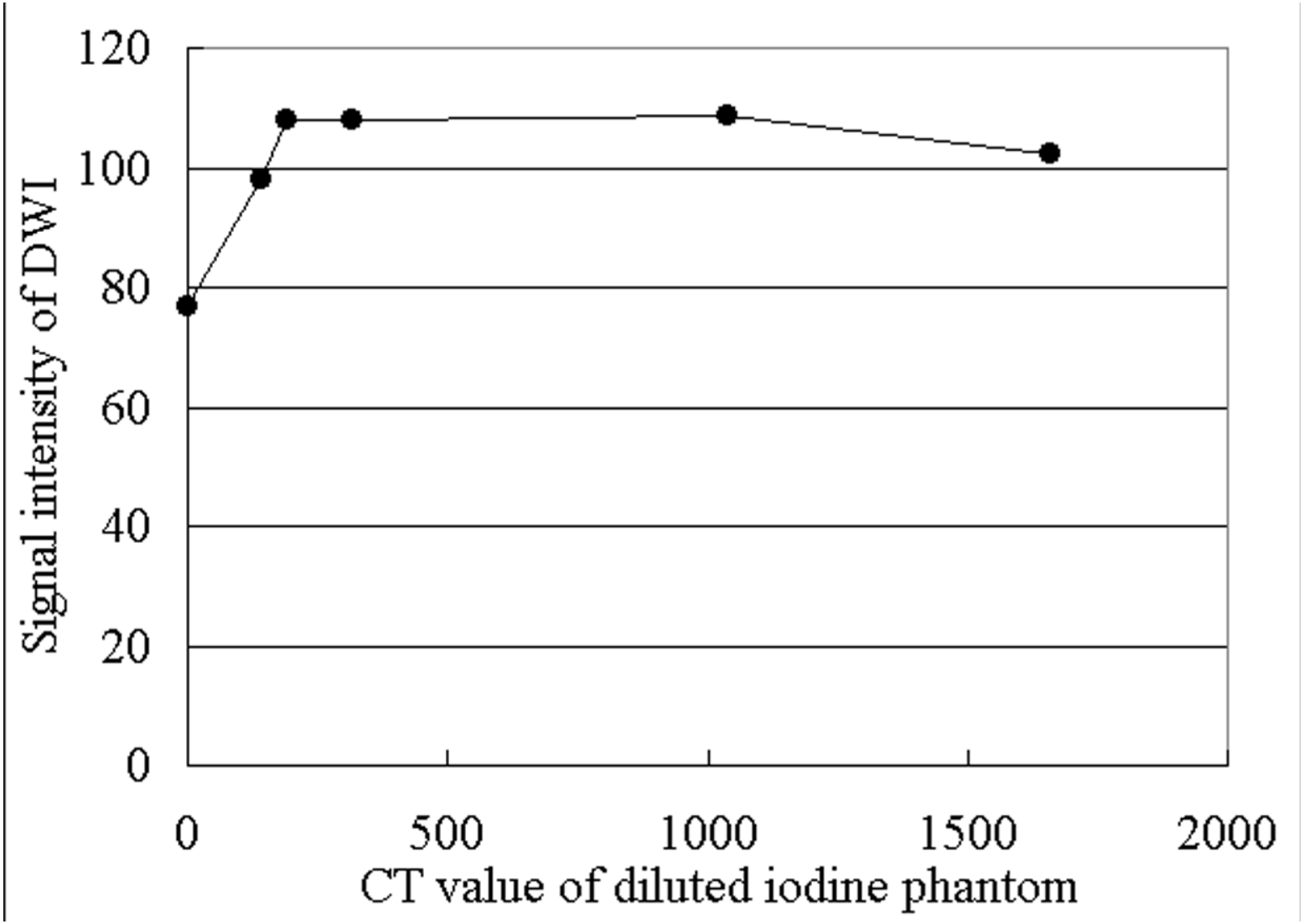
120
100
80
60
40
20
0
Signal intensity of DWI
0
500
1000
1500
2000
CT value of diluted iodine phantom

Fig.5

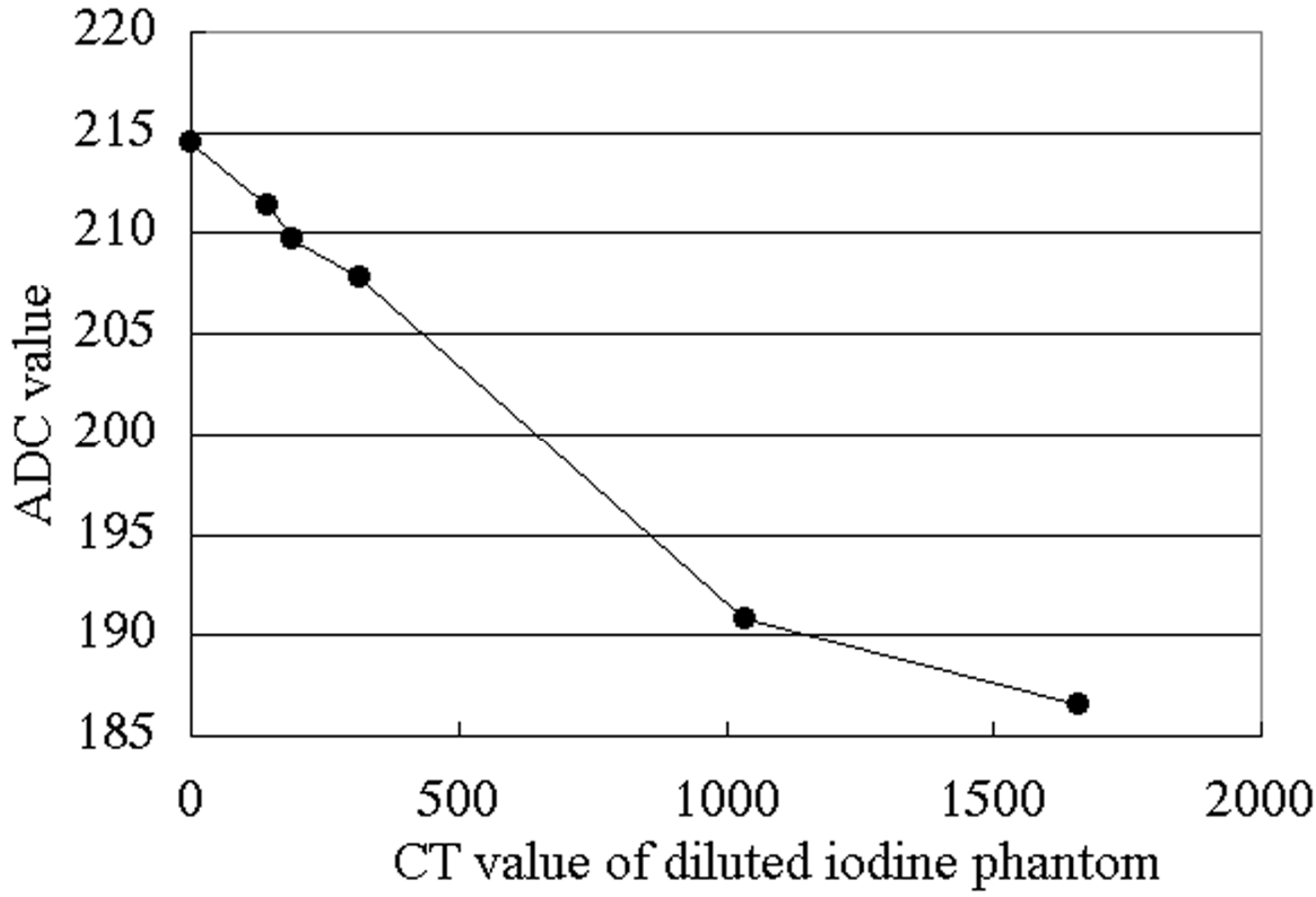
220
215
210
205
200
195
190
185
ADC value
0
500
1000
1500
2000
CT value of diluted iodine phantom

Fig.6

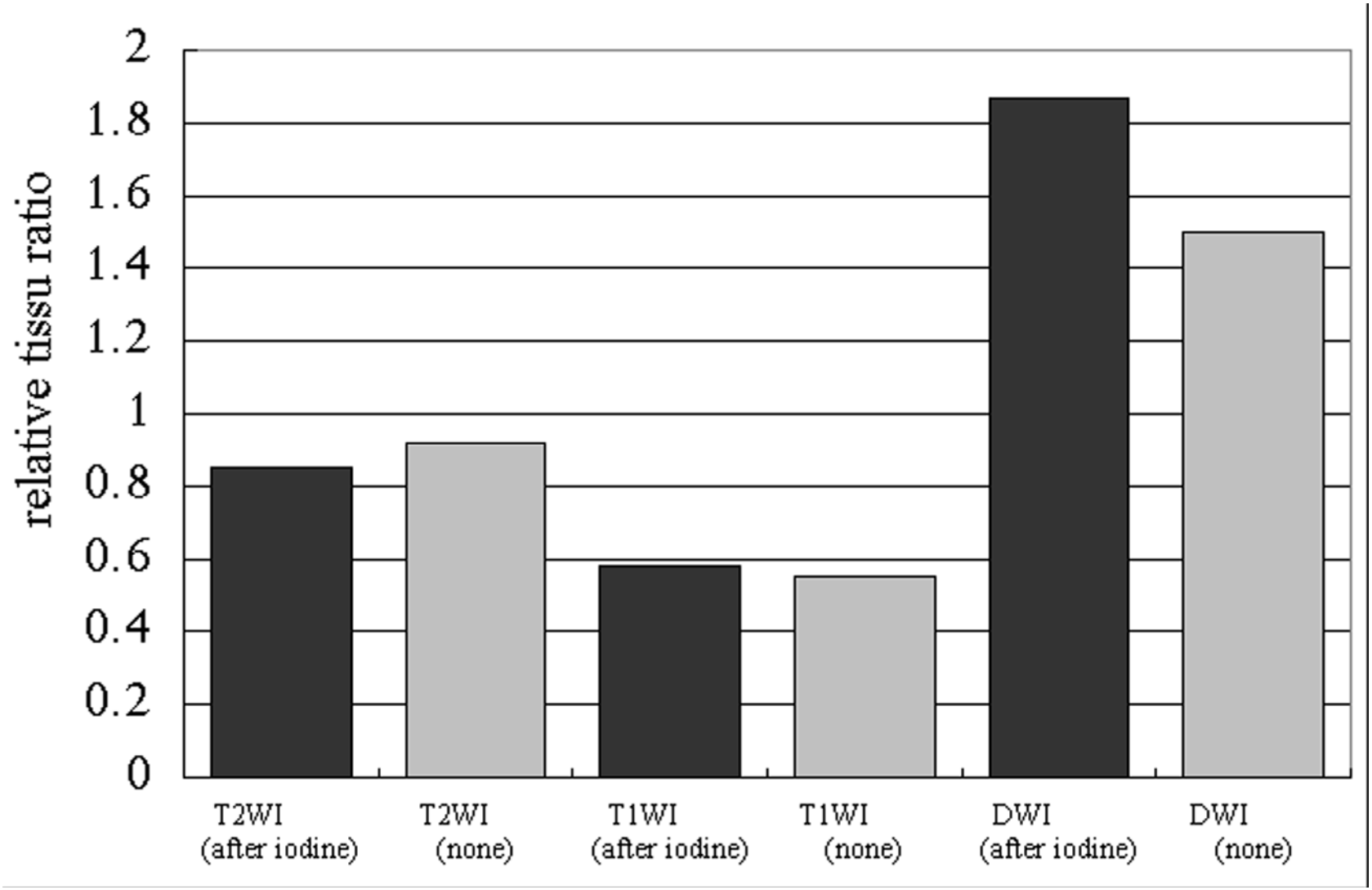
relative tissu ratio
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
T2WI (after iodine)
T2WI (none)
T1WI (after iodine)
T1WI (none)
DWI (after iodine)
DWI (none)

Fig.7

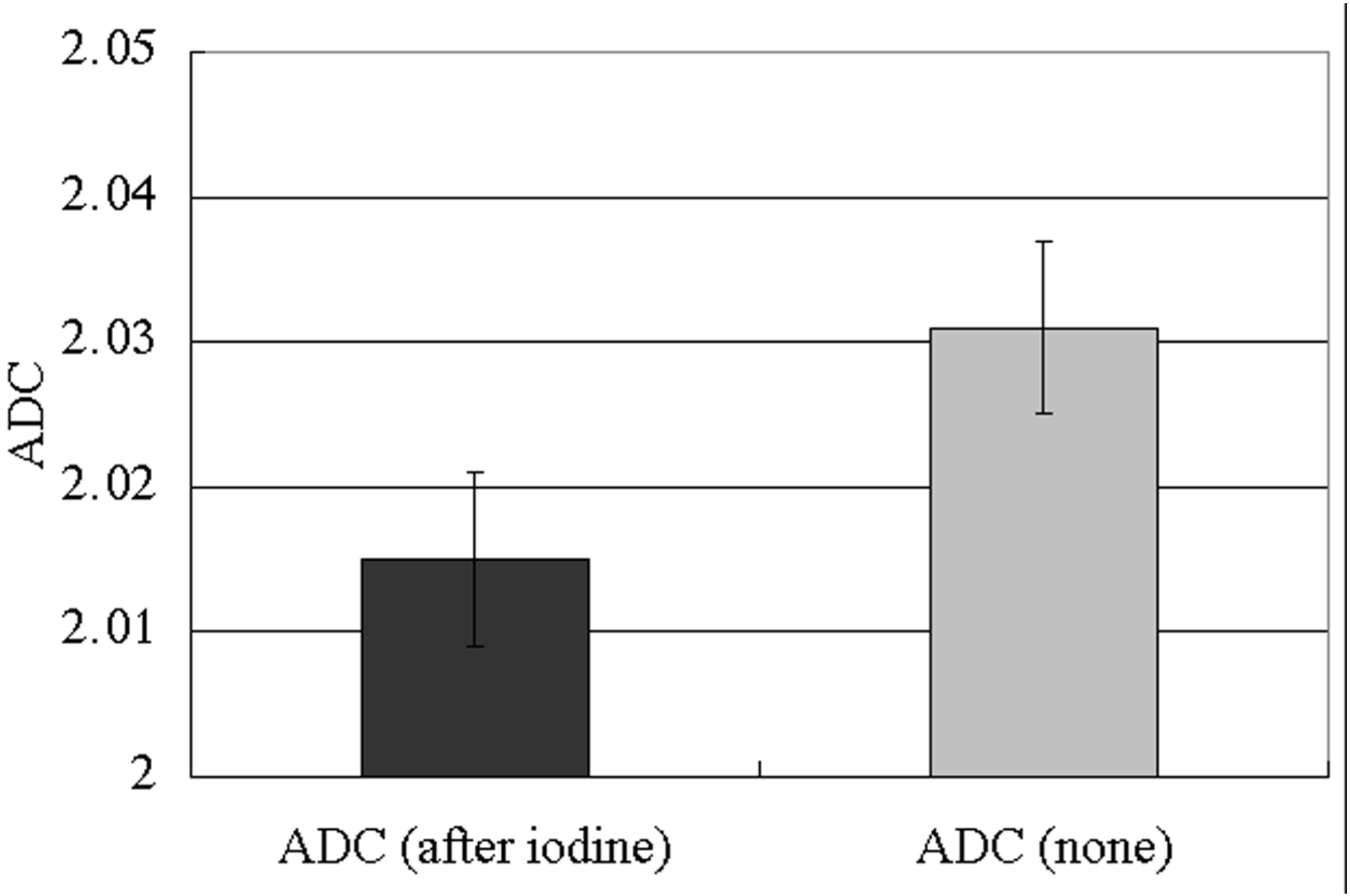

Fig.8

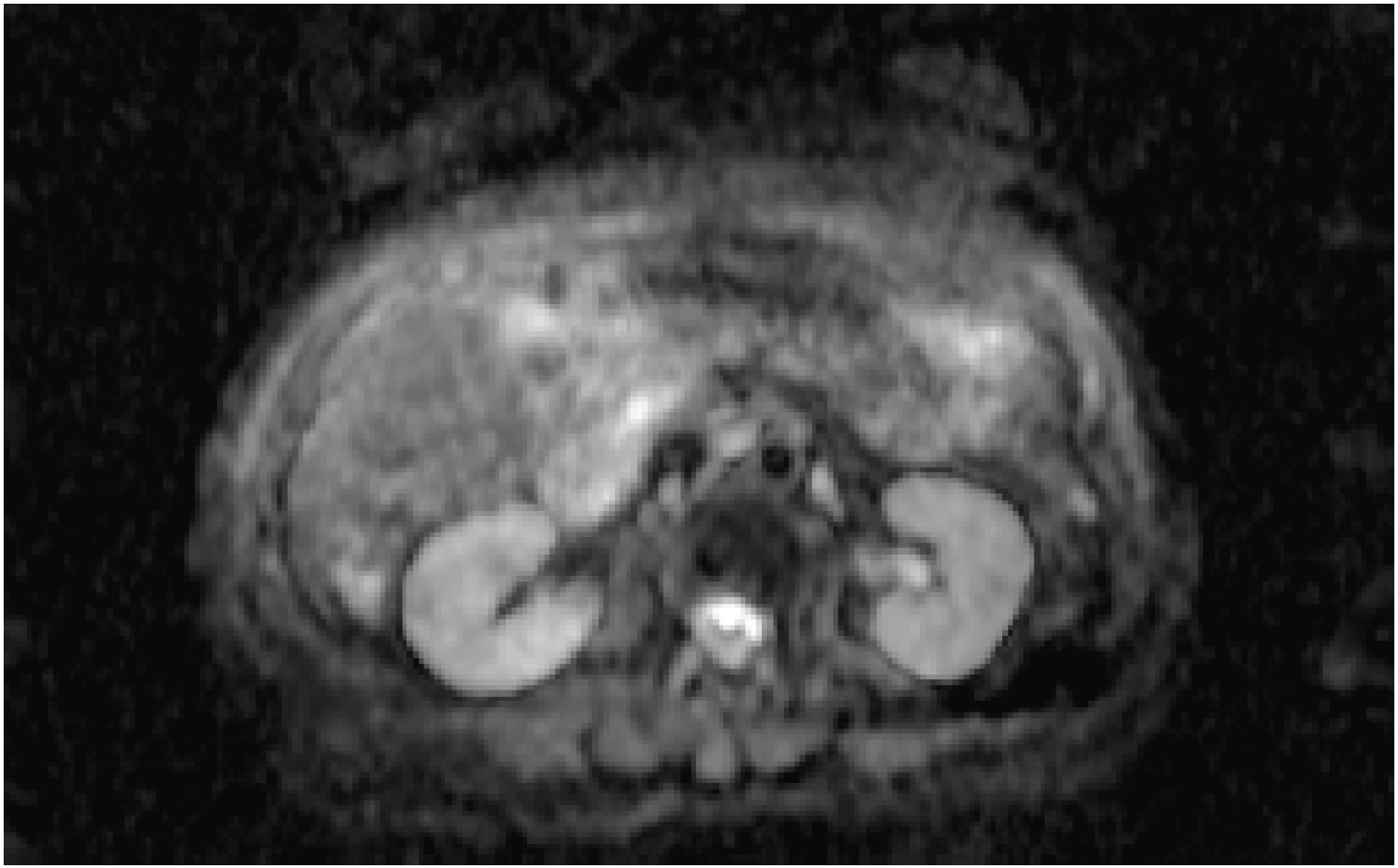

Fig.9

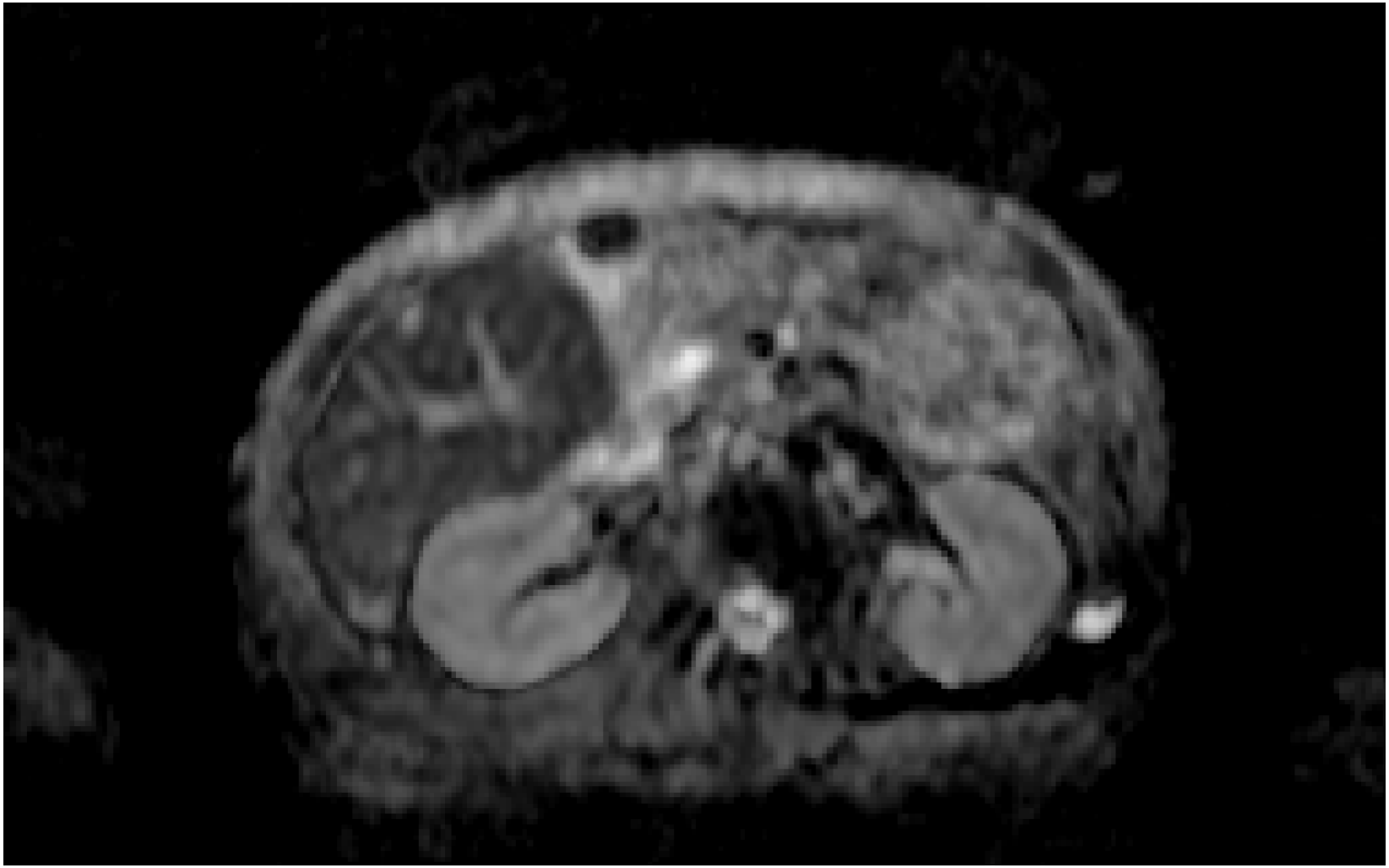

Fig.10

	averaged CT-value(HU)	S.D
meningioma after injected two minutes	204.2	15.2
kidney cortex after injected two minutes	182.3	4.11
bladder after injected 15 minutes	488.2	25.3

Table 1