Analysis of Radiation Doses and Dose Reduction Strategies During Cerebral Digital Subtraction Angiography

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Introduction

Adverse effects of increased use of cerebral Digital subtraction angiography (DSA) are the resulting radiation-induced skin reactions and increased risk of malignancy. This study aimed to identify a method for reducing radiation exposure during routine cerebral DSA.

Methods

A retrospective review of the 138 consecutive adult patients undergoing DSA with biplane angiography system (Artis Zee, Siemens, Germany) from September 2015 to February 2016 was performed. At January 2016, the ‘dose parameter' resetting was done by manufacturing programmer from 2.4μGy to 1.2μGy. The pre-dose parameter reduction (Group 1) and post-dose parameter reduction (Group 2) groups were established.

Table 1. Parameters for Digital Subtraction Angiography

	Two-Dimensional Mode	Three-Dimensional Rotational Angiography
Tube voltage (kVp)	70–74	70
Pulse width (milliseconds)	90	13.5
Current (mA)	160/320	386
Field of view (cm)	32	42
Cu filtration (mm)	0	0
Frames	(15–30) × 2	133 × 2
Phase 1 (arterial phase)	4F/S	30F/S
Phase 2 (venous phase)	1F/S	30F/S
Time	15 seconds	5 × 2 seconds
Mask	30 F/S	5 seconds
Fill	30 F/S	5 seconds
Washout	0.5 F/S	2 seconds

F/S, frames per second.

Angiograms and procedure examination protocols were reviewed according to patient age, gender, and diagnosis while angiography techniques were reviewed on the basis of following radiation dose parameters: fluoroscopy time, reference point air kerma (Ka,r; in mGy), and kerma area product (PKA; in μGym2).

Table 2. Baseline Characteristics

	Total	Group 1 (Dose Parameter, 2.4 μGy)	Group 2 (Dose Parameter, 1.2 μGy)	*P* Value*
Examination date	September 14, 2015–February 12, 2016	September 14, 2015–December 9, 2015	December 10, 2015–February 12, 2016	
Total	138	73	65	
Gender (male:female)	63:75	33:40	30:35	0.214
Mean age, years	58.5 (26–81)	57.4 (37–81)	59.8 (26–76)	0.510
Diagnosis	An 89	An 49	An 40	0.201
	O/S 29	O/S 13	O/S 16	0.142
	Tumor 6	Tumor 4	Tumor 2	0.613
	Others 14	Others 7	Others 7	0.221
Mean selected vessel number	8.14	8.1 (2–15)	8.2 (3–16)	0.114
Mean count of three-dimensional angiography	1.42	1.52 (0–4)	1.20 (0–3)	0.221
Mean total image number	937.5	930.3 (109–9895)	945.7 (250–5424)	0.097

An, aneurysm; O/S, occlusion/stenosis; Others: other vascular diseases, including arteriovenous malformation, arteriovenous fistula, moyamoya disease, intracerebral hemorrhage, and venous thrombosis.
**P* values were calculated by χ^2 tests and means comparison tests (*t* tests).

Results

The Mean Ka,r values in Group 1 and 2 were 1841.5 mGy and 1274.8 mGy, respectively. The mean PKA values in Group 1 and 2 were 23212.5 μGym2 and 14854.0 μGym2, respectively. Ka,r and PKA values were significantly decreased in Group 2, compared with Group 1 ($p<0.001$). Among individual factors, young age is a determining factor of reduced fluoroscopy time ($p<0.001$), Ka,r ($p=0.047$), and PKA ($p=0.022$).

Table 3. Comparison of Time and Radiation Dose Based on Dose Parameter

	Group 1 (Dose Parameter, 2.4μGy)	Group 2 (Dose Parameter, 1.2μGy)	*P* Value*
Mean fluoroscopy time (seconds)	930.3	945.7	0.642
Mean total time (seconds)	1007.9	1026.3	0.618
Mean air kerma (total) (mGy)	1841.5	1274.8	0.000†
Mean kerma-area product (total) (μGym²)	23212.5	14854.0	0.000†

Total time: fluoroscopy time + angiography time.
**P* values were calculated by means comparison tests (*t* tests).
†Statistically significant ($P < 0.05$).

Table 4. Comparison of Time and Radiation Dose Based on Age

	Age-Group 1 (≤60 years)	Age-Group 2 (≥61 years)	*P* Value*
Total number	72	66	
Mean fluoroscopy time (seconds)	503.1	950.2	0.000†
Mean total time (seconds)	618.8	1030.4	0.000†
Mean air kerma (total) (mGy)	1391.2	1777.1	0.047†
Mean kerma-area product (total) (μGym²)	16455.0	20249.2	0.022†

Total time: fluoroscopy time + angiography time.
**P* values were calculated by means comparison tests (*t* tests).
†Statistically significant ($P < 0.05$).

Table 5. Relationship of Factors Other Than Age with Radiation Dose

	Number of Selected Vessels	Number of Three-Dimensional Angiograms	Number of Total Images
P value of mean air kerma (mGy)*	0.281	0.061	0.412
P value of mean kerma-area product (μGym²)*	0.949	0.079	0.440

**P* values were calculated by χ^2 test.

Conclusions

Increased awareness of radiation risks, as well as the establishment of strategies to reduce radiation dose, resulted in decreased radiation doses for DSA. The use of appropriate examinations and low-dose parameters in fluoroscopy contributed significantly to the radiation dose reductions.

Learning Objectives

Despite the development of non-invasive neuroimaging techniques, cerebral digital subtraction angiography (DSA) remains the most useful method for evaluation and treatment of many cerebrovascular diseases. Unfortunately, DSA involves the inevitable risk of exposing both patient and medical team to radiation.

References

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