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Original Article

Investigation of Fluoroscopy Time and Radiation Dose by the Number of Cerebral Angiography Operator Experiences

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Objective: We investigated the fluoroscopy time (FT) and radiation dose by the number of cerebral angiography (CA) operator experiences to clarify the learning curve of CA.

Methods: The subjects were cases for whom CA was performed at our hospital for 5 years between April 2015 and March 2020. Based on the number of CA operator experiences, they were classified into four groups: 1–50 cases (group A), 51–100 cases (group B), 101–200 cases (group C), and 201 cases and later (group D). The FT and radiation dose were retrospectively investigated.

Results: Of the 865 consecutive CA cases, 293 cases for follow-up, i.e. after treatment, 54 for arteriovenous shunt diseases, 21 lacking data, and 1 case requiring intervention for thrombosis during CA were excluded. In total, 496 CA cases were investigated. There were 61 cases in group A, 56 cases in group B, 44 cases in group C, and 335 cases in group D, and there was no significant difference in patient background factors among the groups. The median FT and radiation dose (interquartile range) in each group were 20.2 min (14.6) and 374 mGy (185.3) in group A, 14.8 min (12.1) and 366 mGy (167.9) in group B, 10.8 min (6) and 320 mGy (151.7) in group C, and 9.4 min (6.4) and 336 mGy (171) in group D. The FT was significantly shorter in group C than in group A, and significantly shorter in group D than in groups A, B, and C. The radiation dose was significantly lower in groups C and D than in groups A and B.

Conclusion: This study suggested that CA can be performed alone after experiencing approximately 100 cases as an operator.

Keywords cerebral angiography, operator experience, fluoroscopy time, radiation dose, learning curve

Introduction

Cerebral angiography (CA) is the gold-standard examination of cerebrovascular disease, and the number of neuroendovascular therapies has recently increased. The outcome of target diseases is often the focus of CA and neuroendovascular therapy, but together with thromboembolism and puncture-site complications, exposure of patients and medical staff is an unavoidable problem, for which training and techniques to shorten the fluoroscopy time (FT) and reduce the radiation dose in CA on a routine basis are essential.

For CA, there have been many reports on techniques to reduce the radiation dose,[1)] but only a few studies have been performed based on the specific number of operator experiences and the learning curve of CA has not been clarified. Thus, in this study, we retrospectively surveyed and investigated the FT and air kerma (AK) as the radiation dose in CA by the number of operator experiences.

Materials and Methods

CA was performed on 865 consecutive patients at our hospital in a 5-year period from April 2015 to March

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Table 1 Comparison of patient background factors

Variable	A (N = 61)	B (N = 56)	C (N = 44)	D (N = 335)	χ^2	df	p-value
Age (years)	68 (19)	71 (24)	72.5 (24)	69 (18)			0.613
Male sex—no. (%)	29 (47.5)	23 (41.1)	27 (61.4)	163 (48.7)	4.160	3	0.245
Hypertension—no. (%)	34 (55.7)	31 (55.4)	31 (70.5)	209 (62.4)	3.349	3	0.341
Diabetes mellitus—no. (%)	11 (18.0)	9 (16.1)	9 (20.5)	63 (18.8)	0.359	3	0.949
Hyperlipidemia—no. (%)	19 (31.1)	15 (26.8)	19 (43.2)	134 (40.0)	5.273	3	0.153
Smoking—no. (%)	21 (34.4)	16 (28.6)	8 (18.2)	96 (28.7)	3.358	3	0.340
Cardiovascular disease—no. (%)	6 (9.8)	4 (7.1)	5 (11.4)	34 (10.1)	0.607	3	0.895
Disease group					9.05	6	0.171
Cerebral aneurysm—no. (%)	32 (52.5)	26 (42.6)	18 (40.9)	164 (49.0)			
Ischemic disease—no. (%)	13 (21.3)	14 (25.0)	12 (27.3)	109 (32.5)			
Other—no. (%)	16 (26.2)	16 (28.6)	14 (31.8)	62 (18.5)			

2020. Excluding 293 follow-up patients, such as those after treatment in which the number of blood vessels imaged was not constant, 54 patients with arteriovenous shunt diseases, such as cerebral arteriovenous malformation and dural arteriovenous fistula, in which the radiation dose is expected to increase compared with that in other diseases, 21 patients lacking data, and 1 patient who required therapeutic intervention for thrombosis during examination, 496 patients were included as subjects.

The patients were divided into four groups by the number of CA operator experiences: from the 1st to 50th case as group A, from the 51st to 100th case as group B, from the 101 to 200th case as group C, and the 201 and later cases as group D, and the following items were retrospectively investigated: patient age, sex, the presence of hypertension (HT), diabetes mellitus (DM), hyperlipidemia (HL), cigarette smoking, complications by myocardial infarction (MI) and arteriosclerosis obliterans (ASO), target diseases of examination (cerebral aneurysm, ischemic disease, etc.) as patient background factors based on electronic medical records and summary at discharge, and total FT of front and side tubes and total AK of front and side tubes as evaluation items based on the radiology information system.

For the angiography apparatus, Allura Clarity FD20/20 by Philips (Amsterdam, the Netherlands) was used.

For statistical analysis, continuous variables were analyzed employing the Kruskal–Wallis test and Bonferroni correction, and nominal variables were analyzed by the chi-square test using IBM SPSS Statistics version 22 (IBM, Armonk, NY, USA) and setting the significance level at 0.05.

Results

CA was performed by seven neurosurgeons and one neurologist who belonged to the center during the period. The number of operator experiences was 61 in group A, 56 in group B, 44 in group C, and 335 in group D.

The mean age of all 496 patients was 65.5 (±13.4) years old, 242 (48.8%) were male, and the target disease of examination was cerebral aneurysm in 240 (48.4%), ischemic disease in 148 (29.8%), and others in 108 (21.8%). The other diseases were brain tumor (52 patients), intracranial hemorrhage (50), sinus thrombosis (2), sinus pericranii (1), basilar artery dissection (1), and scrutiny of tetraplegia (1). The puncture site was located in the femoral artery in 485 (97.8%), being the most frequent, radial artery in 7 (1.4%), and brachial artery in 4 (0.8%). The median number of blood vessels imaged was 3 (interquartile range: 1) in all 496 patients and 3 in each group.

The median FT and AK in all 496 patients were 10.5 min (interquartile range: 9.1) and 342.5 mGy (interquartile range: 169.4), respectively.

Regarding the patient background factors, no significant difference was noted among the groups in patient age, sex, the presence of HT, DM, HL, cigarette smoking, complications by MI and ASO, or target disease of examination (cerebral aneurysm, ischemic disease, etc.) (**Table 1**).

The median (interquartile range) FT was 20.2 min (14.6) in group A, 14.8 min (12.1) in group B, 10.8 min (6) in group C, and 9.4 min (6.4) in group D. The median (interquartile range) AK was 374 mGy (185.3) in group A, 366 mGy (167.9) in group B, 320 mGy (151.7) in group C, and 336 mGy (171) in group D. By the Kruskal–Wallis test, a significant difference was noted in both FT and AK

Table 2 Comparison of FT and AK

Variable	A (N = 61)	B (N = 56)	C (N = 44)	D (N = 335)	p-value
FT (min)					<0.001
Median	20.2	14.8	10.8	9.4	
Interquartile range	14.6	12.1	6.0	6.4	
AK (mGy)					0.001
Median	374.0	366.0	320.0	336.0	
Interquartile range	185.3	167.9	151.7	171.0	

AK: air kerma; FT: fluoroscopy time

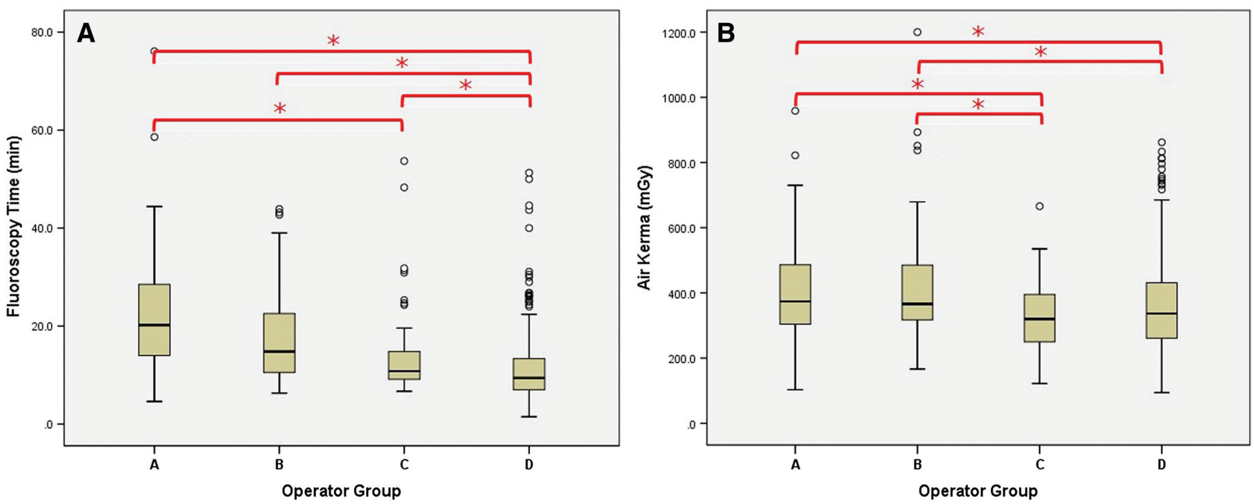

Fig. 1 Median and interquartile range for each group of fluoroscopy time (**A**) and air kerma (**B**). *There is a significant difference between the groups (p <0.05).

among the groups (**Table 2**). After Bonferroni correction, FT was significantly shorter in group C than in group A and that in group D was shorter than that in groups A, B, and C. In addition, AK was significantly lower in groups C and D than in groups A and B (**Fig. 1**, **Table 3**).

Table 3 Comparison of FT (a) and AK (b) by Kruskal–Wallis test and Bonferroni correction

	Crude p-value	Adjusted p-value
(a) FT		
D–C	0.004	0.024
D–B	<0.001	<0.001
D–A	<0.001	<0.001
C–B	0.055	0.330
C–A	<0.001	0.002
B–A	0.069	0.413
(b) AK		
D–C	0.270	1.000
D–B	0.007	0.044
D–A	0.005	0.031
C–B	0.005	0.031
C–A	0.004	0.026
B–A	0.995	1.000

AK: air kerma; FT: fluoroscopy time

Discussion

When performing CA and neuroendovascular therapy, it is necessary to pay attention in shortening the FT and reducing radiation dose. There have been many reports on techniques to reduce the radiation dose. Pearl et al. reported that evaluation of the puncture site in CA by fluoroscopy alone and reduction of the pulse rate during acquisition of the road map are useful.[1] Choi et al. reported that they reduced the radiation dose per frame from 3.6 to 1.8 mGy in CA and endovascular treatment of cerebral aneurysms, and there was no clinical problem with the image quality.[2] In addition, Pearl et al. reported that the radiation dose in CA varied among reports, and in addition to patient characteristics, vascular anatomy, and acquisition conditions, the operator is an influencing factor,[1] but the FT and radiation dose were not reported based on a specific number of operator experiences in any study.

Thus, in this study, we divided the operators by the number of experiences into four groups. In the Japanese

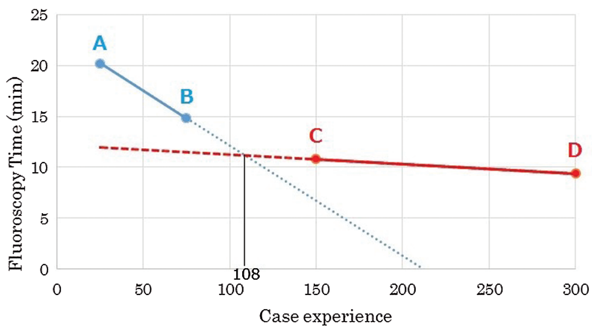

Fig. 2 The center of the range of the number of operator experiences in each group was plotted on the horizontal axis; however, group D was set for 300 cases. The median fluoroscopy time was plotted on the vertical axis. The intersection of the straight line connecting A and B and that connecting C and D was found.

neurosurgeon curriculum, groups A (the 1st to 50th case) and B (the 51st to 100th case) may have roughly corresponded to the first- and second-year senior residents, respectively, group C (the 101 to 200th case) may have corresponded to surgeons before acquiring certification of neurosurgeon, and group D (the 201 and later cases) may have corresponded to certified neurosurgeons.

Regarding the investigation items, items expected to influence catheter insertion and access were mainly investigated as patient background factors, but no significant difference was noted among the groups, including age and past medical history of cardiovascular disease.

Regarding the purpose of examination by CA, only the target blood vessel was imaged during follow-up examination after treatment in several cases and these were excluded. Moreover, it has been reported that the radiation dose during treatment of arteriovenous shunt diseases, such as cerebral arteriovenous malformation and dural arteriovenous fistula, is higher than that in other diseases,[3,4] suggesting that the radiation dose increases during examination compared with that in the other diseases, and thus these cases were also excluded. In the 496 patients in this study, the median FT and AK were 10.5 min and 342.5 mGy, respectively, being comparable with those in previous reports.[5]

In comparison among the groups, FT was significantly shorter in group C than in group A and that in group D was significantly shorter than that in groups A, B, and C. AK was significantly lower in groups C and D than in groups A and B. FT was correlated with the number of operator experiences compared with AK, and this may have been due to variations in the presence of puncture site imaging, number of acquisitions, and execution of 3D rotational angiography and cone-beam CT among operators and patients, whereas FT may purely reflect the skill of operators. Thus, to clarify the CA learning curve, the center of the range of the number of operator experiences (300 cases in group D) was plotted on the horizontal axis and FT was plotted on the vertical axis in each group. The intersection of a straight line connecting groups A and B and that connecting groups C and D was determined, and it was located at the position of 108 operator experiences, suggesting that the skills required to perform CA alone as an operator are acquired after 108 cases (**Fig. 2**). This may be similar to the report by Sato et al. in which there were significantly more high-intensity lesions on MRI diffusion weighted image (DWI) after examination when the number of CA operator experiences was 100 or fewer.[6] In addition, other modalities have recently markedly advanced, with which the number of cases examined by CA may decrease depending on the facilities. The usefulness of a simulator to quickly improve CA skills under this condition has been reported[6,7]; therefore, its use may be considered.

Limitations of this study were that this was a single-center retrospective study. Operators were limited and only three physicians were classified into groups A and B. Therefore, whether individual skills and learning curves influenced the overall results cannot be excluded.

Conclusion

This single-center retrospective study suggested that an operator acquires the skills required to perform CA alone by experiencing approximately 100 cases.

Disclosure Statement

The authors declare no conflicts of interest.

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