Evaluation of Typical Radiation Doses for Cerebral Angiography Using Femoral Catheter-Based Procedures

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Abstract – Cerebral angiography uses a catheter inserted through the femoral artery and guided by fluoroscopy to visualise brain blood vessels involving higher radiation exposure. Prolonged or repeated exposure to radiation during neurointerventional procedures may increase the lifetime attributable risk of radiation-induced effects, including skin injury and cancer, particularly for radiosensitive organs within the head and neck region. This study aims to establish typical doses for local diagnostic reference levels (DRLs) for femoral catheter insertion in cerebral angiography to improve patient safety. Three common clinical indications were analysed in this study including brain aneurysm, brain arteriovenous malformation (AVM), and carotid-cavernous fistula (CCF). Table 1 presents the local typical dose (50th percentile) of kerma-area product (P_{KA}) and reference point air kerma ($K_{a,r}$) for cerebral angiography in comparison with other established national and international DRLs. The typical dose of P_{KA} was 245.02 Gy.cm², while the $K_{a,r}$ was 1259.00 mGy. Both values exceeded the national DRLs (81 Gy·cm² and 389 mGy, respectively), as well as other international DRLs. The higher dose levels observed in this study are likely attributable to the complexity of cases, prolonged fluoroscopy times, and differences in equipment technology. Furthermore, the mean fluoroscopy time reported in other studies was generally lower than this study, which may explain the higher typical dose recorded compared with national and international DRLs.

Keywords – Cerebral angiography, Typical dose, Diagnostic reference level

1 INTRODUCTION

Cerebral angiography is an invasive diagnostic imaging technique to visualise the vascular network of the brain and neck. Its primary clinical purpose is to identify and characterise abnormalities such as aneurysms, arteriovenous malformations (AVMs), stenoses (narrowing), or occlusions (blockages), which are critical precursors to conditions like strokes or cerebral hemorrhages [1].

The procedure involves the insertion of a catheter through the femoral artery, which is guided under fluoroscopic imaging to visualise the cerebral vasculature. Owing to its complexity, cerebral angiography is associated with substantially higher radiation exposure compared to conventional diagnostic imaging procedures. Prolonged or repeated radiation exposure during neurointerventional procedures may increase the lifetime attributable risk of radiation-induced effects, including skin injuries and cancer, particularly in radiosensitive organs within the head and neck region. This study aims to determine the typical doses for establishment of local diagnostic reference levels (DRLs) for femoral catheter insertion in cerebral angiography, with the goal of enhancing patient protection and safe clinical practice in cerebral angiography procedure.

2 MATERIALS & METHODS

2.1 Patient Recruitment

This retrospective study analysed data from 116 patients (aged 18 to 78 years) who underwent cerebral angiography at the Advanced Minimally Invasive Endovascular and Neurointerventional (AMIEN) Unit, Department of Radiology, Hospital Pakar Universiti Sains Malaysia (HPUSM), Kelantan, Malaysia, between January 2020 and December 2024.

2.2 Data Collection

Ethical approval for this study was obtained from the Institutional Ethics Committee, USM Human Research Ethics Committee (JEPeM Code: USM/JEPeM/KK/25010039), prior to data collection. Patient data were collected from cerebral angiography procedures performed using the SIEMENS AXIOM-Artis Zee biplane system and retrieved from the Picture Archiving and Communication System (PACS) at HPUSM.

2.3 Statistical Analysis

Statistical analysis was performed to determine the typical dose values, defined as the second quartile (median) of the dose distribution (kerma-area product, P_{KA} and reference point air kerma, $K_{a,r}$) for cerebral angiography. A comparative analysis was then conducted to evaluate the established typical doses against national and international Diagnostic Reference Levels (DRLs).

3 RESULTS & DISCUSSION

Three common clinical indications were analysed in this study including brain aneurysm, brain arteriovenous malformation (AVM), and carotid-cavernous fistula (CCF). Table 1 presents the local typical dose (50th percentile) of kerma-area product (P_{KA}) and reference point air kerma ($K_{a,r}$) for cerebral angiography in comparison with other established national and international DRLs. The typical dose of P_{KA} was 245.02 Gy.cm², while the $K_{a,r}$ was 1259.00 mGy. Both values exceeded the national DRLs (190 Gy·cm² and 940 mGy, respectively), as well as other international DRLs. The higher dose levels observed in this study are likely attributable to the complexity of cases, prolonged fluoroscopy times, and differences in equipment technology. Furthermore, the mean fluoroscopy time reported in other studies was generally lower than this study, which may explain the higher typical dose recorded compared with national and international DRLs.

4 CONCLUSION

Both P_{KA} and $K_{a,r}$ values increase proportionally with kV, total mA, and total fluoroscopy time. Typical doses for local DRL vary based on different clinical indications. Establishing local diagnostic reference levels is therefore critical to optimise radiation exposure, minimise unnecessary dose, and reduce potential long-term stochastic effects such as radiation-induced cancer. Overall, this study may contribute to radiation protection efforts by lowering the potential long-term risk of radiation-induced cancer, thereby improving patient safety and supporting the principles of justification and optimisation in neurointerventional radiology.

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Table 1. The comparison between local typical dose of $K_{a,r}$ (mGy) and P_{KA} (Gy.cm²) and of this study in comparison with the national and international DRLs (with percentage difference values) for cerebral angiography procedure.

Studies	Reference Point Air Kerma, $K_{a,r}$ (mGy)	Kerma-Area Product, P_{KA} ($Gy.cm^2$)
This study	1259.00	245.02
Malaysia (2025) [2]	940.00 (29.01%)	190.00 (25.30%)
South Africa (2023) [3]	868.50 (36.71%)	209.30 (15.72%)
German (2022) [4]	379.00 (107.45%)	71.40 (109.74%)
Greece (2021) [5]	494.00 (87.28%)	70.00 (111.12%)