Recent Radiation Reduction Strategies for Neurointerventionists

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Efforts to reduce radiation dose during neurointervention may be underappreciated because brief exposure to radiation seems harmless; however, radiation during neurointervention induces stochastic effects such as gene expression alterations and deterministic effects such as cataract formation.1,2 For these reasons, neurointerventionists should understand and implement the principle of “as low as reasonably achievable (ALARA)” every time they step on the fluoroscopy pedal. The following article is a summary of recent strategies in neurointervention that may allow for reducing radiation dose.

The optimization of fluoroscopy settings such as frame rate, filter options, automatic exposure control, focal spot, current, and peak potential according to each specific procedure is critical (Fig. 1). Not every vascular analysis warrants 2D or 3D digital subtraction angiography. Whether it is used to perform a direct puncture into a venous malformation or to gain femoral artery or venous access, ultrasonography can be an invaluable tool to achieve an accurate puncture into a venous malformation or to gain femoral artery or venous access, ultrasonography can be an invaluable tool to achieve an accurate
puncture and localization without radiation. Slattery et al.\(^7\) demonstrated that by using ultrasonography for common femoral artery access, 1 minute 55 seconds of procedure time and mean DAP 199 cGy cm\(^2\) of radiation dose can be reduced, compared to a fluoroscopy-guided approach. Also, Stone et al.\(^8\) demonstrated that ultrasound-guided femoral puncture had a faster median cannulation time (80 seconds vs. 100 seconds) and a higher success rate (93% vs. 86%) compared to fluoroscopy-guided femoral puncture in a prospective randomized control study with 635 patients. Therefore, the application of ultrasonography should be considered in order to reduce radiation exposure, procedure time, and complication risk.

Smaller craniocaudal angulation or true posteroanterior (PA) projection may result in less radiation exposure than the conventional projection (Fig. 3). In a phantom study, Song et al.\(^9\) demonstrated that an increase in the cranial angulation or caudal angulation resulted in a greater radiation dose during routine cerebral angiography. Specifically, a cranial angulation of 20 degrees increased the AK by 5.4%, compared to the true PA projection. Even with copper filter applications, a similar tendency was observed, except for applications with a 0.2-mm copper filter. In an in vivo study of 31 patients, a mean dose reduction of 11% was achieved by the application of PA projection during diagnostic angiography. Although the expected overlap between the skull base and vessels was much higher in the PA projection than in the conventional projection, the visibility of cerebral aneurysms at various locations, using a 4-point scale, was statistically insignificant between two projections.

Fusion of 3D magnetic resonance angiography (MRA) with 2D digital subtraction angiography may also reduce the radi-

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**Fig. 1.** Optimize the fluoroscopy settings. The optimization of fluoroscopy settings such as frame rate, filter options, automatic exposure control, focal spot, current, and peak potential according to each specific procedure is critical. Not every vascular analysis warrants 2D or 3D digital subtraction angiography. Likewise, not every fluoroscopy projection warrants the same pulse rate, focal spot, and frame rates.

**Fig. 2.** Use ultrasonography for localization. Ultrasonography is considered an adjunct modality for arterial or venous access to avoid unnecessary fluoroscopy projection and wire navigation. Whether it is used to perform a direct puncture into a venous malformation or to gain femoral artery or venous access, ultrasonography can be an invaluable tool to achieve an accurate puncture and localization without radiation. CFA, common femoral artery; CFV, common femoral vein.
ation dose. Modern fluoroscopy can import and overlay images from high-resolution MRA and use them as a real-time “virtual” roadmap (Fig. 4). Overlay mapping via 3D MRA may provide various advantages to neurointerventionists in terms of enhanced spatial resolution and capture of surrounding anatomy during the procedure, which ultimately may reduce

**Fig. 3.** Reduce the craniocaudal angle. Smaller craniocaudal angulation or true posteroanterior projection may result in less radiation exposure than the conventional projection.

**Fig. 4.** Take advantage of fusion technology. Fusion of 3D magnetic resonance angiography (MRA) with 2D digital subtraction angiography may also reduce the radiation dose. Modern fluoroscopy can import and overlay images from high-resolution MRA and use them as a real-time “virtual” roadmap. RF, radiofrequency.
the procedure time, contrast media injection, and overall radiation dose. In a retrospective study, Jang et al.\textsuperscript{10} demonstrated that the fusion of 3D MRA with 2D monoplane is feasible and safe for coil embolization of both unruptured and ruptured cerebral aneurysms. From February 2013 to July 2013, coil embolization of 33 patients with this fusion technique had a lower mean radiation dose (3,375 mGy vs. 1,953 mGy), lower fluoroscopy time (62.3 minutes vs. 30.5 minutes), and shortened procedure time (105 minutes vs. 82.2 minutes) in comparison to that of 27 patients who were evaluated using conventional methods. There were no differences in procedural or perioperative complications between the 2 groups (4 vs. 2 patients and 4 vs. 3 patients, respectively).

In conclusion, there are numerous ongoing studies that reflect neurointerventionists’ endeavors and strategies to reduce radiation dose during procedures. Whether performing a simple diagnostic angiography or complex coil embolization for a cerebral aneurysm, a neurointerventionist should always remember and implement the principle of “ALARA”.

Acknowledgments
Illustrations by Jinsoo Rhu M.D. for medical cartoons.

Fund
None.

Conflicts of Interest
The author has no conflicts to disclose.

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REFERENCES
1. Riabroi K, Khanungwanitkul K, Wattanapongpitak P, Krisanachinda A, Hongsakul K. Patient radiation dose in neurointerventional radiologic procedure: a tertiary care experience. Neurointervention 2018;13:110-116
2. Visweswaran S, Joseph S, Hegde V, Annalakshmi O, Jose MT, Perumal V. DNA damage and gene expression changes in patients exposed to low-dose X-radiation during neuro-interventional radiology procedures. Mutat Res 2019;844:54-61
3. Vano E, Fernandez JM, Sanchez RM, Martinez D, Ibor LL, Gil A, et al. Patient radiation dose management in the follow-up of potential skin injuries in neuroradiology. AJNR Am J Neuroradiol 2013;34:277-282
4. Song Y, Han S, Kim BJ, Oh SH, Kim JS, Kim TI, et al. Low-dose fluoroscopy protocol for diagnostic cerebral angiography. Neurointervention 2020;15:67-73
5. van der Marel K, Vedantham S, van der Bom IM, Howk M, Narain T, Ty K, et al. Reduced patient radiation exposure during neurodiagnostic and interventional X-ray angiography with a new imaging platform. AJNR Am J Neuroradiol 2017;38:442-449
6. Kim DJ, Park MK, Jung DE, Kang JH, Kim BM. Radiation dose reduction without compromise to image quality by alterations of filtration and focal spot size in cerebral angiography. Korean J Radiol 2017;18:722-728
7. Slattery MM, Goh GS, Power S, Given MF, McGrath FP, Lee MJ. Comparison of ultrasound-guided and fluoroscopy-assisted antegrade common femoral artery puncture techniques. Cardiovasc Intervent Radiol 2015;38:579-582
8. Stone P, Campbell J, Thompson S, Walker J. A prospective, randomized study comparing ultrasound versus fluoroscopic guided femoral arterial access in noncardiac vascular patients. J Vasc Surg 2020;72:259-267
9. Song Y, Kim Y, Han S, Kim TI, Choi JH, Maeng JY, et al. Estimated radiation dose according to the craniocaudal angle in cerebral digital subtraction angiography: patient and phantom study. J Neuroradiol 2019;46:345-350
10. Jang DK, Stidd DA, Schafer S, Chen M, Moftakhar R, Lopes DK. Monoplane 3D overlay roadmap versus conventional biplane 2D roadmap technique for neurointerventional procedures. Neurointervention 2016;11:105-113