**Efficacy of Radiation Reduction Protocols for Diagnostic Angiography and Basic Interventions in Endovascular Neurosurgery**

Arvin R. Wali MD, MAS, Michael G. Brandel MD, MAS, Sarath Pathuri BS, Brian R. Hirshman MD, PhD, Javier Bravo MD, Jeffrey Steinberg MD, Scott Olson MD, J. Scott Pannell MD, David R. Santiago-Dieppa MD, Alexander A. Khalessi MD, MBA

**Background**

Safe radiation practices and “As Low As Reasonably Achievable” (ALARA) principles are critical to mitigate unnecessary radiation to patients, providers, and staff. Radiation has stochastic and deterministic effects that have deleterious effects on health and lead to complications such as cancer, leukemia, and cataracts. As the indications for neuroendovascular procedures continue to grow, Neurointerventionalists must have a strong command over practices that reduce unnecessary radiation dose. We applied a quality improvement protocol to manipulate default pulse rate and frame rate settings on our Siemens Artis Q biplane to determine if radiation safety practices could allow for quality diagnostic angiograms and the performance of safe and effective interventions.

**Methods**

We implemented a radiation reduction protocol January 1st 2022 in which the default pulse rate and frame rate in our Siemens Artis Q biplane was reduced from 15 pulses per second (p/s) to 7.5 p/s and 7.5 frames per second (f/s) to 4.0 f/s. We performed a retrospective review of prospectively acquired data to calculate the impact of our radiation reduction protocol on total radiation dose, radiation per angiographic run, total radiation exposure, and exposure per run. We examined 29 consecutive diagnostic angiograms (16 prior to intervention, and 13 post intervention) and 16 consecutive, unilateral middle meningeal artery embolizations (MMAEs) (8 prior to intervention, and 8 post intervention). A blinded neuroradiologist reviewed the angiograms to determine if there was sufficient diagnostic information in the angiograms before and after intervention. Univariable and multivariable log-linear regression were performed to account for patient body mass index (BMI), number of angiographic runs, and number of vessels catheterized. Statistical analysis was performed using STATA MP Version 17.0 (Stata Corp LP, College Station, Texas). Significance was defined as p < 0.05.

**Results**

For the diagnostic angiograms, univariable analysis revealed that radiation dose (550.5 vs. 353.3 mGy, p=0.005), radiation dose per angiographic run (34.6 vs. 21.9, p<0.001), total radiation exposure (7050.7 vs. 4490.7 mGym2, p=0.013), and exposure per run (429.8 vs. 281.9, p<0.001) were all significantly decreased after the protocol. On multivariable log-linear regression adjusting for BMI, number of runs, vessels catheterized, and fluoroscopy time, the protocol was associated with a 45.4% decrease in the total radiation dose (p<0.001) and a 53.3% decrease in radiation dose per run (p<0.001). For the MMAEs, univariable analysis revealed that radiation dose (660.9 vs. 407.5 mGy, p=0.002), radiation dose per angiographic run (40.3 vs. 25.7, p<0.001), total radiation exposure (8825.8 vs. 5510.4 μGym2, p=0.002), and exposure per run (537.9 vs. 353.5, p=0.002) were all significantly decreased after the protocol. Both groups were well balanced in terms of clinical characteristics (**Table 1 and 2**). No changes in image quality were identified by an expert interventional neuroradiologist. Fluoroscopy and procedural time did not differ between MMAE groups (20min vs 21min p=0.65).

**Conclusions**

Radiation reduction protocols are highly effective for neuroendovascular interventions. We strongly encourage all interventionalists to be cognizant of pulse rate and frame rate when performing routine interventions to avoid unnecessary radiation towards patients, providers, and

health care staff.

**Table 1. Clinical Characteristics for the Diagnostic Angiography Group**

|  |  |  |  |
| --- | --- | --- | --- |
| **Factor** | **Before** | **After** | **p-value** |
| N | 16 | 13 |  |
| BMI, mean (SD) | 23.5 (3.2) | 26.0 (7.3) | 0.24 |
| Total mGy, mean (SD) | 550.5 (223.1) | 353.3 (80.8) | 0.005 |
| Total Exposure, mean (SD) | 7050.7 (3340.3) | 4490.7 (1024.9) | 0.013 |
| Spin performed, N (%) | 0 (0%) | 3 (23%) | 0.042 |
| Fluoroscopy time (minutes), mean (SD) | 8.9 (5.4) | 8.9 (2.8) | 1.00 |
| Total mGy per minute of fluoroscopy time, mean (SD) | 73.2 (32.0) | 44.0 (17.5) | 0.007 |
| Vessels catheterized, mean (SD) | 4.8 (1.7) | 4.8 (1.6) | 0.95 |
| Total mGy per vessel catheterized, mean (SD) | 121.5 (37.3) | 85.4 (39.3) | 0.018 |
| Total exposure per run, mean (SD) | 429.8 (89.5) | 281.9 (95.3) | <0.001 |
| N of runs, mean (SD) | 16.1 (7.1) | 16.8 (4.3) | 0.78 |
| Total mGy per run, mean (SD) | 34.6 (5.5) | 21.9 (6.1) | <0.001 |

**Table 2.** Clinical characteristics of the MMAE group

|  |  |  |  |
| --- | --- | --- | --- |
| **Factor** | **Before** | **After** | **p-value** |
| N | 8 | 8 |  |
| BMI, mean (SD) | 27.9 (4.0) | 22.5 (6.2) | 0.058 |
| Total mGy, mean (SD) | 660.9 (104.8) | 407.5 (159.2) | 0.002 |
| Total Exposure, mean (SD) | 8825.8 (1763.4) | 5510.4 (1816.3) | 0.002 |
| Fluoroscopy time (minutes), mean (SD) | 20.0 (8.9) | 21.7 (5.9) | 0.65 |
| Total mGy per minute of fluoroscopy time, mean (SD) | 37.1 (11.6) | 18.6 (5.7) | 0.001 |
| Vessels catheterized, mean (SD) | 2.0 (0.0) | 2.0 (0.0) |  |
| Total mGy per vessel catheterized, mean (SD) | 330.4 (52.4) | 203.8 (79.6) | 0.002 |
| Total exposure per run, mean (SD) | 537.9 (115.5) | 353.5 (71.4) | 0.002 |
| N of runs, mean (SD) | 16.9 (4.3) | 15.6 (4.6) | 0.58 |
| Total mGy per run, mean (SD) | 40.3 (6.9) | 25.7 (6.4) | <0.001 |