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Reply:

S. Moskowitz and B. Davros

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Reply:

We thank Mamourian et al for their comments about the radiation exposure in subarachnoid hemorrhage (SAH). We understand that there are significant limitations to the methods we applied. As we understand, there are 2 lines of comment that they are addressing.

The first relates to the fundamental measurements that we reported. Air kerma is a measurement of the exposure to air at a fixed distance from a radiation source. This is the value returned for all C-arm and biplanar equipment. Biologically relevant doses are, however, a related but different item. Air kerma does not account for scatter, angle of inclination to the skin, 2D distribution over an area, and so forth. Because the head is, in fact, usually a complex nonspheric shape, the real skin entry dose seen from imaging studies is not equal to the air kerma reported by the software. Even with a conversion applied, the real life use of radiation is not perfectly represented. Nonetheless, for the purposes of a retrospective analysis, the best (and only) data available for exposure are those gathered by that measure, and hence we used it for our review.

The second concern relates to the measurements that we used to calculate exposure from the variety of sources. The measurements were obtained from regularly scheduled quality and safety checks from all equipment. The doses were consistent with prior measurements and have been since that time. The doses were within the acceptable range for each such study, so we are not concerned with the safety of the equipment or the accuracy of the numbers used for our calculations.

In summary, we have 2 fundamental comments about our article. The first reflects on the overall comments made by Mamourian et al. Air kerma is not a perfect metric to measure skin entry radiation dose. Many factors impact the absorbed dose and the biologic response to any radiation source, including scatter, shape of the head, distribution over the skin, angle of inclination, actual distance of the skin to the source, and so forth. The actual dose a patient receives may be many factors less or more than the air kerma reported by quality assurance studies and software included with the fluoroscopy equipment. A better measure would be direct analysis of the skin entry dose. The use of GafChromic film (Specialty Products, Wayne, New Jersey) would account for many of the variables, even if not a perfect solution itself. Already underway are future endovascular studies that use this to measure total and peak skin entry dose, with consideration of distribution over the skin and eyes. We anticipate that this will control for some of the distinctively high doses seen, and it will demonstrate that the peak skin dose will not be represented reliably by air kerma.

The second comment is that the purpose of this study was not to identify the highest skin dose possible. We were highlighting the fact that in a very sick population of neurovascular patients, repetitive radiation-based imaging studies can result in significant radiation exposure. We believe that great care must be applied to this patient population in this regard, and any technique to reduce unneeded exposure should be considered. We are aware that it is not possible today to expect no exposure at all through a prolonged hospitalization for SAH. However, we hope that the results of our study bring to light a need for conscientious use of imaging; they are not intended to define a standard by which individual patient care should be measured.

S. Moskowitz
B. Davros
Cleveland Clinic Foundation
Cleveland, Ohio

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