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EDITORIAL

Modeling Reality with Emission Tomography: What Is the Point?

In 1913, Niels Bohr presented his now familiar model of the atom, consisting of a central nucleus with "orbiting" electrons. We now know that this model does not accurately and fully represent reality. Indeed, quantum physicists such as David Bohm have argued that protons, neutrons and electrons do not actually exist as particles. Even so, we continue to use Bohr's model for many applications. Why? Because we can accomplish important goals by doing so. My mentor, Henry N. Wagner, Jr., often has said: "Be as rigorous as necessary, not as rigorous as possible."

Quantification is important in the practice of nuclear medicine. "Quantification" means more than assessment of the amount of radioactivity; it implies estimation of physiological or biochemical parameters of interest. Quantification involves a simplification or "filtering" of the raw data—an abstraction. Of necessity, this abstraction is based on a conceptual and associated mathematical model of the physiological or biochemical process. In practice, the need to model, and the utility of a particular model, depend on the model's intended purpose. That is, modeling can only be judged in the context of its usefulness in solving a specific research or clinical problem.

In this issue of *JNM*, Tsuchida et al. (*1*) describe the development and application of a model to correct the nonlinear relationship between regional cerebral blood flow (rCBF) and the uptake of [^{123}I]IMP, ^{99m}Tc-HMPAO and ^{99m}Tc-ECD. I would like to make four points about modeling in emission tomography, the first three of which are illustrated by this excellent article. First, the success with which these investigators were able to produce corrected data with SPECT that correlated well with PET highlights the advances SPECT has made. We now need to think in terms of "emission tomography" rather than distinguishing between SPECT and PET. This is true not only for "image quality" (e.g., spatial resolution, contrast or signal-to-noise ratio), but for estimation of physiological or biochemical parameters, such as rCBF (*1*) or even parameters as difficult to assess as receptor binding (*2*). Second, simplified approaches to kinetic modeling will promote more widespread use of modeling. These include easier acquisition protocols (e.g., the use of only a single dose or simplified blood sampling) and more automated data analyses (*3–5*). Third, since nuclear medicine is so oriented toward images, it seems likely that the type of quantification being discussed here will be presented in the form of images rather than as collections of numbers. Such images, called parametric images, have pixel values that represent a physiological or biochemical parameter rather than radioactivity concentration per se. They facilitate interpretation of regional data because they permit the viewer's brain to recognize regional patterns. For example, the bottom row of Tsuchida et al.'s Figure 3 shows model-corrected images that are no longer simple distributions of radioactivity, but have pixel values that are directly proportional to cerebral blood flow. These images are both more accurate and have higher contrast than the corresponding uncorrected images in the top row of the figure. Excellent additional examples of this point can be found in recent issues of *JNM* (*4,6*). A fourth point, not directly addressed by Tsuchida et al., is the concept of always judging utility in a specific context. The investigators do state that "it is necessary to validate the method in another group of subjects with a larger population and with different physiological and pathological conditions." Such a validation would demonstrate the quantitative accuracy of the model and their correction approach. I would argue that a completely different type of study would be necessary to demonstrate the diagnostic or prognostic accuracy of their approach. Without such a study, we do not really know the clinical utility of the approach, although its advantages for research are clear. An excellent example of 'judgment of utility in context' is found in the January 1996 issue of *JNM* (*7*).

Few who use models believe that they are absolutely accurate descriptions of "reality" (however perceived) (*8*). They need not be in order to be useful. If we can clearly define a problem whose solution requires the ability to describe and (especially) predict the results of further measurements, and if a given model provides the relevant solution in a feasible way, it is useful, and its widespread application should be encouraged. The challenge is in articulating the degree of accuracy required and knowing when (to quote Dr. Wagner again) to "stop grooming the horse and start riding it."

Jonathan M. Links
The Johns Hopkins University
Baltimore, Maryland

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For correspondence or reprints contact: Jonathan M. Links, MD, Department of Radiation Health Sciences, The Johns Hopkins University, 615 N. Wolfe St., Baltimore, MD 21205.

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