Rapid Prototyping Method Applied to the Development of Lung Calibration Phantoms from Patient-Specific Anatomical Data

M Mille, A. Novick, and XG Xu*

* Rensselaer Polytechnic Institute, USA

Accurate and precise measurements of radioactive materials retained in the human body are important for the radiation protection against internal contamination of nuclear workers and the internal dosimetry of patients undergoing nuclear medicine procedures. For *in-vivo* measurements of materials that emit gamma-rays, detectors are placed on or near the surface of the human body for gamma-ray spectroscopy. Calibrations for these measurements are experimentally performed using physical phantoms which simulate the contaminated human subject being measured in terms of geometry, radiation attenuation characteristics, and radionuclide distribution. Existing phantoms have not been revised for decades and do not realistically represent all portions of the population of workers who may be internally contaminated.

This research proposes to use patient-specific anatomical images and modern manufacturing methodologies, such as rapid-prototyping, to revolutionize phantom design. To this end, polygon-mesh files were created to describe the lung surface information of the image-based computational model known as VIP-Man. The lung mesh file was ported into the Z-Corporation 3D printer located in the Advanced Manufacturing Laboratory at Rensselaer Polytechnic Institute. Within a matter of hours, the machine printed a life-size replica of the lung out of a plaster material. While the plaster lung model has the correct geometry, it is not tissue-equivalent to real lungs in terms of radiation attenuation properties. Hence, the plaster prototype model was used to create a silicone rubber mold from which tissue-equivalent copies were cast out of polyurethane foam mixed with high-Z filler compounds. The final lung has similar geometry to that of the VIP-Man computational phantom and similar density and effective atomic number to real human lungs.

In the future, the lung phantoms will be uniformly labeled with radioactivity so that they can be useful for *in-vivo* measurement calibrations. The value of the described method lies in the fact that the method is completely generalizable to one’s specific needs and to many different applications. The challenges and opportunities in the development of phantoms are discussed.

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