CHEST-WALL THICKNESS PREDICTIONS FOR ACTINIDE LUNG COUNTING

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Abstract

Low-energy photons, emitted from actinides in the lungs, are significantly attenuated by the chest-wall tissue. Therefore, the quantitative determination of actinides in the lungs requires an accurate knowledge of the chest-wall thickness for each subject. Although ultrasound techniques have been employed for actual measurements of chest-wall thickness, they are impractical for a routine monitoring program. In practice, *in-vivo* laboratories have developed and utilized prediction equations that relate biometric measurements (e.g., weight and height) to chest-wall thickness. For very low energies (e.g., 17.3- and 20.1-keV uranium x rays from the decay of plutonium), an additional factor that must be considered is the relatively large difference in the attenuation coefficients for muscle and adipose tissues. Previous studies have either ignored these differences, or have utilized attenuation coefficients derived under "narrow beam" geometry conditions. In reality, *in-vivo* measurements are made under "broad beam" geometry conditions (finite size of the detectors and lungs, and no collimation). It would, therefore, be appropriate to use attenuation coefficients derived under these conditions. In this work, we experimentally determine the effective attenuation coefficients under actual *in-vivo* measurement conditions, and apply them to develop more realistic prediction equations.

Ultrasound measurements of 33 male and 37 female subjects were used to determine the muscle and adipose tissue thicknesses over the specific chest areas where the *in-vivo* detectors are normally placed. The "effective" chest-wall thickness for each individual was then calculated from the exponential averages of the measured values. Effective attenuation factors for muscle and adipose tissue were determined from 100% muscle and 87% adipose tissue overlays for the Lawrence Livermore Realistic Phantom. The effective attenuation factors include not only the influence of the broad beam scattering geometry, but also the effect due to the detectors being farther away from the lungs for the thicker overlays. The effective attenuation factors were then combined with the ultrasound measurements to develop realistic prediction equations. Since the *in-vivo* system is routinely calibrated with "equivalent 50% muscle, 50% adipose tissue" overlays, the equations were developed for equivalent chest-wall thicknesses obtained from 50% adipose and 50% muscle tissue thicknesses. The correlation coefficient (R^2) value for the male population was 0.76 with a standard error of 0.18. The R^2 value for the female population was 0.70 with a standard error of 0.22. The predicted values will be compared to other prediction equations.

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