^{123}I-mIBG and the phantom tollbooth

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Scintigraphic myocardial uptake of ^{123}I-metaiodobenzylguanidine (^{123}I-*m*IBG) is usually semiquantified by calculating a heart-to-mediastinum (H/M) ratio, after drawing region of interest (ROI) over the heart (including or not including the cavity) and the upper mediastinum (avoiding the thyroid gland) in the planar anterior view. Then, average counts per pixel in the myocardium are divided by average counts per pixel in the mediastinum.[1]

Despite efforts to standardize myocardial ^{123}I-*m*IBG scintigraphy,[2] difference in collimator use is one of the most important causes of discrepancy in H/M ratio values among institutions. The widespread availability of low-energy (LE) parallel hole collimators determines their common use for ^{123}I studies; however medium-energy (ME) collimators have been shown to provide superior semiquantitative accuracy in these type of studies.[3,4] In addition to the major emission of 159-keV photons, ^{123}I emits high-energy photons of more than 400 keV (approximately 2.87%, main contributor 529 keV, 1.28%), which lead to penetration of the LE collimator septa and cause scatter detected in the 159-keV energy window, resulting in image quality degradation and H/M ratio modification. The H/M ratio is lower when a LE collimator is used because of the increased proportion of mediastinum counts from scattered higher-energy photons.[5] ME collimators minimize the effects of septal penetration (Figure 1).[3–5]

To further complicate the standardization of the technique, the classification of collimators in two major groups of LE and ME is rather simplistic. Camera vendors offer several types of collimators in order to optimize balance among resolution, sensitivity, and applicable energy range, and collimators with equal designation from different vendors are not exactly the same. In addition, vendors can even change the specifications of the collimators without reclassifying them to a different category, which may further increase the variability in H/M ratio among institutions and published studies. It should also be taken into account that other technical gamma camera characteristics such as uniformity may influence the H/M ratio measurement.

To overcome differences in the choice of collimator for H/M ratio quantification, methods of multiple window acquisition and phantom cross-calibration have been reported. Multi-window methods can be easily performed by institutions attending to the capability of current camera-computer systems, but they lack deep validation and clinical experience. Furthermore, dual-energy window methods increase the H/M ratio at expense of reducing heart count density and, consequently, defect contrast.[6]

Three years ago, Nakajima et al. published the results of a large multicenter study of cross-institution phantom calibrations for the quantification of the H/M ratio by various gamma camera and collimator combinations from common vendors.[7] The authors had previously reported the phantom design to easily produce predefined H/M ratios.[6] They had also previously reported the initial standardization approaches in ten centers, supporting the concept that phantom calibration could be used to calibrate the H/M ratios between the ME and LE collimators.[8] The coefficient of conversion obtained by the calibration method of Nakajima and coworkers[7] was measured in 225 phantom experiments in 84 hospitals in Japan. The measured H/M ratio was successfully converted to the standardized H/M ratio among institutions. Moreover, the use of such standardized H/M ratio, comparable to that obtained with the ME collimator, improved risk classification in patients with heart failure.[7]

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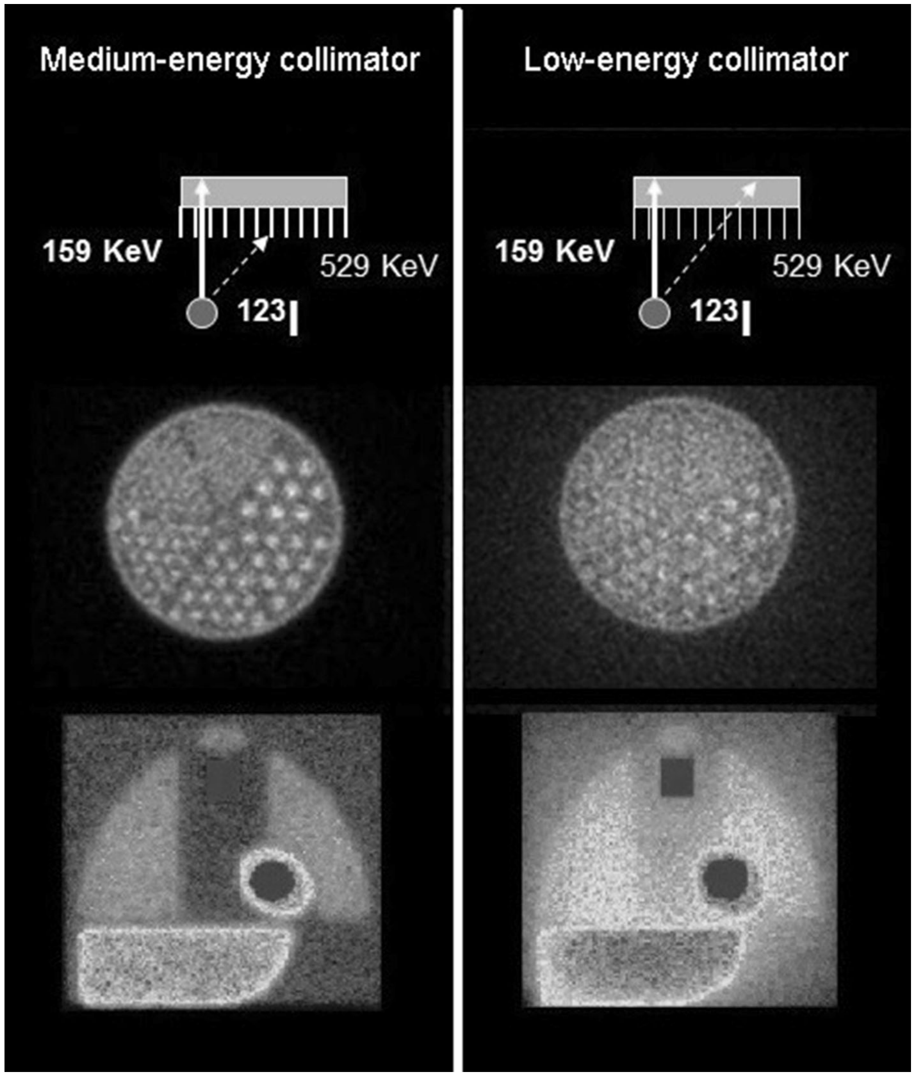

Figure 1. Schematic representation of septal penetration of ^{123}I emission using medium-energy and low-energy collimators *(upper row)*, with corresponding planar images acquired with a Jaszczak phantom (*middle row*) and the phantom used by Verschure et al.[9] (*lower row*). Image quality is better for the medium-energy collimator because of higher contrast and lower noise.

In theory, equal manufactured gamma cameras should provide the same H/M ratio, but in clinical practice this is not true. Therefore, the results obtained in Japan could not automatically be extrapolated to other countries and respective institutions. In this issue of the Journal, Verschure et al.[9] have performed a similar cross-calibration myocardial ^{123}I-*m*IBG phantom study to calculate conversion coefficients for specific individual gamma camera-collimator combinations in 27 European centers: one from Austria, seven from Belgium, 18 from the Netherlands, and one from the United Kingdom. Two hundred and ten phantom studies were performed using three different gamma camera brands ($n_1 = 148$, $n_2 = 44$ and $n_3 = 18$). Collimator types were divided into two categories: LE (grouping LE high resolution—LEHR–; LE general purpose—LEGP; and LE all purpose—LEAP collimators) and ME (grouping low medium-energy general purpose—LMEGP; ME general purpose—MEGP; and ME low penetration—MELP collimators). A core lab based in Japan performed the mathematical calculation of H/M ratios using the standard equation for attenuation. Compton scatter and septal penetration of gamma rays were not included in the formula. As the authors used a slightly modified version of the original Japanese phantom (lighter weight due to some hollow in acrylic parts filled with non-radioactive water), minor differences in reference values were adjusted to obtain matching results with the original phantom. The adjustments derived from the phantom modification by measuring dimensions of each phantom type by CT scan and recalculating the attenuation in the water and acrylics resulted in agreement of conversion coefficients using LEHR, LMEGP, and MEGP collimators using linear regression line.

The reference H/M ratios determined by the structure of the phantom were 2.60 for anterior acquisition and 3.50 for posterior acquisition. As expected, H/M ratios obtained with LE collimators were lower than those obtained with ME collimators. In line with the Japanese multicenter study, in the European multicenter study, the conversion coefficients for LE collimators were also lower than those for ME collimators. Overall, there were no statistically significant differences when the European conversion coefficients of LEHR, LEAP, LMEGP, and MEGP collimators were compared with the Japanese conversion coefficients. Only the conversion coefficients for LEGP and MELP collimators differed significantly, which might be explained by the minor differences between the Japanese and European phantoms.

The results of Verschure et al.[9] support the concept that cross-calibration myocardial ^{123}I-*m*IBG phantom studies allow for conversion of different institutional H/M ratios to standardized H/M ratios, which may facilitate multicenter comparison of myocardial ^{123}I-*m*IBG results. The method can be easily applied reducing variation in outcome measures and thereby further strengthening the clinical role of myocardial ^{123}I-*m*IBG scintigraphy.

When analyzing these results, it should be noticed that phantom studies denote an ideal situation far from human studies, which are subjected to inherent physiological variability of uptake not only in the organs in the field-of-view but also in those not included in it but contributing to additional scatter not modeled by the phantom. In addition, the effect of septal penetration on the estimation of the H/M ratio should also depend on the source geometry, not considered in the cross-calibration phantom studies previously commented, which were based on the homogeneous and flat distribution of the tracer. Thus, phantom studies can only partially mimic patient physical appearance and give an impression of repeatability and variability, but not necessarily reflect the accuracy of measurements. On the other hand, availability of phantom calibration for identical system configuration may improve the camera system independence and thus allow comparison of the multicenter data, or even serial test results at the same institution. These comparisons could even be performed retrospectively applying the appropriate corrections to the already existing multicenter data. Thus, as in Norton Juster's children's book The phantom tollbooth, in which a bored, lonely boy is startled by the unexpected arrival of a large, gift-wrapped package containing a tollbooth, which turns out to be a gateway into a magical parallel universe of the enchanted Kingdom of Wisdom in the Lands Beyond, the cross-calibration phantom study of Verschure et al.[9] may represent the gateway for large-scale clinical implementation of cardiac ^{123}I-*m*IBG scintigraphy. This study extends the Japanese phantom experience to European institutions enabling conversion coefficients for H/M ratio within Europe, which may help myocardial ^{123}I-*m*IBG scintigraphy to obtain more extensive data and enhance the evidence to support its routine clinical application.

Disclosure

The authors declare that they have no conflict of interest.

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