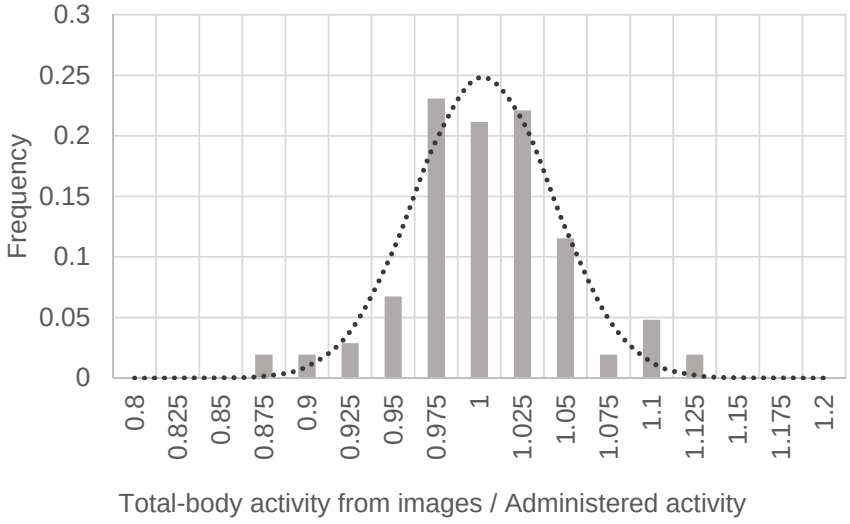
Estimation of the uncertainty in image-derived total-body activity values

For images acquired during the first week, quantified using the pixel-based method (Equation 11), the uncertainty in the activity values were due to *a*) a limited number of detected counts which give rise to noise in pixel values, and *b*) imprecisions in the corrections for attenuation, scatter and system sensitivity. For the late images where the ROI-based method was used, there was an additional uncertainty from ROI delineation.

For estimation of the variance in activity due to (*a*), i.e. σ_a^2, the variance in the detected number of counts, *N*, was estimated from Poisson statistics to $\sigma_N^2 = N$. For the pixel-based quantification method, the variance in each pixel was propagated through Equation 11, and then summed over all pixels. For the ROI-based method the variance in the sum of counts in the total-body ROI was propagated. This gave estimates of the variance in photon emission rate, σ_R^2, which was equal to the variance in activity.

For estimation of effects (*b*) an analysis was made of 104 patient images of ^{177}Lu-Dotatate acquired pre-voiding, at approximately 30 minutes p.i. The total-body activity obtained from the image-based quantification was divided by the administered activity (Supplemental Fig. 1), giving an average ratio of 0.99 ± 0.05 (1 SD). The obtained SD of 0.05 was assumed to reflect the combined imprecision in all applied corrections, and was for the pixel-based method used as estimate of σ_b^2 . For the ROI-based method, and additional variance of 7% was added to account for the uncertainty contribution from ROI drawing.



SUPPLEMENTAL FIGURE 1. Frequency histogram of the ratio of the total-body activity obtained from image-based quantification and the administered activity, for 104 patient studies acquired pre-voiding.

Estimation of the uncertainty in extrapolated activity values

To estimate the uncertainty in the extrapolation from the total-body activity values from the first week to the late acquisition times, the variability in the TAC was investigated. An error model was assumed, following:

$$\hat{A}_{TB}(t) = A_{TB}(t)(1 + \xi_b) + \xi_a \qquad \text{Supplemental Eq. 1}$$

where $\hat{A}_{TB}$ and A_{TB} are estimated and true total-body activity values, respectively, and

$\xi_a \in N(0, \sigma_a)$ and $\xi_b \in N(0, \sigma_b)$ are stochastic variables following normal distributions with expectation value of zero and SDs of $\sigma_a$and σ_b, respectively. Uncertainty propagation through the curve fitting procedure was performed using a Monte Carlo based approach. Here, the measured total-body activity values were used for estimation of A_{TB}, while $\hat{A}_{TB}$ were estimated using Supplemental Equation 1. A number of 10^{12} different TACs were generated. The uncertainty (a) was independent between measurement time points, and for each new value $\hat{A}_{TB}(t)$ a new random sample was therefore drawn from ξ_a. The correction factors were equal for all time points in a TAC, and ξ_b was sampled once for each new TAC. Curve-fitting was made for each TAC, and the extrapolated activity value at the late time point calculated. This yielded 10^{12} estimates of the extrapolated late-time activity, from which the SD was calculated.