Optimization of b-value distribution for four mathematical models of prostate cancer diffusion-weighted imaging using b-values up to 2000 s/mm^2: simulation and repeatability study

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Purpose

To find optimal b-value distributions for monoexponential, stretched exponential, kurtosis and biexponential models of prostate cancer (PCa) diffusion weighted imaging (DWI) using Monte Carlo simulations and repeated DWI examinations.

Methods

Monte Carlo simulations iming to minimize estimation accuracy error were performed using Rician noise. Ten PCa patients underwent in total four repeated 3 Tesla DWI examinations performed using 12 equally spaced b-values (0-2000 s/mm^2). Normalized mean signal intensities of regions-of-interest placed in normal tissue and PCa were fitted. In total, 210 different b-value combinations consisting of 6 b-values, 0 and 100 s/mm^2 included in every b-value distribution, were evaluated in terms of accuracy and repeatability. Repeatability of the fitted parameters was evaluate using intra class correlation coefficient ICC(3,1).

Results

The simulations and in vivo DWI data suggest the optimal b-value distribution for the monoexponential model consists of 4-5 equally distributed b-values in the range of 0-1200 s/mm^2. The parameters of the stretched exponential and kurtosis models are best estimated using 5-7 b-values in the ranges of 300-700 and close to 2000 s/mm^2 in addition to low b-value. B-value distribution consisting of 8-10 b-values in the ranges of 0-100, 800-1200, 1800-2000 s/mm^2 is the preferred method for estimation of the biexponential model parameters of PCa DWI.

Conclusion

The optimized b-value distributions demonstrated improved estimation accuracy and repeatability of DWI signal decay derived parameters.

Clinically relevant sentence:

The use of carefully selected b-values leads to improved estimation accuracy and repeatability of prostate cancer DWI derived parameters.