

Evaluation of the intrinsic ability of MPI systems in detecting perfusion defects - an extension of the quality metrics

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Abstract

Myocardial Perfusion Imaging (MPI) is a procedure based on the gamma ray detection to assess the blood flow through the heart and to locate perfusion defects (PDs). It is based on the application of the ligands marked by the gamma-emitting isotopes. Efficiency of the procedure is influenced by attenuation artifacts and quantitative post-processing algorithm used to obtain the 3D myocardial perfusion distribution presented as a 2D polar map. The defect perfusion index (DPI) was proposed to designate the intrinsic performances of the myocardial perfusion imaging system in detecting PDs [1].

A static semi-anthropomorphic thorax phantom was used to simulate normal and pathological myocardial perfusion conditions. MPI was performed using all technological solutions currently available: dual-detector SPECT systems with thallium-activated sodium iodide (NaI(Tl)) crystal detector and parallel-hole collimators, dual-detector cardio-centric SPECT/CT systems with NaI(Tl)-crystal detector and multi-focal collimators, and cadmium-zinc-telluride (CZT) detector systems with either parallel-hole or multi-pinhole collimators. Additionally, corrections for scatter and attenuation were implemented.

Quantitative analysis was performed using standard quantitative post-processing algorithm routinely used clinically for perfusion assessment. Reference system-specific databases with normal myocardial perfusion were created. These databases take into account the intrinsic attenuation characteristics of both the MPI system and the phantom, and the specific quantitative post-processing algorithm used. Additionally, DPI is determined only in segments covered by the PD. Hence, attenuation artifacts in the rest of the polar map are excluded. Comparison between DPI values for SPECT system with NaI(Tl)-crystal detector systems and CZT systems was performed in static conditions.

Dynamic controlled conditions were obtained by Monte Carlo (MC) simulations of electrocardiographically gated myocardial perfusion SPECT (GSPECT). GSPECT and corresponding non-gated SPECT acquisitions with NaI(Tl)-crystal detector and parallel-hole collimators were simulated by MC-based code SIMIND [2]. The 4D XCAT [3] voxelized dynamic phantom was used to model a standard male patient with both normal and pathological myocardial perfusion conditions. The positions of the PDs were selected in order to match conditions used in the experimental session with the static semi-anthropomorphic thorax phantom. For the NaI(Tl)-crystal detector system with parallel-hole collimators, considered the standard technology, the DPI was evaluated also in dynamic conditions.

The DPI has proven to be a physical descriptor that enables the extension and further advancement of the current MPI quality metrics. Results may be considered as reference values of the intrinsic ability of the MPI system to detect PDs in controlled static and dynamic conditions.

References

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