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Evaluation of Stationary and Semi-Stationary Acquisitions in a Dual-Head Multi-Pinhole Collimator for Myocardial Perfusion SPECT

by

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Abstract

EVALUATION OF STATIONARY AND SEMI-STATIONARY ACQUISISTIONS IN A DUAL-HEAD MULTI-PINHOLE COLLIMATOR FOR MYOCARDIAL PERFUSION SPECT

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Among all forms of illness, coronary artery disease (CAD) is one of the greatest causes of morbidity and mortality in the world. Non-invasive myocardial perfusion (MP) SPECT provides critical information for CAD diagnosis. Conventional myocardial SPECT is performed with two scintillation cameras equipped with parallel-hole collimators, offering relatively low detection efficiency and requiring long acquisition time. Pinhole SPECT offers superior spatial resolution and detection efficiency trade-off for small objects, while multi-pinhole (MPH) SPECT further increases detection efficiency.

In this study, we aim to optimize the design parameters of a MPH collimator based on a standard clinical dual-head SPECT scanner (Infinia Hawkeye 4, GE Healthcare), with two detectors connecting at ~90° apart. The first chapter of this thesis introduces the significance and treatment of CAD, basic principles of SPECT and different collimator configurations. In the second chapter, we introduce general considerations in MPH design, potential image artifacts and image reconstruction algorithm. In the third chapter, a review of existing methods for current research and commercial MPH SPECT systems is discussed. The fourth chapter introduces our MPH design optimization method and evaluation of new stationary and semi-stationary acquisition strategies using simulation studies. The fifth chapter describes our simulation results, comparing different MPH designs with conventional parallel-hole collimator. Potential limitations of this study are discussed in chapter 6. The conclusion and future work are in chapter 7.

The study shows the optimized design parameters are 12-pinhole, acceptance angle of 51°, aperture size of 4.6 mm, collimator length of 15.8 cm and imaging distance of 18.6 cm. The NMSE (normalized-mean-square-error) of L-mode-II (0.326) is the lowest among all stationary designs, while S-mode-II/40° provides the least NMSE result (0.139) among all acquisitions and is 36.1% better than that of LEHR. The NSD (normalized standard deviation)-NMSE and contrast-to-noise result shows that S-mode-II/40° has the best trade-offs. The 2D bias map of S-mode-II/40° approached to that of LEHR. Semi-stationary MPH acquisition substantially improves the image quality as compared to the full stationary design as well as conventional LEHR for MP SPECT.

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