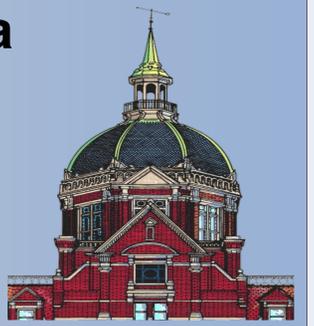




Quantitative Estimation of Organ Time-Activity Curves from SPECT Data using a Two-Camera System

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Objective: Dynamic changes in tracer uptake in the whole heart may be useful as early predictors of cardiovascular disease or heart failure. The goal of this study was to demonstrate the feasibility of measuring dynamic changes in volume-of-interest (VOI) activities using a dual detector gamma camera operating using data obtained at pairs of projection views. Previously we have developed the Qplanar[2] method for estimating the activity organs or other VOI from planar projections. The uses maximum-likelihood estimation techniques combined with accurate models of the image formation to estimate the total activity in a set of 3D VOIs (uniform activity concentration is assumed in each VOI). In this study, we adapted this methodology to extract dynamic information, in the form of the time activity curve for the myocardium and blood pool, from a conventional SPECT acquisition. We evaluated this method using and studied the feasibility of using the resulting TACs as inputs for compartmental analysis using simulated Tc-99m Teboroxime data. This method could eventually be applied to estimation of whole-heart myocardial flow reserve.

Method:

- Modeled uptake in the heart based on literature[1] TAC of Tc-99m Teboroxime.
- Modeled patient anatomy using the 3D XCAT phantom.
- Simulated data were generated using an analytic simulator that models attenuation, scatter and the collimator-detector response
- Modeled acquisition using a two-camera system in a right angle configuration.
- Modeled a 12 minute acquisition with data acquired at 120 views over 360° using continuous rotation.
- Studied the effects of noise by estimating TACs for 30 noise realizations.
- Studied effects of non-uniform myocardial uptake on TAC bias.
- Analyzed the blood and myocardium TACs using a 1-compartment kinetic model to characterize wash-in (K21) and wash-out (k12) parameters from estimated TACs.

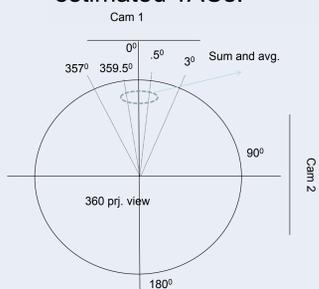


Figure (1)

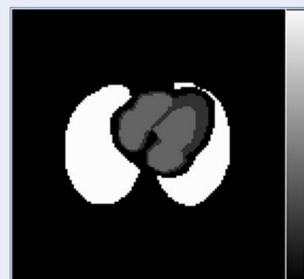


Figure (2a)

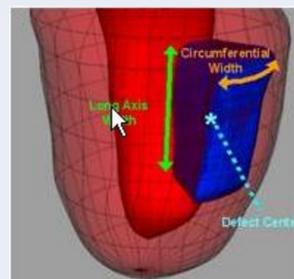


Figure (2b)

Figure 1. Schematic of simulation of method used to simulate continuous rotation of dual detector by averaging 3-sub projections generated at 1° angular increments. Figure (2a) Shows the XCAT phantom of normal myocardium with no perfusion defect. Figure (2b) shows the XCAT heart with a lesion defined as a pie shaped blue wedge in the left ventricle.

Results: Estimated TACs obtained from the heart and blood pool were unbiased when there was uniform activity in the myocardium (Figures 3-4). With a small defect present, which introduced non-uniformity in the myocardium, the bias in the estimated myocardial TAC was relatively small (see Figure 5). For large defects one would define the defect as a separate VOI. The method produces unbiased TACs, though the noise in the estimated TACS resulted in large variation in the estimated kinetic parameters. This indicates a smaller number of acquisitions, and thus a longer time per view, may be desirable.

Figure (3). True, mean, and standard deviation of myocardial TAC at stress from noisy projection data with no myocardial defect present.

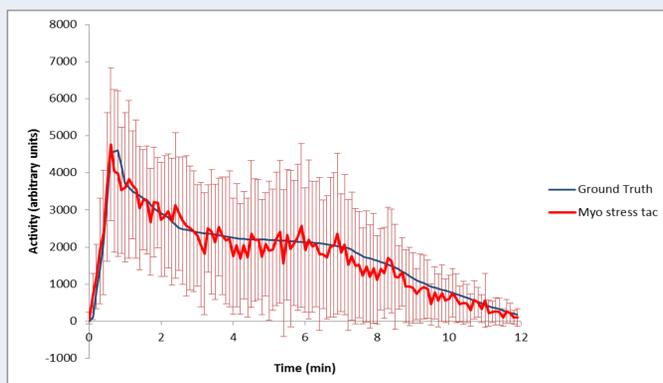
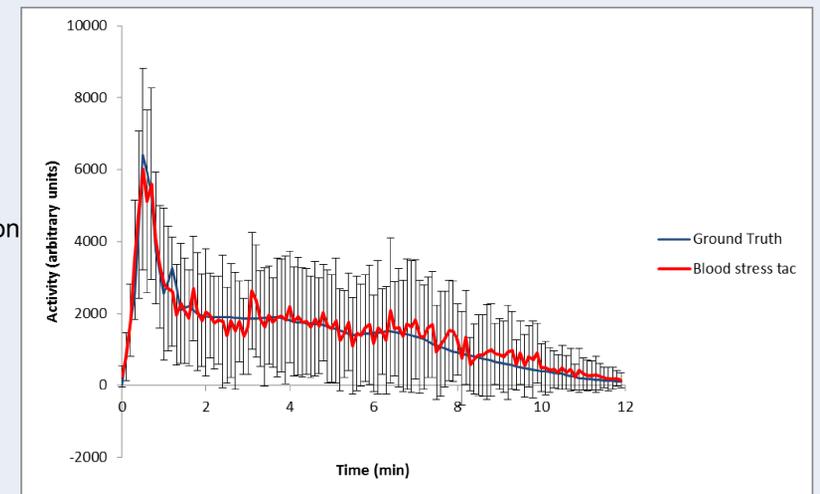


Figure 4. True, mean, and standard deviation of myocardial TAC at stress from noisy projection data with no myocardial defect present.



Estimated Myocardium and Blood Pool TAC %bias

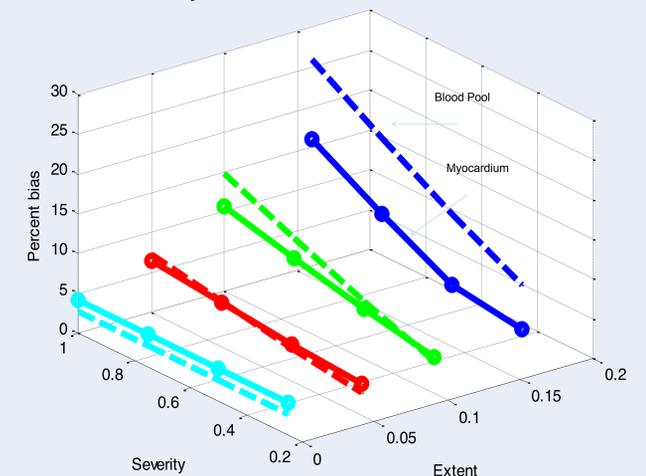
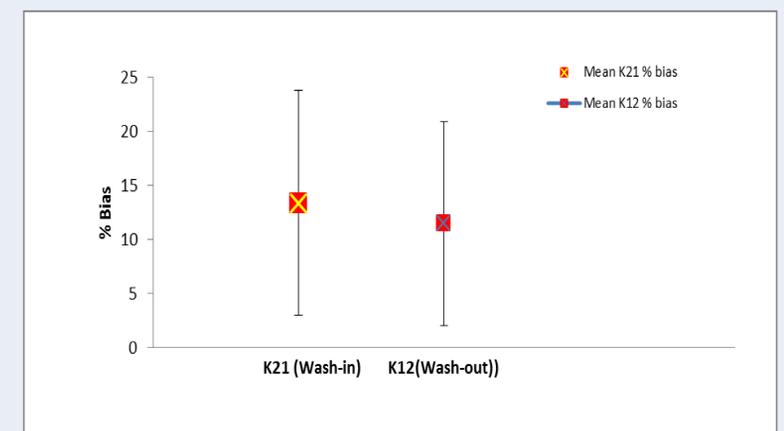


Figure 5. Plot of average % bias in the TAC as a function of perfusion defect extent (0% to 16%) and severity (25% to 100%). For small defects (extent 5% for all severities or severity of 25% for all extents studied) the % bias was small (~5%). For larger defects one could treat the defect as a separate VOI.

Figure (6) Plot of mean % bias of myocardial K21 (wash-in) and K12 (wash-out) parameters stress estimated from 9 noisy datasets and one noise-free dataset. There is substantial spread in the estimated parameters, but the estimate appears unbiased.



Conclusion: The proposed method allows relatively simple extraction of dynamic information about the myocardium and blood pool from a conventional slow acquisition protocol. With no perfusion defect present the heart and blood pool TACs are unbiased. If perfusion defects are small (extent <16%, severity < 50%), accuracy of whole heart TAC and blood pool TAC is also very good. Kinetic parameters estimated from the TACs also appear unbiased, though there is considerable variability. This indicates the need to optimize the data acquisition parameters including the number of projection views.

References: [1] Chiao P-C, Ficaro E P, Dayanikli F, Rogers W L and Schwaiger M 1994a Compartmental analysis of technetium-99m-Teboroxime kinetics employing fast dynamic SPECT at rest and stress *J. Nucl. Med.* 35 1265-73

[2] B. He, Frey E. C., Comparison of conventional model-based quantitative planar and quantitative SPECT image processing methods for organ activity estimation using In-111 agents, *Physics in Medicine and Biology*, vol.51, pp. 3967-3981, 2006