



Nuclear cardiology in the literature: A selection of recent, original research papers

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Received Jan 14, 2019; accepted Jan 14, 2019
doi:10.1007/s12350-019-01610-5

Deep Learning for Prediction of Obstructive Disease From Fast Myocardial Perfusion SPECT. A Multi-center Study

Julian Betancur, Frederic Commandeur, Mahsaw Motlagh, Tali Sharir,

Andrew J. Einstein, Sabahat Bokhari, Mathews B. Fish, Terrence D. Ruddy, Philipp Kaufmann, Albert J. Sinusas, Edward J. Miller, Timothy M. Bateman, Sharmila Dorbala, Marcelo Di Carli, Guido Germano, Yuka Otaki, Balaji K. Tamarappoo, Damini Dey, Daniel S. Berman and Piotr J. Slomka.

Los Angeles, CA

J Am Coll Cardiol Img 2018;11:1654–63

Context: Deep convolutional neural networks trained with a large multicenter population may provide improved prediction of per-patient and per-vessel coronary artery disease from single-photon emission computed tomography myocardial perfusion imaging (SPECT MPI).

Methods and Results: This study evaluated the automatic prediction of obstructive coronary artery disease (CAD) from SPECT MPI by deep learning as compared with total perfusion deficit (TPD). In this retrospective study, data from 1,638 patients (67% men) without known coronary artery disease, who underwent stress 99mTc-sestamibi or tetrofosmin SPECT MPI with solid-state camera scanners at 9 different sites was analyzed. All included patients had invasive coronary

angiography (ICA) performed within 6 months of MPI. Obstructive CAD was defined as $\geq 70\%$ narrowing of coronary arteries ($\geq 50\%$ for left main artery). Left ventricular myocardium was segmented using clinical nuclear cardiology software and verified by an expert reader. Stress TPD was computed using sex- and camera-specific normal limits. Deep learning was trained using raw and quantitative polar maps and evaluated for prediction of obstructive stenosis in a stratified 10-fold cross-validation procedure. The authors found that a total of 1,018 (62%) patients and 1,797 of 4,914 (37%) arteries had obstructive CAD. Area under the receiver-operating characteristic curve for CAD prediction by deep learning was higher than for TPD (per patient: 0.80 vs. 0.78; per vessel: 0.76 vs. 0.73: $p < 0.01$). When deep learning threshold set to the same specificity as TPD, per-patient sensitivity improved from 79.8% (TPD) to 82.3% (deep learning) ($p < 0.05$), and per-vessel sensitivity improved from 64.4% (TPD) to 69.8% (deep learning) ($p < 0.01$). These results suggest that deep learning has the potential to improve automated interpretation of MPI as compared with current employed clinical techniques.

Significance: There is continued progress in the field of artificial intelligence (AI) to provide complementary diagnostic information in cardiovascular imaging. The promising results of this study highlight the ability of AI to further advance the diagnostic ability of high-resolution SPECT. Though statistically significant, the clinical relevance of these small absolute differences in accuracy for detecting anatomical CAD will need further rigorous evaluation in studies evaluating clinically relevant hard cardiovascular outcomes.

Current Status of Patient Radiation Exposure of Cardiac Positron Emission Tomography and Single-Photon Emission Computed Tomographic Myocardial Perfusion Imaging. A Report From the Intersocietal Accreditation Commission Database.

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J Nucl Cardiol 2019;26:363–5.
1071-3581/\$34.00

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Michael C. Desiderio, Justin B. Lundbye, William L. Baker, Mary Beth Farrell, Scott D. Jerome and Gary V. Heller

Morristown, NJ

Circ Cardiovasc Imaging. 2018;11:e007565. DOI: 10.1161/CIRCIMAGING.118.007565

Context: American Society of Nuclear Cardiology (ASNC) had recommended reducing average radiation exposure to patients from nuclear cardiology procedures to <9 mSv in 50% of the patients by 2014. It is unknown whether nuclear cardiology laboratories are achieving this goal for single-photon emission tomography (SPECT) and positron emission tomographic (PET) myocardial perfusion imaging (MPI).

Methods and Results: In this study, the authors evaluated the currently reported patient radiation exposure from nuclear laboratories in the United States. Data on isotope type and dose were used to determine the radiation exposure from sample SPECT (for year 2015) and PET (years 2013 to 2015) reports submitted for laboratory accreditation to the Intersocietal Accreditation Commission. Reported PET MPI radiation exposure for 111 laboratories (532 patient cases) was 3.7 (3.2–4.1) mSv per study with no geographic variation. On the contrary, reported SPECT MPI radiation exposure for 665 laboratories (3067 patient studies) was 12.8 (12.2–14.3) mSv, with the highest radiation exposure from SPECT MPI in the south region. Majority of the SPECT MPI (~85% studies) were performed with Technetium-only protocol, though only $<0.5\%$ employed a stress-only (SO) approach. These results indicate that radiation exposure from SPECT MPI in the United States does not meet the recommendations set forth by ASNC. Average per-patient radiation exposure from PET MPI is significantly lower than SPECT MPI.

Significance: Despite the awareness toward radiation reduction from MPI, the results of this study suggest that radiation reduction practices are not being employed by majority of the laboratories performing SPECT MPI. Particularly striking is the low utilization of SO protocols, which likely stems from the lack of clinically relevant and easy to use patient selection criteria for such a protocol. While, use of a SO or stress-first (SF) approach is intuitive for high-throughput CZT systems, majority of the laboratories still employ standard Anger cameras for SPECT MPI that makes routine application of these protocols challenging. The need of the day is to identify patient selection criteria for SO/SF imaging that can be effectively applied in most laboratories performing SPECT MPI with Anger systems. This along with utilization of advanced reconstruction software can allow for laboratories to perform SO/SF

SPECT MPI in a larger proportion of their patients with effective radiation exposure <9 mSv. Use of new high-resolution CZT systems could bypass this requirement, though replacement of Anger cameras by CZT systems across majority of the laboratories may not be economically viable.

Ventricular Tachycardia (VT) Substrate Characteristics: Insights from Multimodality Structural and Functional Imaging of the VT Substrate Using Cardiac MRI Scar, ^{123}I -Metaiodobenzylguanidine SPECT Innervation, and Bipolar Voltage.

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J Nucl Med. 2019 Jan;60(1):79-85

Context: Posts ischemic adaptation results in characteristic myocardial structural and functional changes in the ventricular tachycardia (VT) substrate. Ability to image this substrate may aid in the management of VT.

Methods and Results: This study aimed to compare imaging correlates of myocardial structural and functional adaptations (late gadolinium enhancement/abnormal innervation) with detailed VT voltage mapping on electrophysiology (EP) study to identify regional heterogeneities in posts ischemic myocardium. The authors studied 15 patients with ischemic cardiomyopathy and drug refractory VT for which they were to undergo radiofrequency ablation. All patients underwent late gadolinium enhancement cardiac MRI (CMR), ^{123}I -metaiodobenzylguanidine (mIBG) SPECT, and high-resolution bipolar voltage mapping, to assess for myocardial scar (on CMR), abnormal innervation ($<50\%$ tracer uptake on mIBG imaging), and low-voltage area (<1.5 mV on EP study), respectively. Three-dimensional reconstructed CMR/mIBG models were coregistered for further comparison. All posts ischemic structural and functional changes were similar in size, median (interquartile range): CMR scar: 46.1 cm^2 (33.1–86.9 cm^2), abnormal innervation: 47.8 cm^2 (40.5–68.1 cm^2), and low-voltage area: 29.5 cm^2 (24.5–102.6 cm^2); $p > 0.05$. However, any single modality underestimated the total VT substrate area (76.0 cm^2 [57.9–143.2 cm^2]; $p < 0.001$), defined as abnormal in at least 1 of the 3 modalities. Within the total VT substrate area, regions abnormal in all 3 modalities were most common (25.2%). However, heterogeneous adaptations were noted in significant regions of the VT substrate

(abnormal in <3 modalities), with the most common features being “abnormal innervation only” (18.2%), “CMR scar plus abnormal innervation only” (14.9%), and “CMR scar only” (14.6%). All 14 VT channel/exit sites (0.88 ± 0.74 mV) were localized to myocardium that demonstrated CMR scar and abnormal innervation, and this specific tissue category accounted for 68.3% of the CMR scar and 31.2% of the total abnormal postischemic VT substrate area. Results of this novel study demonstrate that regional heterogeneities in the postischemic VT substrate are not appreciated by any single modality alone. The coexistence of abnormal innervation and CMR scar may identify “proarrhythmic” adaptations.

Significance: This study shows the feasibility of structural and functional imaging with CMR and mIBG SPECT for identifying postischemic VT substrate. Myocardium with denervated scar is likely to represent arrhythmogenic substrate, and multimodality imaging-based identification of this substrate has the potential to guide VT ablation.

Disclosures

Author has nothing to disclose.

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