Added Value of Artificial Intelligence In Myocardial SPECT and PET Perfusion imaging with anatomic multimodality imaging in the Detection of Cardiac Ischemia

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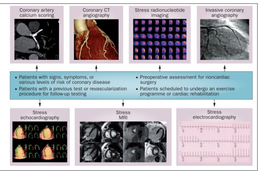
INTRODUCTION

Teaching Objectives:

- To highlight multimodality imaging in Coronary Artery Disease (CAD)
- To review role of AI in Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET) myocardial perfusion imaging (MPI)
- To discuss briefly the methods of Artificial Intelligence (AI) in MPI
- To discuss added advantages of AI to routine SPECT and PET MPI in every stage of the diagnostic, risk-stratification and follow-up of patients affected by CAD

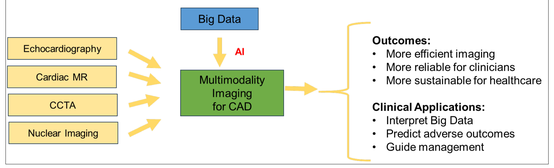
CAD and Multimodality Imaging:

- CAD: leading cause of death world wide
- Multimodality imaging: diagnosis and risk stratification
- Example: coronary computed tomography angiography

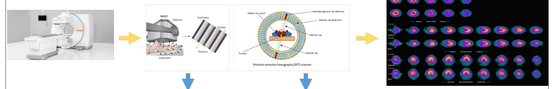


Multimodality Imaging and Artificial Intelligence (AI):

- AI pivotal role in echocardiography, CCTA, cardiac magnetic resonance and nuclear imaging
- AI identify early predictors of adverse outcome that human eyes cannot detect in the fog of "big data"



Nuclear Cardiology for Ischemia Assessment:



Single-photon emission computed tomography (SPECT)

- Pro: Low cost
- Con:
  - Qualitative methods
  - Prone to possible CAD underestimation (non-obstructive)

Positron emission tomography (PET)

- Pro:
  - Quantitative methods
  - Detect microvascular ischemia
- Con:
  - High cost
  - High technical complexity

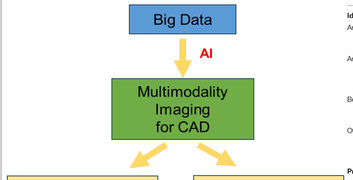
METHODS

- Databases Medical Literature Analysis and Retrieval System Online (MEDLINE)/PubMed and Google Scholar were used for the literature search between 2013 and 2023.
- Key words: "nuclear," "cardiology," "coronary artery disease," "ischemic heart disease," "artificial intelligence," "big data," and "nuclear medicine."
- Editorial, commentaries, and unpublished works were excluded.

RESULTS

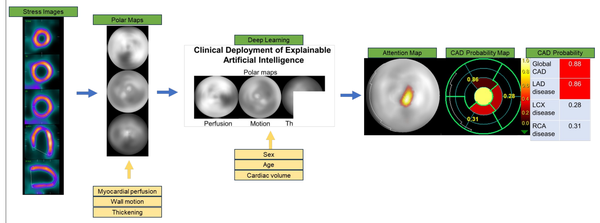
Goals of AI Applications:

Apart from those aimed at image pre-processing and segmentation, the major AI applications to myocardial perfusion SPECT focused on boosting the power of cardiac nuclear imaging in two principal tasks: **to identify patients with obstructive CAD and to define their prognosis**.



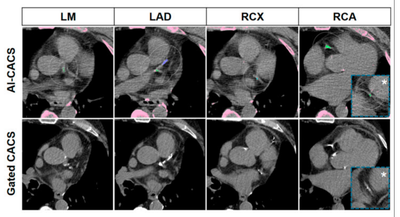
References	Summary
Identification of patients with obstructive CAD	
Arsanjani et al. (56)	Comparison of automated quantification of myocardial perfusion SPECT to expert visual analysis
Arsanjani et al. (57)	Comparison of automated quantification of myocardial perfusion SPECT integrated with clinical information to expert visual analysis and traditional TPD quantification
Betancur et al. (58)	Automated prediction of obstructive CAD by DL algorithm on SPECT as compared with total perfusion deficit (TPD)
Otaki et al. (59)	Automated prediction of obstructive CAD by externally validated DL algorithm on SPECT as compared to expert visual analysis and with total perfusion deficit (TPD)
Prognostic evaluation	
Arsanjani et al. (60)	Application of ML algorithm to SPECT analysis to predict early revascularization in patients with suspected CAD
Betancur et al. (61)	MACE risk prediction with a ML application integrated with clinical and SPECT imaging features
Hu et al. (62)	Efficacy of per-vessel prediction of early revascularization compared among ML application, expert evaluation and standard TPD quantification

AI Application of SPECT for CAD:

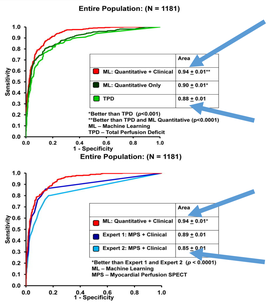


AI Application of PET for CAD:

- Morf C et al.
- 18F-FDG PET/CT + cardiac SPECT
- Fully automated AI measurement of Coronary Artery Calcium Score (CACS)
  - Left main (LM)
  - Left anterior descending (LAD)
  - Right circumflex (RCX)
  - Right coronary artery (RCA)
- Appropriate detection:
  - Sensitivity 85%
  - Specificity 90%

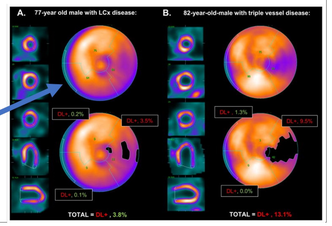


AI Identification of CAD:

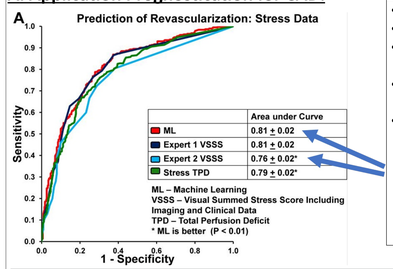


- Arsanjani R et al.
- N = 1,811
- Combined clinical data + quantitative imaging features of SPECT
- Reported that the machine learning (ML) model possessed **comparable or better diagnostic accuracy** than experts and total stress perfusion deficit (TPD)

- Betancur J et al.
- N = 1638
- AUC was higher for deep learning (DL) model than TPD
  - DL 0.80
  - TPD 0.78
- QPS algorithm-generated **polar maps**
  - 2 cases where **DL > TPD**
    - 1 patient: 77 y/o M
    - 3 vessel disease: 82 y/o M

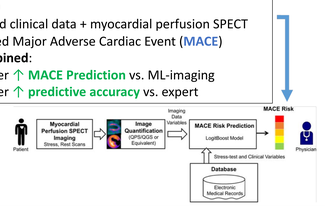


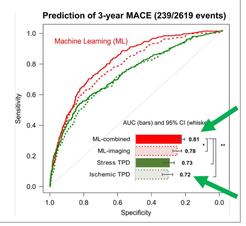
AI Application Prognostication for CAD:



- Arsanjani R et al.
- N = 713
- Combined clinical data + quantitative imaging features of SPECT
- Measured for prediction of revascularization
- When compared to experienced readers, ML reported:
  - Similar sensitivities –
  - Improved specificity ↑
  - Similar/improved AUC – / ↑

- Betancur J et al.
- N = 2619
- Combined clinical data + myocardial perfusion SPECT
- Developed Major Adverse Cardiac Event (MACE)
- **ML-combined**:
  - Higher ↑ **MACE Prediction** vs. ML-imaging
  - Higher ↑ **predictive accuracy** vs. expert





CONCLUSION

Multimodality AI in CAD:

- The medical management of patients with coronary artery disease, one of the most prevalent diseases in the world, is rapidly progressing with the implementation of multimodality imaging in diagnostic and prognostic routine workflows.
- AI applications have proven the ability to significantly improve the detection of coronary artery disease with both an anatomical and a functional imaging approach.
- Thus, the application of Nuclear Cardiology AI with anatomic **multimodality imaging will continue to play a prominent role in every stage of the diagnostic, risk-stratification and follow-up of patients affected by coronary artery disease**. Larger clinical validation and research on safety need to be implemented before large-scale adoption in routine clinical practice.

Nuclear AI in CAD:

- New artificial intelligence (AI) tools have the potential to dramatically enhance the utility of cardiac SPECT/CT and PET/CT in the near future. Incorporation of AI techniques to standardize and automate processing of cardiac SPECT/CT and PET/CT can improve diagnosis, risk prediction, and ultimately patient care
- The new AI techniques to extract and integrate quantitative information can be efficiently translated to SPECT/CT and PET/CT imaging.
- Due to the intrinsically rich information available in flow, perfusion, and CT images, **cardiac SPECT/CT and PET/CT enhanced with AI methods has a true potential to become a frontline modality** for a wide range of cardiovascular applications.

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