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# Study of Myocardial Scintigraphy Synchronized with Electrocardiogram: Applications to Coronary Insufficiency

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**Abstract.**

The aim of this work is to study the correlation between the data from myocardial tomoscintigraphy (MTS) images and the data from electrocardiogram (ECG) signals in order to, on one hand, detect myocardial ischemia in terms of location, intensity, and progression, and on the other hand, optimize this data to obtain more diagnostic information and adapt the treatment of coronary insufficiencies.

Myocardial tomoscintigraphy involves injecting a radiopharmaceutical drug (Sestamibi-99mTc, Tetrofosmin-99mTc, Thallium 201) in two phases (stress and rest), specifically for the indication of cardiac ischemia. Comparing the images from both phases allows for the evaluation of myocardial perfusion.

The acquisition of tomoscintigraphic images is performed using a dual-head gamma camera synchronized with an electrocardiographic signal. This is known as Synchronized Single-Photon Emission Tomography. These cameras, known as Anger or conventional cameras, use a crystal (NaI(Tl)) and photomultiplier tubes to convert detected gamma rays into electrical signals.

The newer generations of gamma cameras have significantly reduced the injected activities and acquisition durations by replacing the NaI(Tl) crystal with a semiconductor: Cadmium-Zinc-Telluride (CZT). This change in the detection chain has increased sensitivity and energy resolution while reducing the dimensions of the detector through the elimination of photomultiplier tubes.

Other hybrid devices combine a gamma camera with a computed tomography scanner (SPECT-CT). This combination involves obtaining CT scan images, which allow for attenuation correction in SPECT images and the estimation of coronary calcium scores through the fusion of three-dimensional images from both acquisition techniques.

The electrocardiogram is the primary technique used to diagnose cardiovascular diseases. Due to its ease of execution, immediate interpretation, low cost of equipment, and accessibility of the procedure, it is widely used by practitioners and accessible to the population.

Developing an early detection technique from an ECG tracing will enable adequate and rapid management of patients, especially during the silent phase of coronary insufficiency.

By integrating advanced imaging techniques, data analysis, and artificials intelligence support systems, the objective of this study is to highlight the relationship between the non-perfused region in the myocardium and the corresponding portion in the ECG tracing, in order to determine the degree of coronary artery stenosis from the electrocardiogram.

***Keywords:*** *Coronary Artery Diseases · Cardiac ischemia · Myocardial Infarction · Artificial Intelligence · Electrocardiogram · Myocardial Tomoscintigraphy · Nuclear Cardiology.*

# 1 Introduction

With the significant development in recent years of myocardial tomoscintigraphy (MTS) synchronized with the electrocardiogram (ECG), the diagnosis of certain cardiovascular pathologies, particularly cardiac ischemia, can be made early, even in its silent phase. Therefore, MTS coupled with ECG is currently considered the reference technique for exploring stress-induced myocardial ischemia during exercise, and it is strongly recommended before any surgical intervention.

Cardiovascular diseases are conditions that affect the heart and/or blood vessels. These conditions include diseases of the coronary arteries that supply blood to the heart, which can lead to myocardial ischemia or even a heart attack.

Early detection of myocardial ischemia helps reduce the risk of irreversible heart complications. It is important to note that the onset of this disease occurs silently and may go undetected even during routine medical consultations.

Studying the electrocardiogram (ECG) signal and myocardial tomoscintigraphy (MST) images, with or without a stress test, allows for the diagnosis of this condition in terms of the intensity and location of coronary artery stenoses.

# 2 Problematic

Cardiac ischemia, a condition characterized by insufficient blood supply to the heart, poses a significant health risk and necessitates early detection for effective intervention. However, the silent nature of the disease and its limited detectability during routine examinations present challenges in timely diagnosis.

Electrocardiogram (ECG) and myocardial tomoscintigraphy (MST) have shown promise in detecting cardiac ischemia. ECG provides insights into heart's electrical activity, while MTS allows visualization of regional perfusion defects. However, there is a need to optimize the combined utilization of these diagnostic techniques to improve accuracy and efficiency in early detection and localization of ischemic regions within the coronary arteries.

Therefore, the primary problem to address is:
How can the integration and optimization of ECG and myocardial tomoscintigraphy be achieved to enhance early detection of cardiac ischemia, considering the silent nature of the disease and the importance of precise localization of perfusion defects?

# 3 Methodology

This is a retrospective study. Data from over 200 patients who underwent myocardial scintigraphy (with or without a stress test) between January 2017 and December 2022 were collected, categorized, and processed.

For the ischemia test, patients underwent a stress test on a cycle ergometer or a treadmill. Other patients received pharmacological stress (slow intravenous injection of 0.56 mg/kg Dipyridamole). This stress test was followed by the injection of 7 to 10 mCi of Technetium-99m Sestamibi.

Two hours later, these patients received a second injection with three times that of the first administered dose. Image acquisition was performed 15 minutes after the administration of the radiopharmaceutical drug.

An exploitation form was established to organize certain patient information, such as gender, age, cardiovascular risk factors, MTS results, and ECG results. The analysis of these entries led to the creation of four patient categories.

# 4 Solution

To further increase early detection of cardiac ischemia through the optimization of ECG and myocardial tomoscintigraphy correlation, the future work aims to apply advanced data analysis techniques, including machine learning algorithms, to analyze the combined ECG leads and tomoscintigraphy images. This can help identify patterns, correlations, and predictive markers that enhance the accuracy and efficiency of ischemia detection.

# 5 Conclusion

Early detection of cardiac ischemia through the optimization of ECG and myocardial tomoscintigraphy plays a crucial role in reducing the risk of irreversible cardiac complications. By integrating these diagnostic tools and utilizing advanced imaging techniques, data analysis, and artificials intelligence based clinical decision support systems, healthcare professionals can accurately identify and localize perfusion defects associated with ischemia. This enables timely intervention and tailored management approaches for patients with coronary insufficiency. Continued research and collaboration in this field will further enhance the

effectiveness and reliability of these diagnostic methods, ultimately leading to improved patient outcomes and better management of cardiac ischemia.

## References (3-6 in Basic)

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