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# Photon counting computed tomography for atherosclerotic plaque characterization

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**SUMMARY**

Photon-Counting Computed Tomography (PCCT) represents a significant advancement in the field of medical imaging, offering enhanced capabilities for the characterization of atherosclerotic plaques. Atherosclerosis, a leading cause of cardiovascular diseases, involves the build-up of plaques within the arterial walls, which can lead to serious health issues like heart attacks and strokes. Accurate characterization of these plaques is crucial for diagnosis, risk assessment, and treatment planning. PCCT, with its superior resolution and material differentiation capabilities, holds great promise in improving the detection and analysis of these plaques. PCCT differs from conventional CT in its detection mechanism. Traditional CT systems use energy-integrating detectors that measure the total energy deposited by incoming X-ray photons, providing an average value across a broad spectrum. In contrast, PCCT utilizes Photon-Counting Detectors (PCDs), which count individual photons and measure their energy levels. This allows PCCT to capture more detailed information about the X-ray spectrum and improves image quality and material differentiation.

**Keywords:** Photon; Tomography; Plaques; Energy; Detector; Material; Quality

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## INTRODUCTION

By measuring the energy of each photon, PCCT can perform spectral imaging, distinguishing between different materials based on their energy-dependent X-ray absorption characteristics. PCCT systems generally offer higher spatial resolution compared to conventional CT, allowing for more detailed visualization of small structures. By discarding low-energy photons and reducing electronic noise, PCCT can produce images with better contrast and lower noise levels. PCDs are the heart of PCCT technology. They are composed of semiconductor materials such as Cadmium Telluride (CdTe) or Cadmium Zinc Telluride (CZT), which are capable of converting incoming X-ray photons into electrical signals [1].

An X-ray photon enters the detector and is absorbed by the semiconductor material, generating electron-hole pairs. An electric field within the detector drives the electron-hole pairs towards electrodes, creating an electrical signal proportional to the energy of the absorbed photon. The electrical signals are processed to count the number of photons and measure their energies, enabling the creation of spectral images. Atherosclerosis is a chronic inflammatory condition characterized by the accumulation of lipids, cholesterol, and cellular debris within the arterial wall, forming plaques. These plaques have a thick fibrous cap and are less likely to rupture. They cause symptoms primarily through the gradual narrowing of the artery, leading to reduced blood flow. These plaques have a thin fibrous cap and a large lipid core, making them prone to rupture. Rupture can lead to the formation of a blood clot, potentially causing a heart attack or stroke. Understanding the composition and structure of these plaques is essential for predicting their behavior and associated risks. Identifying vulnerable plaques can help predict the likelihood of acute cardiovascular events, enabling preventive measures.

Detailed knowledge of plaque composition can guide therapeutic decisions, such as the choice between medical management and interventional procedures. Assessing plaque progression or regression over time can evaluate the effectiveness of treatments. PCCT's ability to differentiate materials based on their energy-dependent X-ray absorption profiles is particularly valuable in plaque characterization. Different components of atherosclerotic plaques such as calcium, lipids, and fibrous tissue have distinct spectral signatures. PCCT can effectively distinguish these components, providing a detailed analysis of plaque composition [2-4].

## LITERATURE REVIEW

PCCT can accurately measure the calcium content within plaques, which is an important marker of plaque stability. By analysing the spectral data, PCCT can differentiate between lipid-rich necrotic cores and fibrous caps, aiding in the identification of vulnerable plaques. PCCT systems offer higher spatial resolution compared to conventional CT, enabling better visualization

of small and complex structures within the arterial walls. This enhanced resolution allows for more precise measurement of plaque dimensions and morphology, which is crucial for accurate risk assessment.

The noise reduction capabilities of PCCT contribute to clearer images with better contrast, facilitating the detection of subtle changes in plaque composition and structure. This is particularly important in the early detection of vulnerable plaques, where small variations in tissue properties can indicate significant risks. Coronary Artery Disease (CAD) is one of the most common manifestations of atherosclerosis. PCCT's superior imaging capabilities can significantly improve the detection and characterization of coronary artery plaques.

## DISCUSSION

Identify Plaque Components: By differentiating between calcified and non-calcified plaque components, PCCT can identify features associated with plaque vulnerability, such as a thin fibrous cap and a large lipid core, aiding in risk stratification. Detailed imaging provided by PCCT can assist in planning and guiding interventional procedures, such as Percutaneous Coronary Interventions (PCI), ensuring better outcomes. Peripheral arterial disease, another common form of atherosclerosis, affects the arteries supplying blood to the limbs. High-resolution images and material differentiation can improve the detection of atherosclerotic plaques in peripheral arteries. Detailed assessment of plaque morphology and composition can aid in determining the severity of PAD and guiding treatment decisions.PCCT can be used to monitor changes in plaque characteristics over time, providing insights into disease progression and treatment efficacy. Atherosclerosis affecting the cerebrovascular system can lead to strokes and Transient Ischemic Attacks (TIAs). Advances in detector materials and designs aim to improve count rate capabilities and energy resolution, enhancing the overall performance of PCCT systems. Development of sophisticated algorithms for image reconstruction, noise reduction, and material decomposition is essential for maximizing the benefits of PCCT. Large-scale clinical studies are needed to validate the efficacy of PCCT in various applications and establish its role in routine clinical practice [5,6].

## CONCLUSION

Photon-counting computed tomography represents a transformative advancement in the field of medical imaging, offering unprecedented capabilities for the characterization of atherosclerotic plaques. Its superior material differentiation, enhanced spatial resolution, and improved noise reduction provide detailed insights into plaque composition and morphology, facilitating accurate risk assessment and treatment planning. While technical and clinical challenges remain, ongoing research and development efforts hold promise for further enhancing the capabilities of PCCT and integrating it into routine clinical practice. As this technology continues to evolve, it has the potential to significantly improve the diagnosis, management, and outcomes of patients with atherosclerotic cardiovascular diseases.

## ACKNOWLEDGEMENT

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## CONFLICT OF INTEREST

None.

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