Artificial intelligence enhanced computed tomography coronary angiography in stable chest pain:

A multi-modal pathway for risk stratification of non-obstructive coronary artery disease

R Crichton [1], E MacAlindon [2], S Hothi [2]
[1] University Hospitals Birmingham, [2] Heart and Lung Institute, Royal Wolverhampton Hospital

The Problem

Coronary artery disease (CAD) is a leading cause of premature death in the UK. Over the past six decades premature mortality rates have fallen dramatically however recent trends indicate a troubling reversal.[1] Radiologically obstructive disease accounts for only one third of the cardiac related deaths in the stable angina population with the majority of deaths occurring in patients with non-obstructive CAD.[2] This indicates a substantial unmet healthcare need for risk stratification and preventive treatment within this subgroup. One method to risk stratify patients in this non-obstructive CAD cohort may be to utilise opportunistic artificial intelligence (AI) analysis of coronary computed tomography angiography (CTCA) studies, integrating these in existing clinical pathways to target preventative therapy. Several tools have shown promise in stratifying risk throughout this population these however real-world deployments and use remain limited.[3,4,5]

Objectives

To evaluate the feasibility of real-world deployment and potential clinical impact of multiple integrated AI-based CTCA analyses, including existing fractional flow reserve computed tomography (FFR-CT, HeartFlow, Mountain View, USA), coronary Plaque Analysis (HeartFlow, Mountain View, USA), and a multi factor tool, CaRi-Heart Score (Caristo, Oxford, UK) within an NHS district general hospital.

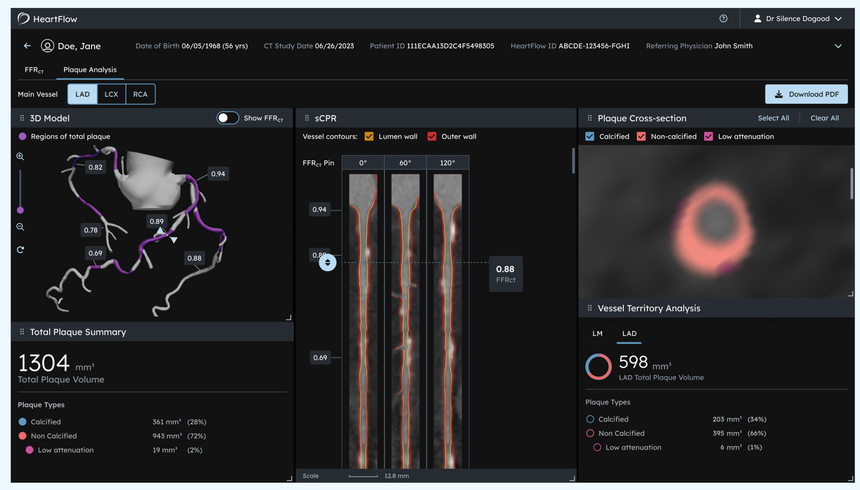
Methods

A prospective service evaluation was undertaken of patients presenting to a Rapid Access Chest Pain Clinic in whom CTCA was indicated. 50 consecutive CTCA results revealing a 30-90% stenosis in a major epicardial vessel were included. All scans underwent subsequent AI analysis from November 2024 to March 2025. Clinical outcomes were tracked via electronic patient records (EPR), examining adherence to clinical guidelines and subsequent management decisions.

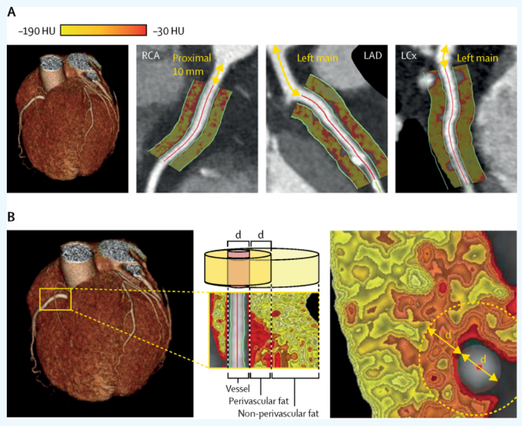
HeartFlow Plaque Analysis and FFR-CT

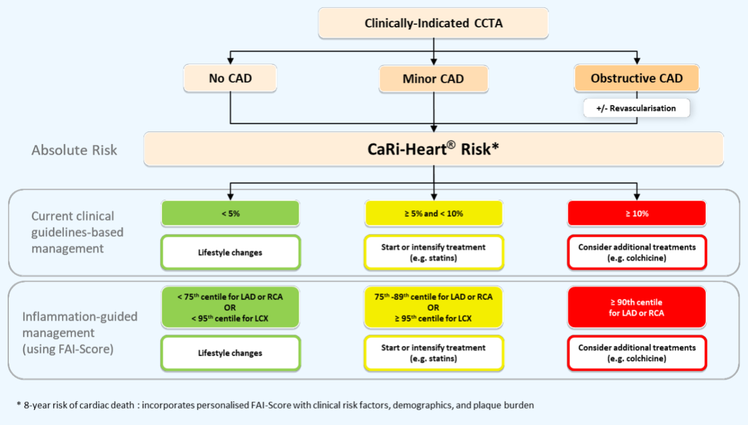
Plaque Analysis has been deployed as a demonstration tool currently under an adaption to current authorisations for third party data processing by HeartFlow. Plaque volume and characterisation has been strongly associated with major adverse cardiac events (MACE) risk through several studies.[5,6] Plaque volume and characteristics may be of stronger predictive value than any traditional clinical risk factor as suggested in the PARADIGM registry data. The clinical utility, final cut off values and integration into clinical pathways, however, is not yet established.

FFR-CT has been incorporated into the NICE guidelines since 2017 with variable impacts on diagnostic accuracy and economic outcomes, albeit consistently demonstrating high negative predictive values.[8] FFR-CT provides a measure of the impact of a stenotic lesion upon flow within the coronary arteries and 3D modelling of lesions for intervention planning. The major health economic impact of FFR-CT within the NHS has been to safely reduce the number of invasive coronary angiograms with an FFR-CT of >0.8 being highly predictive of a non-flow limiting angiogram.



HeartFlow Interactive Dashboard including FFRCT, Plaque Analysis and Roadmap





Perivascular Fat Attenuation Index visual, Suggested Clinical Pathway for CaRi-Heart

Caristo CaRi-Heart Score

The CaRi-Heart score has been provided to a four of NHS Trusts as part of a national pilot scheme to assess feasibility and clinical utility of the model under research authorisations. The tool integrates perivascular fat attenuation and plaque volume assessment from CTCA alongside traditional cardiovascular risk factors to provide a risk of death over the following 8 years if no intervention is provided.[3] The utility and intervention impact based upon available therapies (lipid modification and anti-inflammatories) is not fully established.

Results

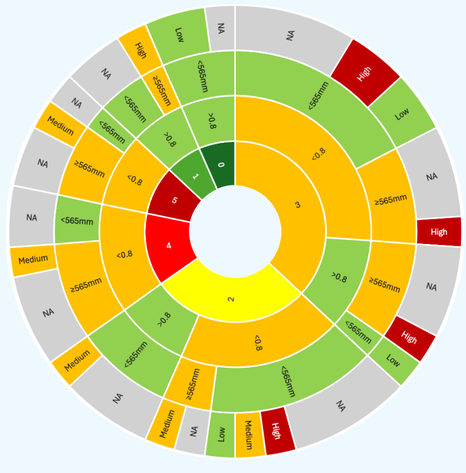
Of the 50 patients evaluated (58% male, mean age 64 years). Among the 22 individuals with positive FFR-CT findings (≤0.80),11 had distal disease only, 3 required urgent angiography due to acute coronary syndrome (ACS), 3 underwent elective angiography, with 1 case requiring surgical intervention. Plaque volume analysis was completed in all 50 cases and indicated significant plaque volumes (≥565mm³) in 18 patients, 17 of whom were prescribed statins. Multi-factor scoring was completed in 22 patients and identified 16 patients at moderate-to-high risk (>5% mortality over 8 years if no intervention provided) of whom 82% had non-obstructive CAD by conventional and FFR-CT assessments. Overall, 80% of patients were prescribed lipid modification agents with 8% citing intolerance. There was no significant difference in prescribing when stratified by AI risk tool.

Conclusion

AI-enhanced CTCA demonstrates the capacity to identify patients who may be at a higher cardiovascular risk within a non-obstructive CAD population, potentially guiding intensified preventive therapies. Multimodal analysis is feasible however true integration of these models into the clinical pathway was limited due to the current use cases. This work does not delineate the utility of the tool output, whilst multiple trials have correlated outputs with cardiovascular risk, further causality and treatment impacts in this specific cohort are not yet clear. Larger-scale, prospective studies are therefore required to validate these findings and determine optimal intervention strategies.

Next steps include refining each tool's predictive utility through optimal cut off values and weighting for plaque volume and plaque characteristics, review of outcome data based upon intervention and finally true integration into the clinical pathway.

Distribution of cases by CAD-RADS, FFRCT, total plaque volume and CaRi-Heart score



References
[1] British Heart Foundation , "Early heart disease deaths rise to 14-year high," *BHF Press,* 2024.
[2] M. Kenneth Chan, "Inflammatory risk and cardiovascular events in patients without obstructive coronary artery disease: the ORFAN multicentre, longitudinal cohort study," *The Lancet,* vol. 403, no. 10444, pp. 2606-2618, 2024.
[3] E. K. Oikonomou, "Standardized measurement of coronary inflammation using cardiovascular computed tomography: integration in clinical care as a prognostic medical device," *Cardiovascular Research,* vol. 117, no. 13, pp. 2677-2690, 2021.
[4] M. James Dundas, "Interaction of AI-Enabled Quantitative Coronary Plaque Volumes on Coronary CT Angiography, FFRCT, and Clinical Outcomes: A Retrospective Analysis of the ADVANCE Registry," *Circulation: Cardiovascular Imaging* , vol. 17, no. 3, p. e016143, 2024.
[5] M. D. e. al, "ADVANCE-DK 7 year follow up," *in press,* in press.
[6] P. Prof M C Williams, "Coronary CT angiography-guided management of patients with stable chest pain: 10-year outcomes from the SCOT-HEART randomised controlled trial in Scotland," *The Lancet,* vol. 405, no. 10475, pp. 329-337, 2025.
[7] Donghee Han, MD, "Machine Learning Framework to Identify Individuals at Risk of Rapid Progression of Coronary Atherosclerosis: From the PARADIGM Registry." *J Am Heart Assoc.* 2020;9: e013958. DOI: 10.1161/JAHA.119.013958
[7] National Institute for Health and Care Exellence (NICE) , "HeartFlow FFRCT for estimating fractional flow reserve from coronary CT angiography," *Medical Technologies Guidance,* vol. MTG32, 2021.

The Royal Wolverhampton NHS Trust

NHS England

Fellowship in Clinical AI
NHS Digital Academy Programme