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Research paper

Utility of magnetocardiography (MCG) in the assessment of obstructive coronary artery disease before and after percutaneous coronary intervention: A case series

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1. Introduction

Invasive coronary angiography (ICA) in symptomatic patients suspected of having obstructive coronary artery disease (CAD) is a common diagnostic procedure in the setting of stable ischemia heart disease (SIHD) and acute coronary syndrome (ACS) as recommended by ACC/AHA guidelines. Cardiologists often use non-invasive testing, including functional stress tests and/or coronary computed tomography angiography (CCTA), with or without fractional flow reserve (FFR), to help decide if ICA is clinically appropriate in the setting of SIHD, especially in the intermediate-risk patient. However, even with these non-invasive modalities, predicting who might benefit from PCI remains clinically challenging.

Despite applying guideline recommendations to proceed to ICA in the presence of new decline in LV systolic function, clinical heart failure, chest pain refractory to goal-directed medical therapy, and/or non-invasive testing suggestive of significant >50 % left main disease, many individuals who go on to have a non-emergent ICA do not have evidence of obstructive CAD (i.e. >70 % stenosis) [1]. In fact, the diagnostic yield of epicardial disease in patients with SIHD is only 40–60 % [2,3].

Non-invasive testing modalities offer a variety of functional and anatomical information, as well as differences in cost and time allocation. Functional stress tests have sensitivities and specificities ranging between 45 % and 94 % with greater accuracy associated with more expensive and less available modalities such as coronary CTA with FFR or PET MPI [4]. While these non-invasive modalities offer added value, they are limited in either diagnostic accuracy, cost, and/or availability. Exploring novel diagnostic approaches to patients suspected of having obstructive CAD with functional ischemia and predicting who would benefit from ICA may be beneficial.

Magnetocardiography (MCG), a non-invasive, contactless technique that detects the magnetic fields produced by cardiac electrical activity, holds significant promise. This case series explores the ischemic changes seen on MCG in response to revascularization and investigates the potential of MCG, specifically the CardioFlux MCG system: first, as a non-invasive modality that may predict who would benefit from ICA, and second, as a serial diagnostic tool pre- and post-revascularization to assess the patient longitudinally.

2. Case 1 presentation

A 49 year old male with a past medical history of known CAD, hypertension, hyperlipidemia, and type II diabetes presented to the emergency department with acute chest pain. Vital signs were all within normal limits. EKG revealed sinus rhythm with nonspecific ST and T wave abnormalities. Initial troponin level was negative. Given concern for unstable angina, cardiology was consulted. Approximately 5 h after presentation, the patient underwent MCG scan which showed a multipolar magnetic field pattern in the T-wave, indicative of ischemia (Fig. 1).

Patient then underwent ICA which revealed 75 % stenosis of the mid-vessel left anterior descending (LAD) with TIMI grade 3 flow. Percutaneous coronary intervention with drug eluting stent (PCI with DES) was performed on the LAD artery with 0 % residual stenosis and TIMI grade 3 flow (Fig. 2).

Repeat MCG scan was conducted two hours post PCI. The post-intervention MCG showed distinct normalization of the T wave when

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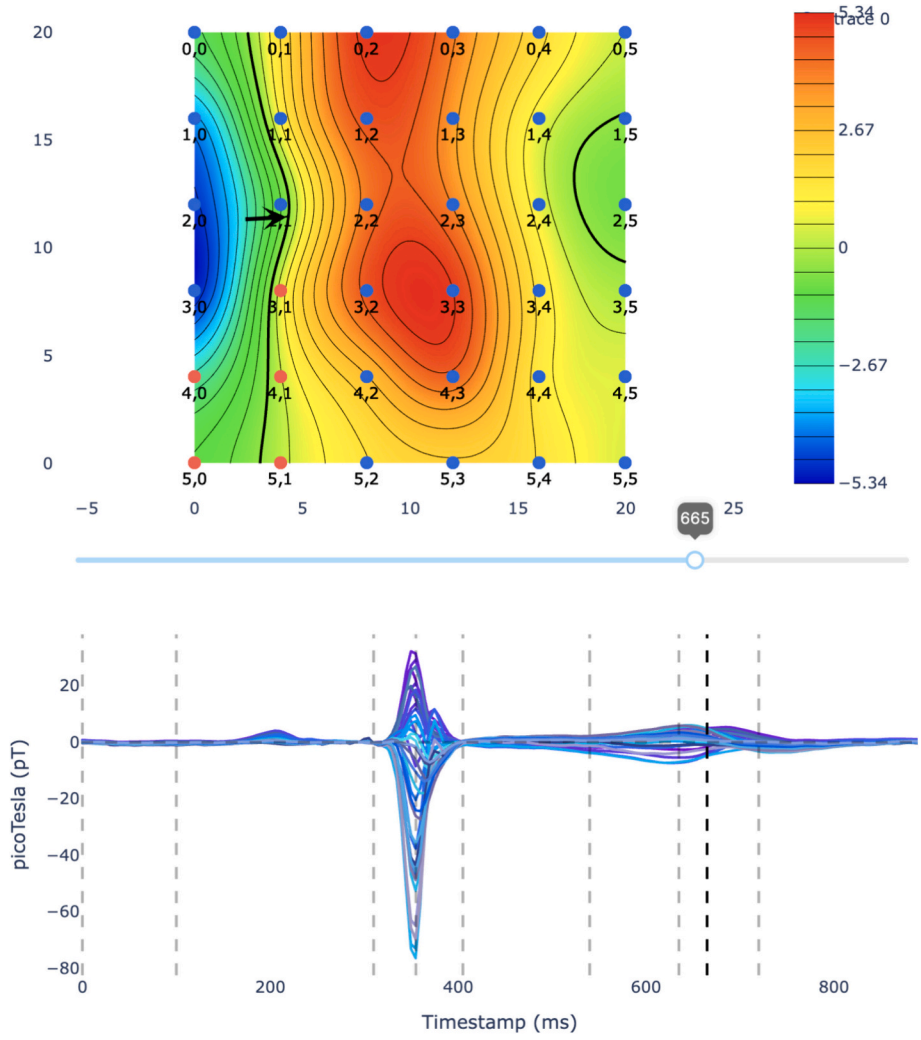

Fig. 1. MCG prior to ICA showing multipolarity, (two positive poles illustrated in red) during the T wave, an abnormal magnetic field pattern indicative of ischemia. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

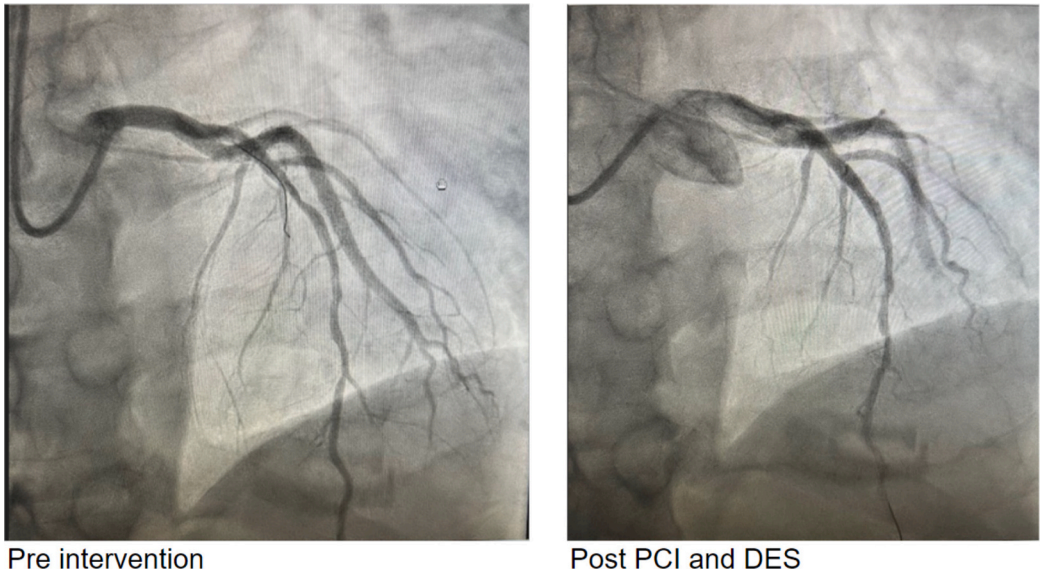

Fig. 2. Coronary angiography showing 75 % stenosis of the left anterior descending (LAD) artery pre and post PCI with DES.

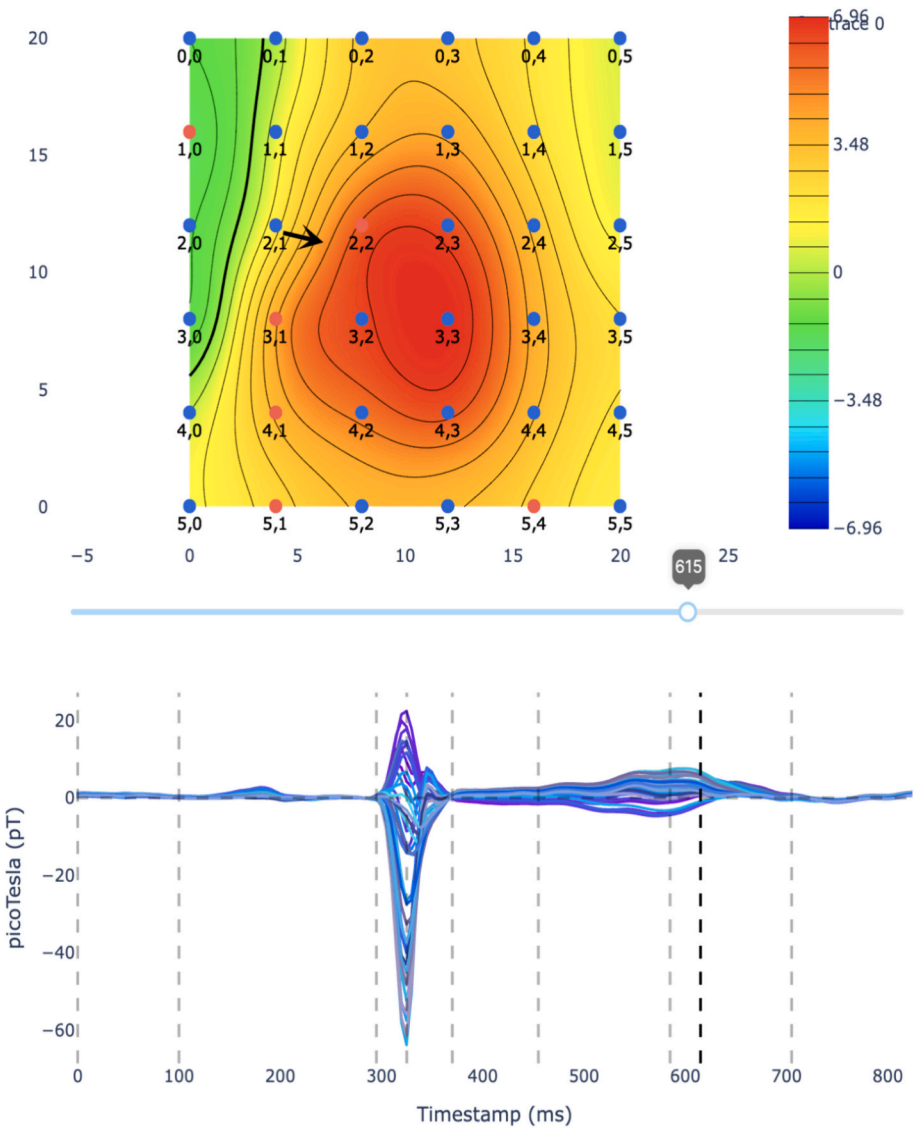

Fig. 3. Post-intervention MCG showing a convergence of the multipolar red positive poles into single positive pole during the T wave, indicative of improved coronary flow and resolution of ischemia. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

compared to the pre-intervention MCG which may be a result from improved coronary flow. The magnetic field changed from an abnormal multipolar configuration pre-intervention to a more normal dipolar configuration, indicative of improved coronary flow and resolution of ischemia (Fig. 3).

3. Case 2 presentation

A 68 year old male with a PMH of hypertension was evaluated at the cardiology office for intermittent dyspnea and chest pain on exertion. The patient underwent a nuclear stress test which was suggestive for reversible inferior and inferolateral wall ischemia along with new reduced Left Ventricular Ejection Fraction.

Resting MCG scan was performed prior to ICA. His scan revealed multipolar positive (red) magnetic poles, suggestive of obstructive CAD (Fig. 4A). During coronary angiography, the patient was noted to have 80 % stenosis of the second obtuse marginal branch (OM2) with TIMI grade 3 flow. PCI with DES was performed with 0 % residual stenosis and TIMI grade 3 flow. Five hours post procedure, repeat MCG scan was performed showing the single positive magnetic pole reverted to a normal non-ischemic dipole, one positive and one negative, configuration (Fig. 4B, Fig. 5).

4. Discussion

Abnormalities in MCG as an indicator of coronary ischemia have existed for some time and are making a resurgence [5], primarily due to improved magnetic sensor technology and advancements in computing. The deviation from a stable dipolar configuration (a single positive and single negative magnetic pole) to a multipolar configuration in the ST segment or T wave to suggest coronary ischemia has been reported previously [6].

The MAGNETO study demonstrated the value of multipolarity, alongside other MCG specific features, when evaluating suspected ACS in intermediate-risk emergency department patients [7]. This case series shows the novel use of MCG as a serial non-invasive diagnostic modality pre- and post-PCI in patients with SIHD and ACS.

A noteworthy observation in this study is the rapid normalization of abnormal magnetic field patterns in the T wave following successful PCI, suggesting that MCG successfully detected acute ischemic changes and as well as contemporaneous improvement after revascularization. By aligning MCG findings with successful PCI and subsequent angiography

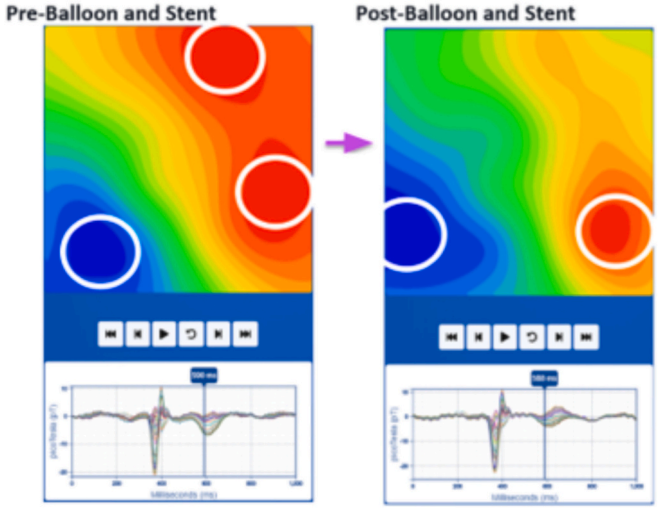

Fig. 4. Panels A and B pre and post PCI: A (left) was performed before PCI and shows one negative (blue) pole, but two distinct positive (red) poles suggestive of ischemia secondary to obstructive CAD. Five hours post PCI the patient underwent a repeat MCG, B (right) showing a normal dipolar configuration of a single blue and single red pole consistent with no ischemia.

results, this report establishes a proof-of-concept that serial MCG may indicate ischemic changes and subsequent response to revascularization, especially early post-PCI.

Although this report includes only two cases with limited long-term follow-up data, it expands the potential for clinical applications of MCG in several aspects. First, it shows MCG can aid in identifying coronary ischemia in a suspected but undiagnosed population with non-specific ECG results. Second, it demonstrates the feasibility of repeat MCG scanning to monitor patients and their response to revascularization. Finally, it also opens the door to explore non-invasive MCG as a predictor of which patients may benefit from ICA.

If these findings are validated in larger scale studies, they may suggest that MCG could serve as a valuable and effective non-invasive diagnostic modality for identifying functional ischemia secondary to epicardial disease as well as a simple serial assessment for evaluating patients in whom intervention was performed.

5. Conclusion

This case series underscores the utility of MCG in assessing ischemia in patients with anginal symptoms. The observed normalization of the magnetic field pattern in the patient's T wave following successful coronary intervention within a few hours highlights the potential of MCG as a serial non-invasive diagnostic modality post-PCI. While larger scale studies are warranted, implementing MCG in clinical practice may help with resource utilization, and expedite diagnosis and treatment, benefitting patients that are being evaluated for SIHD and ACS.

Ethics statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work/ethics reported in this paper.

CRediT authorship contribution statement

Nicholas Coriasso: Writing – review & editing, Writing – original draft, Conceptualization. **Edouard Daher:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

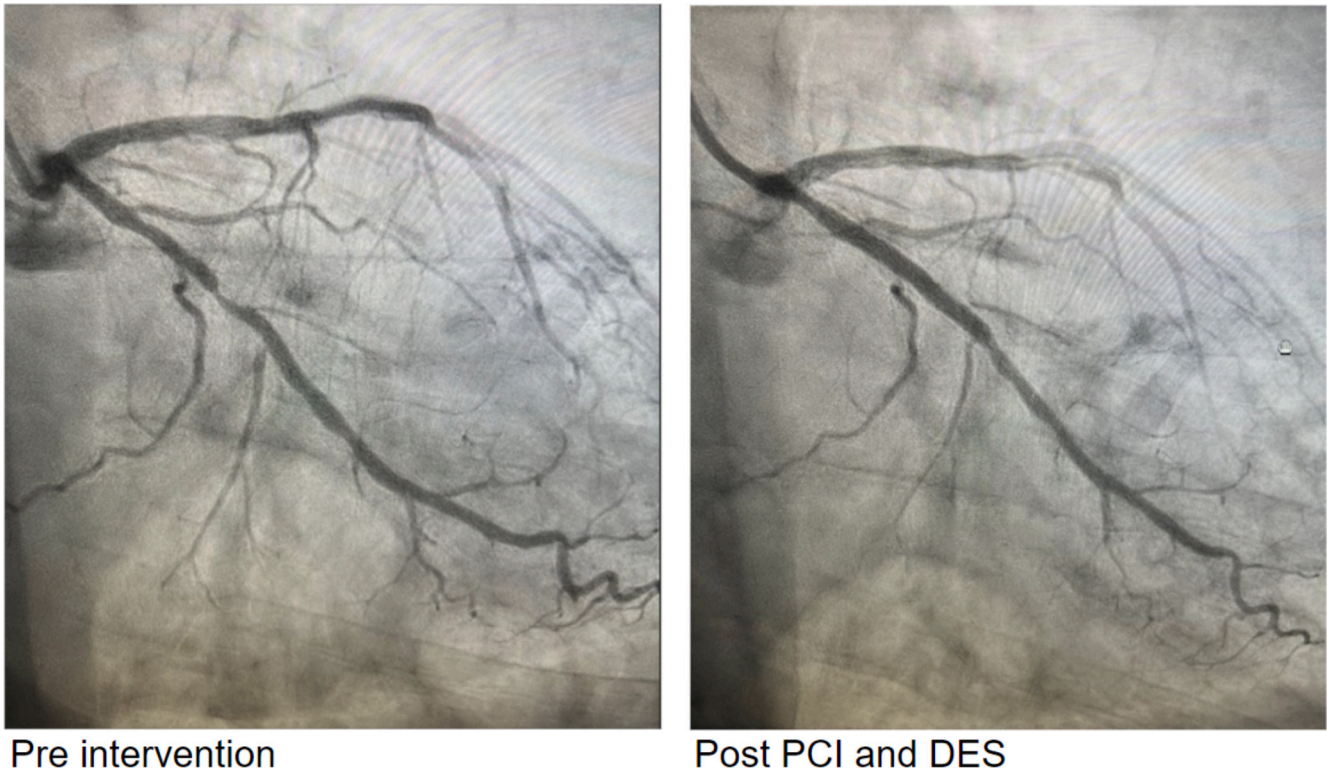

Fig. 5. Coronary angiography showing 80 % stenosis of the second obtuse marginal branch (OM2) pre and post PCI with DES.

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