Non Invasive Assessment of Relevant Coronary Occlusion through Mathematical Analysis of Spectral ECG Components (MCG) with comparison with Coronary Angiography in Symptomatic Patients

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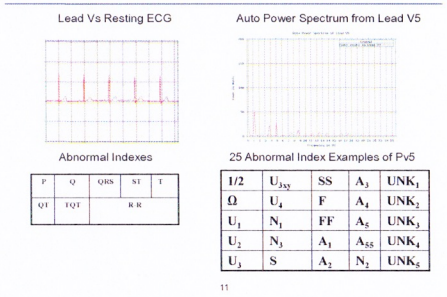
Risk assessment of relevant coronary occlusion in symptomatic patients at Emergency Room is essential for a correct management of these patients. The Mathematical Multifunction Analysis of ECG Spectral Components (Multifunction CardioGraphy – MCG Premier Heart – USA) based on Systems Theory, allows to extract all the spectral information content of ECG , to evaluate micro-ischemia on **resting ECG** high resolution digital recordings but not visible on standard ECG. Six different Mathematical transformations are performed: 1) Autopower spectrum, 2) Phase angle shift, 3) Impulse response, 4) Cross correlation, 5) Coherence Function, 6) Transfer Function and their 166 indexes are compared to a database of 40.000 patents (with CA analysis).

Example: Comparison of ECG data to MCG data



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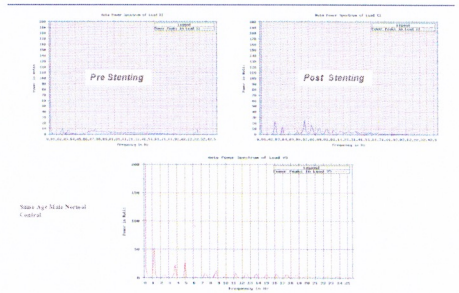
Example: Pre and Post Stenting Change in the Auto Power Spectrum Index



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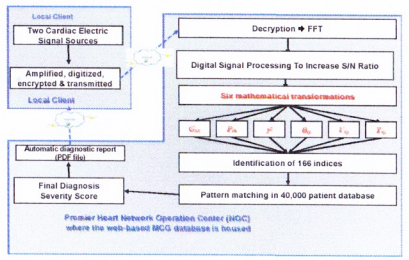
How MCG is performed



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Our experience is based on more than 110 patients, with any indication for Coronary Angiography but **no ECG sign of Ischemia**, and it is unique because patients received CA analysis of collateral circulation and detailed analysis of the inherent pathologies of False Positive / Negative patients to try to establish the limit of application of the method. Endpoint: Detection of hemodynamically relevant coronary stenosis via CA. Results on 110 patients with CA available (on total of 116 patients recruited) performed from 1 to 25 hours after MCG. 21 patients were excluded from analysis: 9 with concomitant important cardiovascular pathologies (Valvular, Dilated Cardiomyopathy, etc); 4 with double vasodilator therapy (nitrates and diltiazem) or carvasin; 5 with CA borderline results (i.e.: Occlusion value is at limit. without additional info with IVUS); 3 with Poor Quality MCG. Total included patients: 89; MCG identified 45 True Positive, 31 True Negatives, 12 False Positive and 1 False Negative.

	Coronary Angiography +	Coronary Angiography -
MCG +	45 (50,5%)	12 (13,4%)
MCG -	1 (1.1%)	31 (34.8%)

Sensitivity: 97.8%
Specificity: 72.0%
PPV: 78.9%
NPV: 96.8%

MCG vs. ECG

	ECG, a Reductionist Tool	*MCG, a Systems Analysis Tool*
A	A theoretical single dipole, plotted on an Einthoven ECG 2-D scale Model (time vs. voltage).	Multiple mathematical functions based on the LaGrange-Euler model and Systems Theory
B	single-cycle approach, single lead and evaluating segments of the waveform (e.g. ST Segment, T-Wave, QT intervals,...)	Leads II & V5 and across multiple cardiac cycles to extract multiple non-linear mathematical relationships.
C	Requires an on-site experienced clinician for subjective over-read	Automatic computer generated evidence based objective and reliable reporting
D	Accuracy impaired by bundle branch blocks, paced rhythms	Accuracy unaffected by ECG wave morphology, such as BBB, or Paced rhythms
E	No instantly and automatically accessible normalized and validated digital empirical clinical database	Dependent to a large normalized, validated and readily accessible digital empirical database for report automation
F	dependent on risk factors clinical presentation/History and expert opinions	Independent of risk factors, patient history or clinical presentation, or expert opinion

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Discussion: Sensitivity is higher than other published papers because we have used a more sensitive criteria for MCG analysis (Score ≥3 instead of Score ≥4). Such a high Sensitivity value (97%), allows a very safety delay of the CA procedure and/or a late elective non-invasive test. Specificity is lower than published papers, but our patients are consecutive and most of the 12 patients False Positive are diabetic or hyperglycemia or hypertensive. These patients are therefore anyhow with microcirculation problems. We have analyzed the presence of collaterals in the 6 patients with seeming positive CA (>70% occlusion or >50% occlusion in Coronary Main Artery) and negative MCG. Most of these patients had CA visible collaterals that improve flow at microcirculation level despite the presence of >70% occlusion. Interestingly the only one false negative was under single vasodilator therapy and Score of 2. Planned new trials will use Fractional Flow Reserve in the analysis of functionally significant coronary stenosis.

Conclusion: MCG method is a fast, risk/radiation free and low expensive method for Non Invasive Assessment of Relevant Coronary Occlusion. High Sensitivity of this method may allow delaying CA or other diagnostic modalities available for symptomatic patients based on MCG results for a better management of these patients.

Declaration of Interest: G.C., G.M., E.B. none. D.M. Consultant but no compensation for this study. Mail for info: dmarangoni@tin.it