

Supplementary file

Association of ECG markers with myocardial fibrosis as assessed by Cardiac Magnetic Resonance in different clinical settings - A systematic review

Table S1: Quality Assessment of Case-control studies

Non-ischemic cardiomyopathy									
Piers SR ¹⁸	*	*	*	*		*	*	*	7
Becker MAJ ¹⁹	*	*	*	*		*	*	*	7
Myotonic dystrophy patients									
Cho MJ ²⁰	*	*	*	*		*	*	*	7
Myocardial infarction									
Nadour W ²¹	*	*	*	*	**	*	*	*	9
General population									
Inoue YY ²²	*	*	*	*	**	*	*	*	9
Wieslander B ²³	*	*	*	*		*	*	*	7
Others pathologies									
De Lazzari M ²⁴	*	*	*	*	*	*	*	*	8
Mewton N ²⁵	*	*	*	*	*	*	*	*	8
Sobue Y ²⁶	*	*	*	*	*	*	*	*	8
Wieslander B ²⁷	*	*	*	*	*	*	*	*	8

NOS scale: A) Selection domain: 1= Is the case definition adequate; 2= Representativeness of the cases; 3= Selection of Controls; 4= Definition of Controls; B) Comparability: 5= comparability of cases and controls on the basis of the design or analysis; C) Exposure: 6= Ascertainment of outcome; 7= Same method of ascertainment for cases and controls; 8= Non-Response Rate.

Table S2: Quality Assessment of Cohorts studies

Author	1	2	3	4	5	6	7	8	Total stars
Myotonic dystrophy patients									
Cardona A ²⁸	*	*	*	*		*	*	*	7
Myocardial infarction									
Chew DS ²⁹	*	*	*	*	*	*	*	*	8
Myocarditis									
Ferrero P ³⁰	*	*	*	*		*	*	*	7
Fischer K ³¹	*	*	*	*	**	*	*	*	9
Others pathologies									
Ciuffo L ³²	*	*	*	*	**	*	*	*	9

NOS scale: A) Selection domain: 1= representativeness of the exposed cohort; 2= selection of the non-exposed cohort; 3= ascertainment of exposure; 4= outcome of interest was not present at start of study; B) Comparability: 5= comparability of cohorts on the basis of the design or analysis; C) Exposure: 6= assessment of outcome; 7= follow-up long enough for outcome to occur; 8= adequacy of follow up.

References

1. Bi X, Yang C, Song Y, Yuan J, Cui J, Hu F, Qiao S. Quantitative fragmented QRS has a good diagnostic value on myocardial fibrosis in hypertrophic obstructive cardiomyopathy based on clinical-pathological study. *BMC Cardiovasc Disord* 2020;20(1):298.
2. Chen X, Zhao T, Lu M, Yin G, Xiangli W, Jiang S, Prasad S, Zhao S. The relationship between electrocardiographic changes and CMR features in asymptomatic or mildly symptomatic patients with hypertrophic cardiomyopathy. *Int J Cardiovasc Imaging* 2014;30 Suppl 1:55-63.
3. Chen S, Wang X, Huang L, Chen Y, Zhang Q. Performance of 12-lead electrocardiogram Selvester QRS scoring criteria to diagnose myocardial scar in patients with hypertrophic cardiomyopathy. *Ann Noninvasive Electrocardiol* 2020;25(5):e12762.
4. Riza Demir A, Celik O, Sevinc S, Uygur B, Kahraman S, Yilmaz E, Cemek M, Onal Y, Erturk M. The relationship between myocardial fibrosis detected by cardiac magnetic resonance and Tp-e interval, 5-year sudden cardiac death risk score in hypertrophic cardiomyopathy patients. *Ann Noninvasive Electrocardiol* 2019;24(5):e12672.
5. Dohy Z, Verecke A, Horvath V, Czimbalmos C, Szabo L, Toth A, Suhai FI, Csecs I, Becker D, Merkely B, Vago H. How are ECG parameters related to cardiac magnetic resonance images? Electrocardiographic predictors of left ventricular hypertrophy and myocardial fibrosis in hypertrophic cardiomyopathy. *Ann Noninvasive Electrocardiol* 2020;25(5):e12763.
6. Fronza M, Rainieri C, Valentini A, Bassi EM, Scelsi L, Buscemi ML, Turco A, Castelli G, Ghio S, Visconti LO. Relationship between electrocardiographic findings and Cardiac Magnetic Resonance phenotypes in patients with Hypertrophic Cardiomyopathy. *Int J Cardiol Heart Vasc* 2016;11:7-11.
7. Grall S, Biere L, Clerfond G, Mateus V, Prunier F, Furber A. ECG characteristics according to the presence of late gadolinium enhancement on cardiac MRI in hypertrophic cardiomyopathy. *Open Heart* 2014;1(1):e000101.
8. Guerrier K, Madueme PC, Jefferies JL, Anderson JB, Spar DS, Knilans TK, Czosek RJ. Unexpectedly low left ventricular voltage on ECG in hypertrophic cardiomyopathy. *Heart* 2016;102(4):292-7.
9. Kawasaki T, Harimoto K, Honda S, Sato Y, Yamano M, Miki S, Kamitani T. Notched QRS for the assessment of myocardial fibrosis in hypertrophic cardiomyopathy. *Circ J* 2015;79(4):847-53.
10. Konno T, Hayashi K, Fujino N, Oka R, Nomura A, Nagata Y, Hodatsu A, Sakata K, Furusho H, Takamura M, Nakamura H, Kawashiri MA, Yamagishi M. Electrocardiographic QRS Fragmentation as a Marker for Myocardial Fibrosis in Hypertrophic Cardiomyopathy. *J Cardiovasc Electrophysiol* 2015;26(10):1081-7.
11. Matsuki A, Kawasaki T, Kawamata H, Sakai C, Harimoto K, Kamitani T, Yamano M, Matoba S. Ventricular late potentials and myocardial fibrosis in hypertrophic cardiomyopathy. *J Electrocardiol* 2020;58:87-91.
12. Park CH, Chung H, Kim Y, Kim JY, Min PK, Lee KA, Yoon YW, Kim TH, Lee BK, Hong BK, Rim SJ, Kwon HM, Choi EY. Electrocardiography based prediction of hypertrophy pattern and fibrosis amount in hypertrophic cardiomyopathy: comparative study with cardiac magnetic resonance imaging. *Int J Cardiovasc Imaging* 2018;34(10):1619-1628.
13. Sakamoto N, Sato N, Oikawa K, Karim Talib A, Sugiyama E, Minoshima A, Tanabe Y, Takeuchi T, Akasaka K, Saijo Y, Kawamura Y, Hasebe N. Late gadolinium enhancement of cardiac magnetic resonance imaging indicates abnormalities of time-domain T-wave alternans in hypertrophic cardiomyopathy with ventricular tachycardia. *Heart Rhythm* 2015;12(8):1747-55.
14. Suwa K, Satoh H, Sano M, Nobuhara M, Saitoh T, Saotome M, Urushida T, Katoh H, Tawarabara K, Ohtani H, Wakabayashi Y, Takase H, Terada H, Takehara Y, Sakahara H, Hayashi H. Functional, morphological and electrocardiographical abnormalities in patients with apical hypertrophic cardiomyopathy and apical aneurysm: correlation with cardiac MR. *Open Heart* 2014;1(1):e000124.

15. Tangwiwat C, Kaolawanich Y, Krittayaphong R. Electrocardiographic predictors of myocardial fibrosis and apical hypertrophic cardiomyopathy. *Ann Noninvasive Electrocardiol* 2019;24(2):e12612.
16. Sakamoto N, Sato N, Talib AK, Sugiyama E, Minoshima A, Tanabe Y, Fujino T, Takeuchi T, Akasaka K, Saijo Y, Kawamura Y, Hasebe N. Late Gadolinium Enhancement on Cardiac MRI Correlates with QT Dynamicity Represented by QT/RR Relationship in Patients with Ventricular Arrhythmias. *Ann Noninvasive Electrocardiol* 2016;21(2):126-35.
17. Oebel S, Dinov B, Arya A, Hilbert S, Sommer P, Bollmann A, Hindricks G, Paetsch I, Jahnke C. ECG morphology of premature ventricular contractions predicts the presence of myocardial fibrotic substrate on cardiac magnetic resonance imaging in patients undergoing ablation. *J Cardiovasc Electrophysiol* 2017;28(11):1316-1323.
18. Piers SR, Askar SF, Venlet J, Androulakis AF, Kapel GF, de Riva Silva M, Jongbloed JJ, van Tintelen JP, Schalij MJ, Pijnappels DA, Zeppenfeld K. QRS prolongation after premature stimulation is associated with polymorphic ventricular tachycardia in nonischemic cardiomyopathy: Results from the Leiden Nonischemic Cardiomyopathy Study. *Heart Rhythm* 2016;13(4):860-9.
19. Becker MAJ, Allaart CP, Zweerink A, Cornel JH, van de Ven PM, van Rossum AC, Germans T. Correlation between septal midwall late gadolinium enhancement on CMR and conduction delay on ECG in patients with nonischemic dilated cardiomyopathy. *Int J Cardiol Heart Vasc* 2020;26:100474.
20. Cho MJ, Lee JW, Lee J, Shin YB, Lee HD. Relationship Between Fragmented QRS Complexes and Cardiac Status in Duchenne Muscular Dystrophy: Multimodal Validation Using Echocardiography, Magnetic Resonance Imaging, and Holter Monitoring. *Pediatr Cardiol* 2017;38(5):1042-1048.
21. Nadour W, Doyle M, Williams RB, Rayarao G, Grant SB, Thompson DV, Yamrozik JA, Biederman RW. Does the presence of Q waves on the EKG accurately predict prior myocardial infarction when compared to cardiac magnetic resonance using late gadolinium enhancement? A cross-population study of noninfarct vs infarct patients. *Heart Rhythm* 2014;11(11):2018-26.
22. Inoue YY, Ambale-Venkatesh B, Mewton N, Volpe GJ, Ohyama Y, Sharma RK, Wu CO, Liu CY, Bluemke DA, Soliman EZ, Lima JA, Ashikaga H. Electrocardiographic Impact of Myocardial Diffuse Fibrosis and Scar: MESA (Multi-Ethnic Study of Atherosclerosis). *Radiology* 2017;282(3):690-698.
23. Wieslander B, Nijveldt R, Klem I, Lokhnygina Y, Pura J, Wagner GS, Ugander M, Atwater BD. Evaluation of Selvester QRS score for use in presence of conduction abnormalities in a broad population. *Am Heart J* 2015;170(2):346-52.
24. De Lazzari M, Zorzi A, Cipriani A, Susana A, Mastella G, Rizzo A, Rigato I, Bauce B, Giorgi B, Lacognata C, Iliceto S, Corrado D, Perazzolo Marra M. Relationship Between Electrocardiographic Findings and Cardiac Magnetic Resonance Phenotypes in Arrhythmogenic Cardiomyopathy. *J Am Heart Assoc* 2018;7(22):e009855.
25. Mewton N, Strauss DG, Rizzi P, Verrier RL, Liu CY, Tereshchenko LG, Nearing B, Volpe GJ, Marchlinski FE, Moxley J, Killian T, Wu KC, Spooner P, Lima JA. Screening for Cardiac Magnetic Resonance Scar Features by 12-Lead ECG, in Patients with Preserved Ejection Fraction. *Ann Noninvasive Electrocardiol* 2016;21(1):49-59.
26. Sobue Y, Harada M, Koshikawa M, Ichikawa T, Yamamoto M, Okuda K, Kato Y, Sarai M, Watanabe E, Ozaki Y. QRS-based assessment of myocardial damage and adverse events associated with cardiac sarcoidosis. *Heart Rhythm* 2015;12(12):2499-507.
27. Wieslander B, Xia X, Jablonowski R, Axelsson J, Klem I, Nijveldt R, Maynard C, Schelbert EB, Sorensson P, Sigfridsson A, Chaudhry U, Platonov PG, Borgquist R, Engblom H, Couderc JP, Strauss DG, Atwater BD, Ugander M. The ability of the electrocardiogram in left bundle branch block to detect myocardial scar determined by cardiovascular magnetic resonance. *J Electrocardiol* 2018;51(5):779-786.
28. Cardona A, Arnold WD, Kissel JT, Raman SV, Zareba KM. Myocardial fibrosis by late gadolinium enhancement cardiovascular magnetic resonance in myotonic muscular dystrophy type

1: highly prevalent but not associated with surface conduction abnormality. *J Cardiovasc Magn Reson* 2019;21(1):26.

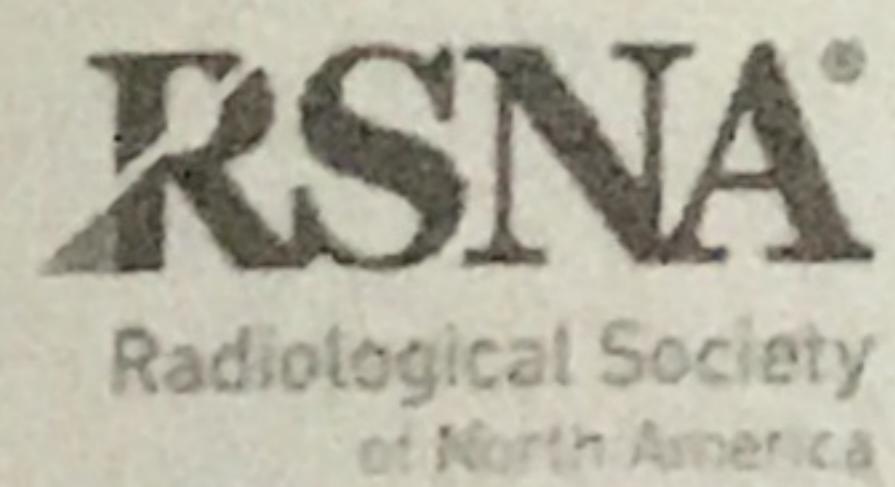
29. Chew DS, Wilton SB, Kavanagh K, Vaid HM, Southern DA, Ellis L, Howarth AG, White JA, Exner DV. Fragmented QRS complexes after acute myocardial infarction are independently associated with unfavorable left ventricular remodeling. *J Electrocardiol* 2018;51(4):607-612.

30. Ferrero P, Piazza I, Kuhl U, Grosu A, Tschope C, Senni M. QRS fragmentation as a possible electrocardiographic diagnostic marker in patients with acute myocarditis: preliminary histopathological validation. *ESC Heart Fail* 2020;7(5):2527-2533.

31. Fischer K, Marggraf M, Stark AW, Kaneko K, Aghayev A, Guensch DP, Huber AT, Steigner M, Blankstein R, Reichlin T, Windecker S, Kwong RY, Grani C. Association of ECG parameters with late gadolinium enhancement and outcome in patients with clinical suspicion of acute or subacute myocarditis referred for CMR imaging. *PLoS One* 2020;15(1):e0227134.

32. Ciuffo L, Bruna V, Martinez-Selles M, de Vasconcellos HD, Tao S, Zghaib T, Nazarian S, Spragg DD, Marine J, Berger RD, Lima JAC, Calkins H, Bayes-de-Luna A, Ashikaga H. Association between interatrial block, left atrial fibrosis, and mechanical dyssynchrony: Electrocardiography-magnetic resonance imaging correlation. *J Cardiovasc Electrophysiol* 2020;31(7):1719-1725.

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Figure 2

Inoue Y Y, Ambale-Venkatesh B, Mewton N, et al. Electrocardiographic Impact of Myocardial Diffuse Fibrosis and Scar: MESA (Multi-Ethnic Study of Atherosclerosis)¹. *Radiology* 2017;282:690–698.

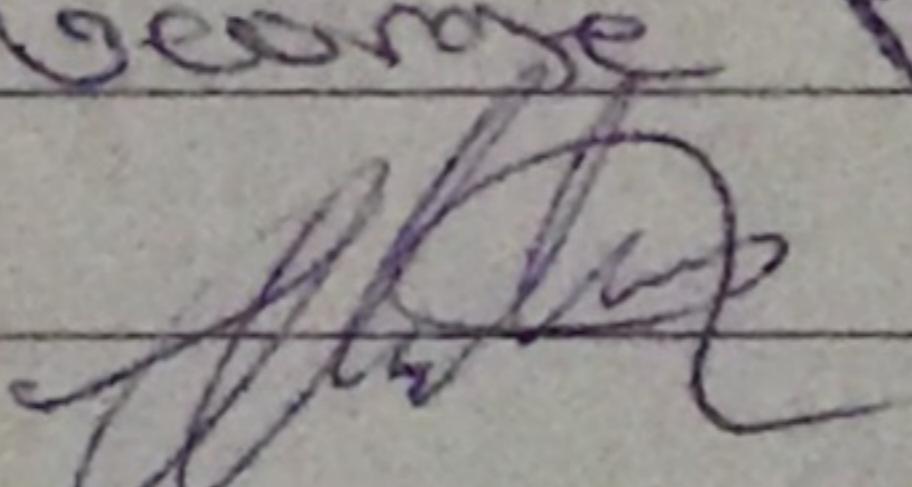
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