



#### *PRESIDENT* MAURO RINALDI

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## GIORNATE CARDIOLOGICHE TORINESI

TURIN, October 25<sup>th</sup>-27<sup>th</sup> 2018 Starhotels Majestic Cardiac magnetic resonance Clinical applications

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Brader et al. Journel of Cardiovanuler Hegentic Resonance 2013, 15:9 http://www.jcmr-online.com/carders/15/1/9

 Journal of Cardiovasco Magnetic Resonance

#### RESEARCH

#### European cardiovascular magnetic resonance (EuroCMR) registry – multi national results from 57 centers in 15 countries

Oliver Bruder<sup>1</sup>, Anja Wagner<sup>3</sup>, Massimo Lombardi<sup>11</sup>, Jüeg Schwitter<sup>4</sup>, Albert van Rossum<sup>3</sup>, Günter Pill<sup>4</sup>, Detiev Nothnagel<sup>2</sup>, Henning Steen<sup>4</sup>, Steffen Petersen<sup>4</sup>, Elle Nagel<sup>21</sup>, Sanjag Prasad<sup>21</sup>, Jula Schumm<sup>31</sup>, Simon Greukch<sup>12</sup>, Alessandro Cagnolo<sup>3</sup>, Pierre Monney<sup>4</sup>, Christina C Deluig<sup>2</sup>, Thorsten Dill<sup>13</sup>, Herbert Frank<sup>14</sup>, Georg Sabin<sup>3</sup>, Steffen Schweider<sup>13</sup> and Heilio Mahrholiti<sup>17</sup>



# Cardiac magnetic resonance – Clinical applications

# **EuroCMR Registry**



#### Bruder et Al, JCMR 2013



Cardiac magnetic resonance – Clinical applications

## EuroCMR Registry Impact of CMR on patient management

		N or quartiles
All	100%	27781
Completely new diagnosis not suspected before	8.7%	2354/27006
Therapeutic consequences		
Change in medication	25.0%	6689/26743
Invasive procedure	16.8%	4510/26778
Hospital discharge	10.2%	2738/26771
Hospital admission	1.4%	386/26780
Impact on patient management (new diagnosis and/or therapeutic consequence)	61.8%	16677/27006
Values are % (n).		

Bruder O, JCMR 2013



The global cardiac magnetic resonance registry (GCMR) of the Society for Cardiovascular Magnetic Resonance

#### (63% USA Centres)

**Growth of CMR indications in the GCMR cohort, 2001–2012** 



Kwong RY, JCMR 2017





Cardiac magnetic resonance – Clinical applications

# CARDIOMYOPATHIES





Cardiac magnetic resonance – Clinical applications

Advantages of CMR for the assessment of heart disease – **1) Cardiac morphology and function** 



Specific advantages of CMR

LV apex -Apical HCM -Apical aneurysm -Thrombus Basal anterior wall and septum -Asymmetric HCM -Cardiac masses Lateral wall
-Circumflex artery
territory
-Dystrophinopathies

**Right ventricle** -Cardiomyopathies -Congenital heart disease





CMR is the **gold standard** to assess cardiac **volumes**, **mass** and **function** 

Grothues F, Am J Cardiol, 2002; Grothues F, Am Heart J, 2004; Walsh TF, Cardiol Clin 2007





#### Specific advantages of CMR in the assessment of cardiac morphology – Thrombus detection



Srichai MB, Am Heart J, 2006; Weinsaft JV, JACC 2008; Delewi R, Eur J Radiol, 2012





Advantages of CMR for the assessment of heart disease – 2) Tissue characterization



- T1-weighted images (native myocardium)
- Fat



- T2-weighted images (native myocardium)
- Edema



T2\*-weighted images (native mayocardium)





Late enhancement (post-contrast)

Fibrosis (scar)











Cardiac magnetic resonance – Clinical applications

Advantages of CMR for the assessment of heart disease – **3) Quantitative tissue characterization – Parametric mapping** 







Cardiac magnetic resonance – Clinical applications



Modell JCMR 2008





Cardiac magnetic resonance – Clinical applications

**CMR to define etiology – Late enhancement patterns** 









#### **Dual pathology occurs!**





Cardiac magnetic resonance – Clinical applications

#### Ischemic versus non ischemic cardiomyopathy



- Impact of CMR on diagnosis
- Impact of CMR on patient management





#### **Differential diagnosis of myocardial hypertrophy**





## Parametric mapping for the differential diagnosis of cardiac hypertrophy



Haaf et al. Journal of Cardiovascular Magnetic Resonance (2016) 18:89





# Cardiac magnetic resonance – Clinical applications

#### Recommendations for cardiac imaging in patients with suspected or established heart failure Recommendations Class\* Level\* Ref 1 TTE is recommended for the assessment of myocardial structure and function in subjects with suspected HF in order to establish ı. a diagnosis of either HFrEF, HFmrEF or HFpEF. TTE is recommended to assess LVEF in order to identify patients with HF who would be suitable for evidence-based I. pharmacological and device (ICD, CRT) treatment recommended for HFrEF. TTE is recommended for the assessment of valve disease, right ventricular function and pulmonary arterial pressure in patients with н an already established diagnosis of either HFrEF, HFmrEF or HFpEF in order to identify those suitable for correction of valve disease. TTE is recommended for the assessment of myocardial structure and function in subjects to be exposed to treatment which I. potentially can damage myocardium (e.g. chemotherapy). Other techniques (including systolic tissue Doppler velocities and deformation indices, i.e. strain and strain rate), should be IIa. considered in a TTE protocol in subjects at risk of developing HF in order to identify myocardial dysfunction at the preclinical stage. CMR is recommended for the assessment of myocardial structure and function (including right heart) in subjects with poor н acoustic window and patients with complex congenital heart diseases (taking account of cautions/contra-indications to CMR). CMR with LGE should be considered in patients with dilated cardiomyopathy in order to distinguish between ischaemic and non-Ha. ischaemic myocardial damage in case of equivocal clinical and other imaging data (taking account of cautions/contra-indications to CMR). CMR is recommended for the characterization of myocardial tissue in case of suspected myocarditis, amyloidosis, sarcoidosis, Chagas disease, Fabry disease non-compaction cardiomyopathy, and haemochromatosis (taking account of cautions/contra-1 indications to CMR). Non-invasive stress imaging (CMR, stress echocardiography, SPECT, PET) may be considered for the assessment of myocardial ischaemia and viability in patients with HF and CAD (considered suitable for coronary revascularization) before the decision on ΠЬ 116-118 revascularization. Invasive coronary angiography is recommended in patients with HF and angina pectoris recalcitrant to pharmacological therapy or symptomatic ventricular arrhythmias or aborted cardiac arrest (who are considered suitable for potential coronary revascularization) in order to establish the diagnosis of CAD and its severity. Invasive coronary angiography should be considered in patients with HF and intermediate to high pre-test probability of CAD and the presence of ischaemia in non-invasive stress tests (who are considered suitable for potential coronary revascularization) in IIa. order to establish the diagnosis of CAD and its severity. Cardiac CT may be considered in patients with HF and low to intermediate pre-test probability of CAD or those with equivocal IIb non-invasive stress tests in order to rule out coronary artery stenosis. Reassessment of myocardial structure and function is recommended using non-invasive imaging: - in patients presenting with worsening HF symptoms (including episodes of AHF) or experiencing any other important cardiovascular event; - in patients with HF who have received evidence-based pharmacotherapy in maximal tolerated doses, before the decision on device implantation (ICD, CRT); - in patients exposed to therapies which may damage the myocardium (e.g. chemotherapy) (serial assessments).

#### CMR in ESC Guidelines

#### on heart failure

- cardiac function
- tissue characterization
- stress (ischemia

#### detection)

2016 ESC Guidelines - Heart failure





# 2) Specific advantages of CMR in defining prognosis

**Right ventricular function** 

#### Table 2. Study Outcome Data According to Presence (RVSD+) or Absence (RVSD-) of Right Ventricular Systolic Dysfunction.

	RVSD-	RVSD +		
Outcome	(n=164)	(n=86)	Hazard Ratio (95% CI)	P Value
Primary end point, No. of patients (%)				
All-cause mortality or cardiac transplantation	17 (10.4)	42 (48.8)	5.90 (3.35-10.37)	< 0.001
All-cause mortality	16 (9.8)	36 (41.9)	5.51 (3.06-9.94)	< 0.001
Cardiac transplantation	1 (0.6)	6 (7.0)	13.01 (1.56-108.26)	0.018
Secondary end points, No. of patients (%)				
Cardiovascular mortality or cardiac transplantation	15 (9.2)	35 (40.7)	5.62 (3.07-10.30)	< 0.001
Cardiovascular mortality	14 (8.5)	29 (33.7)	5.12 (2.70-9.70)	< 0.001
Heart failure death, heart failure hospitalization, or cardiac transplantation*	13 (7.9)	32 (37.2)	6.13 (3.21-11.70)	< 0.001
Heart failure death	3 (1.8)	17 (19.8)	14.19 (4.15-48.45)	< 0.001
Heart failure hospitalization	12 (7.3)	27 (31.4)	5.61 (2.84–11.10)	<0.001

250 pts with DCM

RVEF < 45% in 86 pts (34%)

Primary end point (all cause mortality and HTx ): 49% pts with RV dysfunction and 10% pts without RV dysfunction (p < 0.001)

Gulati A, Circulation 2013





# Cardiac magnetic resonance – Clinical applications

#### Late enhancement



$\begin{array}{c c c c c c c c c c c c c c c c c c c $					All-	ause	mort	ality		
$\frac{\mathbf{P}_{\substack{\substack{n \in n \\ n \neq n \\ n \\$	Studyname		Statisti	ca for ea	ch study				ed ratio and 90	50
Assumul (2004)       2.794       5.794       5.744       5.927       1.546       5.927         Yan (2006)       5.002       5.002       5.001 <th></th> <th>Hazard ratio</th> <th>Lower</th> <th>Upper limit</th> <th>Z-Value p</th> <th>-Value</th> <th></th> <th>ICI</th> <th>F T</th> <th>CF+</th>		Hazard ratio	Lower	Upper limit	Z-Value p	-Value		ICI	F T	CF+
Yun (2006)       2.746       1.322       2.679       2.711       0.007         Wu (2006)       0.306       1.011       1.565       1.561       0.000         Checke (2007)       0.706       1.516       0.505       5.541       0.000         Checke (2007)       0.706       0.706       0.706       0.706       0.706       0.706         Checke (2017)       1.506       0.507       6.537       0.206       0.600       0.007       0.706	Assomult (2006)	2,796	0.761	10,291	1.548	0.122		LOI		
Wu (2006)       6.000       1.001 15:055       1.001       0.000         Karle (2006)       8.303       2.542 27:290       3.001       0.000         Karle (2006)       2.200       1.006       5.100       3.146       -3.302       0.100         Karle (2017)       2.101       1.016       5.100       3.146       -3.302       0.100         Belo (2011)       1.116       1.016       5.005       1.011       0.000       0.001       0.	Yan (2006)	2.748	1.322	5.679	2.711	0.007				-
Nate       2000       8.300       2.502       5.501       6.000         Oreany (2000)       2.300       1.504       5.001       6.000       1.500         Oreany (2000)       2.300       1.504       5.002       6.100       1.500         One (2011)       1.500       5.002       6.502       6.502       6.502       6.502         Nether (2011)       1.600       5.002       6.502       6.502       6.502       6.502       6.502         Nether (2011)       1.600       1.500       5.001       2.200       6.001       0.001	Wiu (2008)	6.000	1.001	35.955	1.961	0.050				-
Checking (2009)         2.280         1.684         3.083         5.544         0.900           Checking (2010)         3.796         5.151         1.566         0.420         0.420           Checking (2011)         3.796         5.151         1.566         0.420         0.420           Badio (2011)         1.806         0.500         1.801         0.566         0.445           Badio (2011)         1.806         0.500         1.801         0.806         0.446           Kene (2012)         5.400         3.101         5.566         0.001         0.446           Kene (2012)         5.400         3.202         0.001         0.001         0.446           Kene (2012)         3.444         0.446         4.500         0.001         0.01         0.446           Kene (2012)         3.444         0.446         4.500         0.001         0.01         0.1         0.1         0.01         0.1         0.01	Kalle (2009)	8.530	2.540	27,296	3.501	0.000				-
Kone (2010)         0.700         0.150         3.446         -0.320         0.740           Bedo (2011)         1.716         0.116	Cheorg (2009)	2.200	1.656	3.063	5.144	0.000				
Cho (2011)       1,170       0.191       1.902       0.440       0.429         Mole (2011)       1,800       0.502       0.812       0.812       0.816         Lefter (2011)       1,800       0.502       0.812       0.816       0.816         Lefter (2011)       1,800       0.502       0.812       0.816       0.816         Lefter (2011)       0.600       1.001       5.646       0.800       0.800         Leven (2012)       0.600       2.299       2.534       3.223       0.801         Muler (2013)       1.444       0.419       0.510       0.540       0.500       0.400         Muler (2013)       1.444       0.419       0.110       0.110       0.110       0.110       0.110         Muler (2013)       1.444       0.419       0.110	Kono (2010)	0.760	0.150	3.845	-0.332	0.740				
Bete (2011)         1.110         1.810         6.322         2.000         6.046           New (2011)         1.800         5.001         1.801         5.001	Oho (2018)	1.798	0.181	16.962	0.483	0.629				+
New (2011)       1.880       0.507       6.872       0.874	Bello (2011)	2,110	1.018	4.372	2:009	0.045				-
Lawner (2011)         8.000         1.001 30.000         1.000 30.000         1.000 30.000         1.000 30.000         1.000 30.000         1.000 30.000         1.000 30.000         1.000 30.000         1.000 30.000         1.000 30.000         1.000 30.000         1.000 30.000         1.000 30.000	Bes (2011)	1.890	0.502	6.812	0.825	0.395				-
New (2012)         5.010         1.302         5.200         6.001           New (2012)         5.000         2.202         8.001         1.002         5.000           New (2013)         5.444         5.500         5.202         8.001         1.002         5.000           Multer (2013)         5.444         5.400         5.900         6.001         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002         6.000         1.002	Lehrke (2011)	6.000	1.801	35.955	1.901	0.050				
Leyval(2012)       0.000       2.200       0.001         Muler (2013)       3.444       0.419       4.054       0.801         Muler (2013)       3.444       0.419       4.054       0.801         Muler (2013)       1.444       0.419       4.054       0.801         Muler (2013)       1.444       0.419       4.054       0.801         Muler (2014)       2.000       0.322       1.316       0.175       0.446         Muler (2017)       2.000       1.325       4.750       0.801       0.001         Healthay (2017)       2.000       3.701       6.554       0.000       0.1       1       10         Kow rake with USE we       More rake with USE we         rdiovascular Mortality       Cardiovascular mortality       Image: the with USE we       More rake with USE       Image: the with USE we         respond (2006)       2.300       1.017       1.017       2.000       1       1.017       1       10         respond (2006)       2.300       1.027       1.019       2.010       1       1       1.02       1         respond (2006)       2.300       1.019       <	Klem (2012)	5.610	1.990	15.795	3.265	0.001				
Neutron (2011)         3.446         1.500         5.346         3.891         0.801           Galaci (2013)         1.446         1.500         4.340         0.810         0.801           Galaci (2013)         1.446         1.600         4.600         4.600         0.801           Galaci (2013)         2.446         1.800         4.600         0.801         0.901           Macrin (2014)         1.241         0.110         1.321         0.110         1.910         0.110         1.910           Macrin (2014)         2.441         0.110         1.324         0.121         0.11         1         0.01           Macrin (2014)         2.441         2.300         3.701         0.510         0.801         0.11         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01         1         0.01 <th< td=""><td>Leyve(2012)</td><td>8.000</td><td>2.259</td><td>28.334</td><td>3.223</td><td>0.001</td><td></td><td></td><td>_</td><td>-</td></th<>	Leyve(2012)	8.000	2.259	28.334	3.223	0.001			_	-
Numeric (2011)         1.444         0.419         4.974         0.400         0.000           Macric (2014)         2.000         5.227         1.186         0.715         0.800           Macric (2014)         2.000         5.277         1.186         0.715         0.801           Macric (2017)         2.001         1.244         0.116         1.347         0.317         1.341         0.316         1.348         0.316         0.316         1.348         0.316         0.31         1.345         0.316         1.341         0.316         1.341         0.317         1.341         0.317         1.341         0.317         1.341         0.317         1.	Netham (2013)	3,140	1.505	6.340	3.191	0.001			-	
Outload         Option         2,000         1,000	Muller (2013)	1,444	0.410	4,974	0.565	0.500				
Name         Option         1.244         0.116         0.175         0.840           Maxer (2015)         1.247         0.116         0.175         0.840           Maxer (2015)         1.247         0.116         0.175         0.840           Maxer (2017)         2.300         0.126         0.175         0.840           Maxer (2017)         2.300         0.126         0.175         0.11           Balanci (2017)         2.300         0.127         0.11         0.1           Balanci (2014)         0.11         0.11         0.1         0.1           Balanci (2014)         0.11         0.10         0.11         0.1           Balanci (2014)         0.101         0.11         0.11         0.1           Balanci (2014)         0.101         0.101         0.11         0.11         0.1           Balanci (2004)         2.300         0.601         9.425         1.236         0.217         1.001           Balanci (2004)         2.300         0.601         9.425         1.236         0.217         1.014           Balanci (2004)         2.300         0.601         9.425         1.236         0.217         1.014           Balanci (2004)	Guilate (2013)	2.960	1.800	4.000	4.620	0.000				
Numericality         Sufficiency	Macria (2014)	2.000	0.349	13.185	0.763	0.440				_
Non-Point State         Non-Point State         Non-Point State           Interview         State	Mano (2014)	1,011	3.155	0.474	6.003	0.001			_	-
Industry (UVVV)         2.001         2.000         3.701         0.504         0.000           Bits         0.1         1         90           Bits delives         Bits delives           Bits delives         Bits delives           Cardiovascular mortality           Bits delives         Bits delives           Hote with the sech stack         Bits delives           Hote with the sech stack         Bits delives         Bits delives         Different with LOE we with the sech stack           Hote with the sech stack         Bits delives         Bits delives         Different with LOE we with the sech stack           Hote with the sech stack         Bits delives         Bits delives         Bits delives           Hote with the sech stack         Bits delives           Hote with the sech stack         Bits delives           Bits delives         Bits delives           Bits delives         Bits delives           Bits delives         Bits delives           Bits delives         Bits deliv	Mallahov (2017)	2,200	1.128	4 705	1 141	0.000				-
Bits to the set of t	Hamping (PSTIC)	2.000	1.141	3,704	0.004	0.000			-	
Non-rota with USE ver Non-rota with USE ver Non-rota with USE ver Non-rotality           Cardiovascular mortality           Bedra name         Ratifieties for each steric         Second static and 1955.01           Hazard Lower User         Viewer Lotter with USE ver Non-rotality         Second static and 1955.01           Hazard Lower User         Statistics for each steric         Second static and 1955.01           Hazard Lower User         Statistics for each steric         Second static and 1955.01           Hazard Lower User         Statistics for each steric         Log E -         L GE +           Macromodi (2006)         2.360         0.601         9.425         1.236         0.217           Nonoscitudity         Statistics for each steric         Light Static and 1955.01         L GE -         L GE +           Macromodi (2006)         2.360         0.601         9.425         1.236         0.217         1         0.000           Vie (2007)         2.200         1.500 <td></td> <td>2.991</td> <td>2.000</td> <td>1.11</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>		2.991	2.000	1.11						
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Corong (2006)         10.990         3.737         31.791         4.374         0.990           Nu (2006)         6.000         1.001         55.965         1.891         0.990           Nu (2006)         6.000         1.001         55.965         1.891         0.990           Nu (2006)         2.200         0.306         15.990         0.791         0.429           Aahka (2011)         6.000         1.001         55.965         1.891         0.980           Aahka (2011)         6.000         1.001         55.965         1.891         0.980           Aahka (2013)         3.880         2.209         6.548         5.076         0.900           Aahka (2013)         3.880         2.209         6.548         5.076         0.900           Aahka (2013)         3.880         2.209         6.548         5.076         0.445           Aahdi (2013)         3.880         2.000         7.77         8.785         0.900           Aahdi (2014)         1.340         0.110         1.990         0.174         0.882           Aamiday (2017)         3.600         2.045         5.717         4.953         0.900           0.028         0.11         1	ndiovascu Butznese	Har M	Station Station Inst 0.601	ty C	ardio thately 2-veue	P3900	ılar m	LG	E- I	GE+
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Impact of LGE on prognosis in ischemic and non-ischemic cardiomyopathy. A meta-analysis. Ganesan AN, Int J Cardiol, 2018

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Cardiac magnetic resonance – **Clinical applications** 

## **Future perspective - Parametric mapping**



Wong T. et al. Circulation 2012

1.0

Years of Follow-up

0.5

compared to others

mpared to others

1.5





Cardiac magnetic resonance – Clinical applications

**CMR to Identify Reversible** 

## 3)CMR to guide therapy



Segments with LGE > 50% didn't show contractility improvement

Impact of CMR on patient management (revascularization)

- Wall thickness < 4-5 mm: recovery unlikely
- Viability < 20-30% of LV: recovery unlikely
- Coronary anatomy, chronic ischemia duration, extent of revascularization, site of viable and non viable segments, comorbidities influence contractility recovery



Kim RJ New Engl J Med 2000



Preliminary data on CMR role in selection of pts for primary prevention ICD therapy



Gianluca Pontone et al. Circ Cardiovasc Imaging. 2016;9:e004956

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Future perspective – CMR score for selection of pts with heart failure for primary prevention ICD therapy

CarDiac MagnEtic Resonance for Primary Prevention Implantable CardioVerter DebrillAtor ThErapy international registry: Design and rationale of the DERIVATE study

Andrea Igoren Guaricci <sup>a,1</sup>, Pier Giorgio Masci <sup>b,1</sup>, Valentina Lorenzoni <sup>c</sup>, Jurg Schwitter <sup>b,1</sup>, Gianluca Pontone <sup>d,\*,1</sup>

Prospective, international, multicenter, observational registry of NICM and ICM pts with chronic heart failure and reduced LVEF
Clinical evaluation, TTE and CMR
Identification of prognostic CMR parameters for a better selection of patients with heart failure being worthy of primary prevention ICD therapy





Cardiac magnetic resonance – Clinical applications

# ISCHEMIC HEART DISEASE





Cardiac magnetic resonance – Clinical applications







**CMR in ischemic heart disease** 



Ventricular volumes and function



Tissue characterization



Stress perfusion





#### 1) STABLE CORONARY ARTERY DISEASE - A) ASSESSMENT OF MYOCARDIAL ISCHEMIA



2013 ESC guidelines on the management of stable coronary artery disease





Regione Lombardia Cardiac magnetic resonance – Clinical applications

## **Diagnostic & prognostic performance of stress CMR**

Table 1 Large scale clinical validation of stress perfusion CMR since 2008					
Authors	Year	Study design	n	Results	
Diagnostic accuracy					
Hamon et a/w11	2010	Meta-analysis; 35 studies	2154	Sensitivity=89%, specificity=80%	
Greenwood et al <sup>8</sup>	2011	Prospective; single centre	752	Sensitivity=87%, specificity=83%	
Schwitter et al <sup>9</sup>	2012	Retrospective; multicentre	515	Sensitivity=67%, specificity=61%	
Jaarsma et a/ <sup>w12</sup>	2012	Meta-analysis; 37 studies	2841	Sensitivity=89%, specificity=76%	
Prognostic data					
Bingham et a/ <sup>w4</sup>	2011	Retrospective; single centre	908	AER for negative stress CMR <1%/year	
Lipinski et a/ <sup>w2</sup>	2013	Meta-analysis; 19 studies*	11 636	AER for negative stress CMR <1%/year	
Gargiulo et al <sup>w3</sup>	2013	Meta-analysis; 14 studies†	12 178	AER for negative stress CMR=1%/year	

\*Including 4 studies using dobutamine stress for inducible wall motion abnormality.

finduding 6 studies using dobutamine stress for inducible wall motion abnormality.

AER, combined annualised event rate (cardiac death or myocardial infarction); CMR, cardiovascular magnetic resonance.



#### Prognostic Value of Cardiovascular Magnetic Resonance and Single-Photon Emission Computed Tomography in Suspected Coronary Heart Disease: Long-Term Follow-up of a Prospective, Diagnostic Accuracy Cohort Study

John P. Greenwood, MB ChB, PhD; Bernhard A. Herzog, MD; Julia M. Brown, MSc; Colin C. Everett, MSc; Jane Nixon, PhD; Petra Bijsterveld, MA; Neil Maredia, MB ChB, MD; Manish Motwani, MB ChB, PhD; Catherine J. Dickinson, BM BCh, MA, PhD; Stephen G. Ball, MB BChir, PhD; and Sven Plein, MD, PhD



Table 4. Predictors of MACEs, by Multivariable Analysis

Predictor	Hazard Ratio (95% CI)	P Value
CMR		
Abnormal result	2.3 (1.5-3.6)	< 0.001
Age	1.0 (1.0-1.1)	< 0.001
Male sex	1.1 (0.71-1.7)	>0.20
Diabetes mellitus	1.1 (0.65-2.0)	>0.20
Current smoker	1.2 (0.67-2.0)	>0.20
Total cholesterol	0.99 (0.83-1.2)	>0.20
Hypertension	1.0 (0.70-1.5)	>0.20
Family history	0.86 (0.57-1.3)	>0.20
SPECT		
Abnormal result	1.41 (0.94-2.1)	0.10
Age	1.1 (1.0-1.1)	< 0.001
Male sex	1.2 (0.79-1.9)	>0.20
Diabetes mellitus	1.2 (0.71-2.1)	>0.20
Current smoker	1.2 (0.7-2.1)	>0.20
Total cholesterol	1.0 (0.84-1.2)	>0.20
Hypertension	1.1 (0.72-1.6)	>0.20
Family history	0.95 (0.63-1.4)	>0.20

CMR = cardiovascular magnetic resonance; MACE = major cardiovascular event; SPECT = single-photon emission computed tomography.

Five-year follow-up of the CE-MARC study indicates that compared with SPECT, CMR is a stronger predictor of risk for MACEs, independent of cardiovascular risk factors, angiography result, or initial patient treatment.

Greenwood JP, Ann Internal Med 2016

Time to Event, mo





2) MINOCA (Myocardial Infarction with NOrmal Coronary Arteries)

# ESC working group position paper on myocardial infarction with non-obstructive coronary arteries

Stefan Agewall<sup>1\*</sup>, John F. Beltrame<sup>2</sup>, Harmony R. Reynolds<sup>3</sup>, Alexander Niessner<sup>4</sup>, Giuseppe Rosano<sup>5,6</sup>, Alida L. P. Caforio<sup>7</sup>, Raffaele De Caterina<sup>8</sup>, Marco Zimarino<sup>8</sup>, Marco Roffi<sup>9</sup>, Keld Kjeldsen<sup>10</sup>, Dan Atar<sup>1</sup>, Juan C. Kaski<sup>6</sup>, Udo Sechtem<sup>11</sup>, and Per Tornvall<sup>12</sup>, on behalf of the WG on Cardiovascular Pharmacotherapy



#### Eur Heart J 2016





## 2) MINOCA (Myocardial Infarction with NOrmal Coronary Arteries)



#### TAKOTSUBO

ACUTE MYOCARDITIS



Impact of CMRon diagnosisImpact of CMRon patientmanagement

#### PRINZMETAL

MYOCARDIAL INFARCTION





Cardiac magnetic resonance – Clinical applications



Kidambi A, Eur Hear J 2016; Thygesen K, Eur Heart J 2018





Cardiac magnetic resonance – Clinical applications

# 4) Ischemic cardiomyopathy

## CMR to Identify Reversible Myocardial Dysfunction





Kim RJ New Engl J Med 2000

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Cardiac magnetic resonance – Clinical applications

# **4) CARDIAC ARREST**



Whenever possible, perform CMR before ICD implantation if cause of aborted SCA is not clear



 Visited by a cardiologist: no significant past medical history, no family history of heart disease, physical examination normal, abnormal EKG (not shown), mild LVH at echo, other parameters normal

• Referred for CMR in the suspect of HCM

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Cardiac magnetic resonance – Clinical applications

# CMR...in the real world



Long axis cines -Mild LVH -Normal LV and RV function -No LVOT obstruction

Short axis cines -Mild wall motion abnormality of the midapical inferolateral (IL) wall







Cardiac magnetic resonance – Clinical applications

# CMR...in the real world



#### LGE images

-Subendocardial LGE in the mid-apical inferolateral wall

> Ischemic pattern!



Regione Lombardia Cardiac magnetic resonance – Clinical applications

# CMR...in the real world



## **3D free-breathing self navigated whole-heart acquisition** -Normal origin of coronary arteries



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# **CMR...in the real world**



HsTn, NT pro-BNP, CRP, electrolytes, renal function and blood count normal

Assessed by paediatric cardiologist; admitted to paediatric cardiology ward for further assessment





Cardiac magnetic resonance – Clinical applications

# **CMR...in the real world**



Stress ergometry -Reduced effort tolerance -Downsloping ST depression -No arrhythmias -No chest pain

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Cardiac magnetic resonance – Clinical applications

# **CMR...in the real world**



Left coronary artery



Right coronary artery Coronary angiography -Severe 3-vessel disease -Aneurysms of LAD and CX -Sub-occlusion of intermediate branch -OCT showed alterations of coronary walls also in apparently normal segments



# **CMR...in the real world**

- Lipid profile and coagulation normal (no mutations), LAC -
- Diagnosis: severe 3-vessel disease in likely Kawasaki disease (sub-clinical acute phase)
- PCI with multiple DES
- DAPT, beta-blockers, statins

## **CMR supplied**

- new diagnosis
- impact on patient management
- impact on prognosis (revealed unknown severe ischemic heart disease)

		N or quartiles
All	100%	27781
Completely new diagnosis not suspected before	876	2354/27006
Therapeutic consequences		
Change in medication	25.0%	6689/26743
Invasive procedure	16.8%	4510/26778
Hospital discharge	10.2%	2738/26771
Hospital admission	1.4%	386/26780
Impact on patient management (new diagnosis and/or therapeutic consequence)	61.8%	16677/27006
the second		

#### EuroCMR Registry





Cardiac magnetic resonance – Clinical applications

# Once you eliminate the impossible, whatever remains, no matter how improbable, must be the truth. Arthur Conan Doyle

# ...and this is CMR ! Thank you for your attention

patrizia.pedrotti@ospedaleniguarda.it